AN APPLICATION OF THE VALUE STREAM MAPPING AND COMPUTER SIMULATION TO REDUCE THE SERVICE TIMES FOR PATIENTS IN THE EMERGENCY CARE UNIT: A CASE STUDY OF THE OUT-PATIENT EMERGENCY CARE UNIT, SRINAGARIND HOSPITAL

Laongdao Khunngio*, Panitarn Peerapattana

Department of Industrial Engineering, Faculty of Engineering, KhonKaen University,
Muang, KhonKaen 40002
e-mail: kunngiev@hotmail.com

Abstract

This research has been conducted to investigate the problems of an average time for patients remaining longer in the Emergency Care Unit; therefore, its objectives are 1) to propose guidelines for improving the service performance in order to reduce the service times for patients through an application of the Lean tools to create the Value Stream Mapping for identifying wasteful activities as well as determining the scenarios of service process improvement, and 2) to create a computer simulation model for use in comparing the service times for patients of each scenario. From the study of the three main types of patients which are the patients returning home without intervention, the patients receiving x-rays and blood tests with diagnosis to return home, and the patients receiving blood tests with diagnosis to return home; the service process improvement could be identified into seven scenarios and the results from computer simulation indicated that the fifth scenario of improvement could most reduce the average times for the types 1 and 2 patients while the seventh scenario could most reduce the average time for the typed-3 patients. The decreased average times between the fifth and seventh scenarios of improvement are almost the same, but the seventh scenario could be further developed and immediately implemented into an operation. Therefore the seventh scenario has been proposed for improving the service process, which could reduce the average service times for the patients of types 1, 2, and 3 to 18.36, 11.94, and 9.26 per cent respectively.

Keywords: Out-Patient Emergency Care Unit, Lean tools, Value Stream Mapping, Computer Simulation

Introduction

Hospital is one of the most important agencies for health care which needs to have a well-managed and effective system to help make the working process more efficient and reduce time consumption in order to decrease the risks that could jeopardize the lives of the patients especially those who are in an emergency care unit, the unit that serves medical treatment 24 hours a day and is most vital to the lives of the patients since it acts as the first stage for injuries from an accident or sudden illness in both emergency and crises conditions, including those who suffer from disasters which require urgent assistance from either inside or outside the hospital.

Statistics on the number of patients who were treated at the Out-patient Emergency Care Unit of Srinagarind Hospital in between the years 2006-2011 tended to increase while the limitation of service resources resulting in longer average times for patients to remain in the emergency care unit. Consequently it adversely affected the health of the patients both physically and mentally. Therefore, the objective of this research is to propose guidelines for improving the service efficiency in order to reduce the service times for patients.
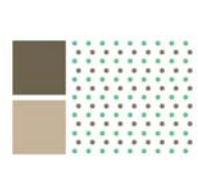
The concept of Lean has been applied in both manufacturing and service industries to reduce waste manipulating in organizations Thetprasit. (2010) [1] e.g., its application in the value stream diagrams to identify the value of production process and its application in factorial experimental design 22 to improve productivity in manufacturing parts of the ceiling glass lamp. The results showed that the proper baking temperature was 165 °C and the baking time was 75 minutes. The study of these factors revealed that the number of broken pieces could be reduced to 6 per cent, which can optimize the baking efficiency to 55.56 per cent and the removal of waste could reduce the total production from 10 days to 7 days or 30 per cent as well. Eric. et al. (2009) [2] have adopted Lean principles to apply in the emergency care unit of a hospital. The results showed that a number of patients coming for treatment increased by 23.9 per cent and the times they remained in the system slightly decreased. Moreover, patients' satisfaction also increased; they received faster services, but the costs of service did not increase accordingly.

Meanwhile, the simulation has been applied to improve the production process and provide a more efficient service process. Phruksaphanrat. et al. (2007) [3] studied the production lines of soft circuit, which is an important component of a hard disk drive. Creating a simulation model for the circuit operation lines assisted the study and analysis in correctly finding the problems through the production lines. Then taking the theory of constraints to identify the limitations of the system that should be modified, it is clear that the rate of productivity increased by 150 per cent.

Lowya. et al. (2003) [4] studied the out-patient service system at the dispensary of Khon Kaen Hospital by using the simulation to find a service policy of the system on the number of service providers at various servicing points that could make the average times for patients to remain not too long in the system. The researchers used five policy simulations and found that the fifth simulation could provide the least average times for patients to remain and wait in the system which were 17.02 and 9.86 minutes respectively.

From the researches mentioned above which related to the concept of Lean and simulation, it was found that the Lean tools could help identify wasteful activities or services e.g., the Value Stream Mapping, while the simulations showed that they could imitated the actual working process without the work interruption. That cause the cost reduction of experiment and the experiment could also be repeated as needed. Moreover, they also provided various approaches that could be used to improve performance.

This research has; therefore, applied not only the Value Stream Mapping to identify waste activities manipulated in the service process in order to find guidelines to improve the services, but also applied simulations to evaluate the service times for patients in each guideline in order to effectively improve the service process at the Out-patient Emergency Care Unit, a case study of Srinagarind Hospital.

Methodology

1. Identifying, Analysis and Solutions the Problem

The study on the ratio of doctors to patients in the morning, afternoon, and evening shifts from January to March, 2011, showed that the proportion of physicians in residency to patients in the morning shift was the greatest in average which was 1:36. This research has; therefore, chosen to study only the service process of the morning shift. The results from the study on the number of patients coming for treatment, which were screened into four levels, indicated that the number of patients on average in the rush and non-rush levels was 96.71 per cent of all patients in the morning shift. The researchers have; therefore, chosen to study the patients of these levels only.

The researchers have also classified the patients into the rush and non-rush levels according to the guidelines for a wide range of treatment depending on the severity of the disease, in order to be used for further studies.

The study on the number of each type of patients in the morning shift from January to March, 2011, by using the Pareto diagram to select types of patients, found that the total number of patients in the three main types; 1) the patients returning home without intervention, 2) the patients receiving X-rays and blood tests with diagnosis to return home, and 3) the patients receiving blood tests with diagnosis to return home; were 67.32 per cent of all patients. Therefore, these 3 main types were chosen to conducted for the average times used in the emergency care unit starting from the beginning of the process of admission to medical diagnosis with permission to return home or stay for further treatment at the hospital or be referred to other hospitals for further treatment. In this study, their pending or awaiting times in the processes of admission, drug prescription, or referring to other hospitals will not be included because they are beyond the control of the emergency unit.

The problem encountered in the current out-patient emergency care unit was the average times that the patients remained in the system for so long, this research has; therefore, used the Value Stream Mapping to identify waste activities manipulated in the service process. The VSM of this study culled the current state mapping [1, 5] could be created as show in Fig.1. It is clear that the waste process is the waiting times before medical treatment and medical diagnosis, which are 72.92 and 26.73 minutes per person respectively.

So, the analysis for indentifying the causes of problem particularly the waiting times before medical treatment and diagnosis, needs brainstorming from all related all persons in order to establish the Cause and Effect Diagram to show such the causes and provide solution.

For the Cause and Effect Diagram, solutions to the problems can be identified into three guidelines as follows:
1. Use a barrier to build the examination room at the observation area to reduce the average time for diagnosis by doctors to about 2 minutes.
2. Store and separate the stocks between the examination room and the observation room to reduce the average time for intervention by nurses to about 3 minutes.
3. Install the Accident and Emergency Information System (AE IS) program in all computers located in the examination room and add a current status of room number before the name of the patient to reduce the average time of the medical treatment process by doctors to about 3 minutes.
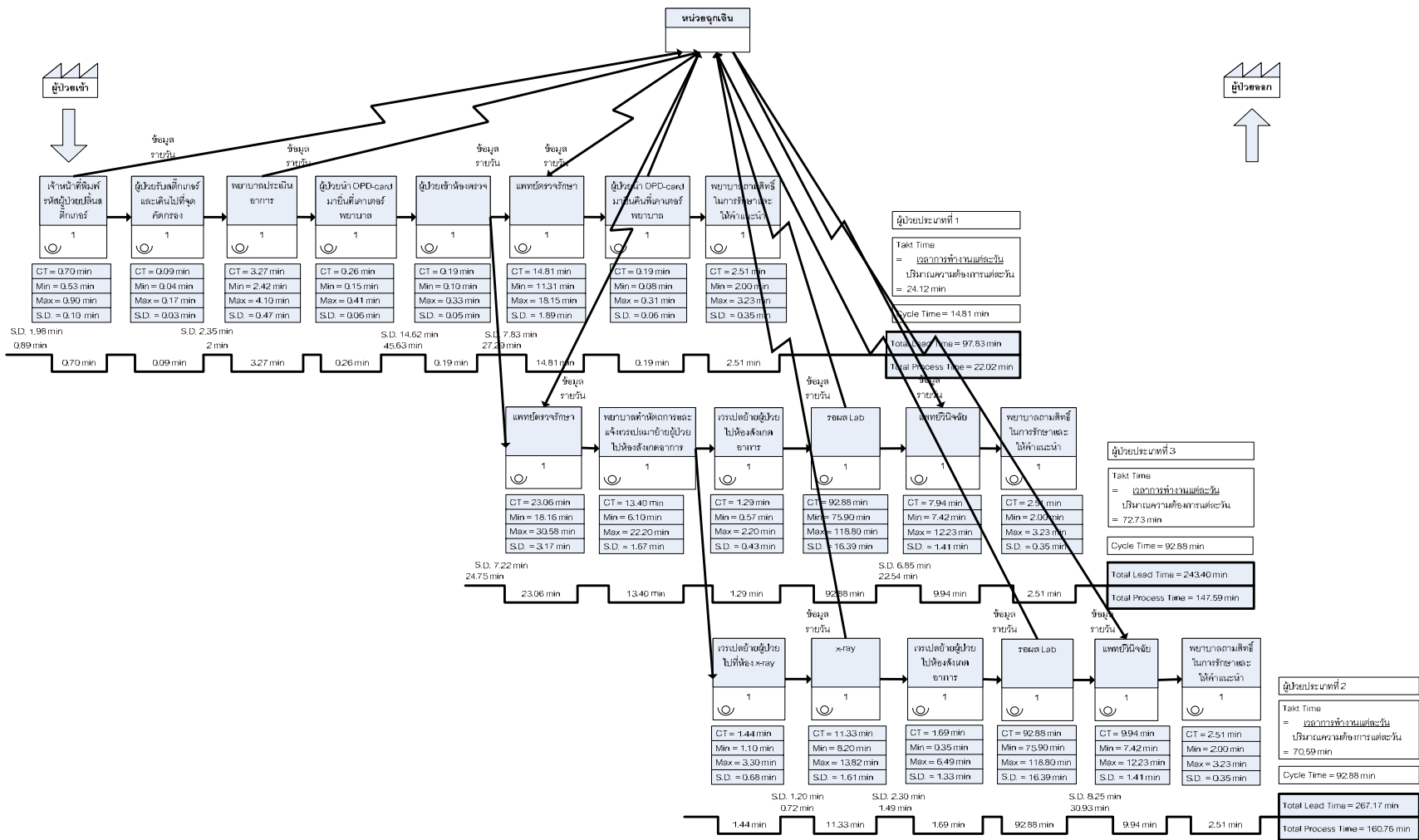
Figure 1 show the current state of VSM

2. Simulation of Service System for Patients

2.1 Testing for the Sufficiency of Data

1. Number of patients admitted

This research investigated the service of a case study in the morning shift which started from 7:30 a.m. to 15:30 p.m., Monday through Friday. The times taken to collect the number of patients served each day covered 25 days and were divided into eight periods a day as follows; 7:30 to 8:30, 8:30 to 9:30, 9:30 to 10:30, 10:30 to 11:30, 11:30 to 12:30, 12:30 to 13:30, 13:30 to 14:30, and 14:30 to 15:30,. The testing for the sufficiency of data used the analysis of variance with three examination approaches; 1) to test the normal distribution of the data, 2) to test the independence of the data, and 3) error and an approximate value of the observed value, before taking all examined data into analysis for variance of the two factors, the factors of days and periods that affect the number of patients treated. It was found that the factor of days did not significantly affect the number of patients treated (P-value > 0.05) whereas the factor of periods did significantly affect the number of patients treated (P-value < 0.05). The relationship between the two influencing factors did not significantly affect the number of patients treated also (P-value > 0.05); therefore, such the data could be taken to test for the appropriateness of data distribution.

2. Testing for the Appropriateness of Data Distribution (Goodness of Fit Test)

2.1 The test for the appropriateness of data distribution of the average number of patients served in each period used the Goodness of Fit Test to create the model of the current simulation patients' serviced. The data of the number of patients that passed the sufficiency test were also taken to investigate and the results revealed that all periods were Poisson distribution.

2.2 The test for the appropriateness of data distribution of the service times used the Goodness of Fit Test to create the simulation model of the current services process. The data of the service times that passed the sufficiency test were also taken to investigate and the results revealed that the time of each service process was Normal distribution.

2.2 The Current Simulation Model

From the current service process study of the three-typed patients, the simulation model of current state can now be created by using the Arena 13.0 [6] program and its validity test can be organize as the following steps:

Checking for Accuracy

1. To find the number of processing runs, the program could calculate with a total of 30 cycles. [5, 6]

2. Verification

Due to the data collection has been done for 25 days, the test by the Arena program was thus carried out at 25 days (36,000 minutes) as to be used in a statistical test by input data of both the number of entering patients and the service times in each process (which were already

tested for the appropriateness of data distribution or Goodness of Fit Test) in order to check whether or not the simulated value matches with the actual value from data collection through a program processing for 30 times, the test results are shown in Table 1.

Table 1 Verification of the current simulation model compared with actual data.

Comparison	Data	
	Actual	Simulated
Length of test (days)	25	25
No. of patients treated (persons)	1475	1479
Patients returning home (minutes)(1)	97.825	97.200
Patients with x-rays and lab(minutes)(2)	250.500*	248.700
Patients with lab (minutes)(3)	243.400	247.500

*Means duration from critical path.

3. Checking for Validation of the current simulated model compared with the actual data.
From Table 1, simulated data was taken for a hypothesis test for Mean (T-test) by testing the average times of both the actual and simulated data that the patients remained in the emergency care unit. The T-test results are shown in Table 2.

Table 2 shows the test results (T-test) of the average times in service.

		One-Sample Test			
		t	df	Sig. (2-tailed)	Mean Difference
1	Test Value = 97.2	0.166	39	0.869	0.625
2	Test Value = 248.7	0.123	39	0.903	1.8
3	Test Value = 247.5	-0.365	39	0.717	-4.1

Table 2 indicates that P-value value of all types of patients is greater than 0.05. The main assumption is therefore accepted that is the average times derived from a comparison between the actual data and the simulated data for patients remaining in the emergency unit are not significantly different, and the model can be taken for further development.

3. Determination of the scenarios for Improvement and create a simulation model based on proposed scenarios
From the three guidelines for improvement in Art 1, 7 scenarios of improvement can be determined as follows.
1. Scenario 1, the first guideline to reduce the average time for diagnosis by doctors to about two minutes.
2. Scenario 2, the second guideline to reduce the average time for intervention by nurses to about three minutes.
3. Scenario 3, the third guideline to reduce the average time of medical treatment procedures to about three minutes.

4. Scenario 4, the combination of the first and the second guideline.

5. Scenario 5, the combination of the first and the third guideline.

6. Scenario 6, the combination of the second and the third guideline.

7. Scenario 7, the combination of all 3 guidelines.

All of the above scenarios are evaluated by using a process analytical tool (process analyzer) of the Arena program.

Result and Discussion

Comparison of the average times between the actual data and the simulated data for patients remaining in the emergency unit has been done by the hypothesis test of Mean or T – test. The results indicated that the average times for patients remaining in the emergency care unit of the current process were significantly longer than those of the fifth and seventh proposed scenario (P-Value < 0.05) of all types of patients. Therefore, comparison of the decreasing percentage of average times between the actual data and the simulated data of the fifth and seventh scenario has been done as shown in Table 3.
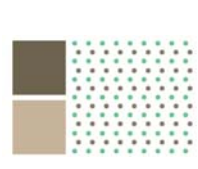
Table 3 Comparison of the decreasing in average service times for the three - typed patients.

Types of Patients	No. of Patterns (Scenario)	Average Times (Minute)		Average Times Decreased (Minute)	Percentage
		Actual	Simulated		
1	5	97.83	78.92	18.91	19.33
	7	97.83	79.87	17.96	18.36
2	5	250.50	220.54	29.96	11.96
	7	250.50	220.60	29.90	11.94
3	5	243.40	221.07	22.33	9.18
	7	243.40	220.87	22.53	9.26

Table 3 indicates that the average service time of patient types 1 and 2 under the fifth scenario can be most reduced as 19.33 and 11.96 per cent respectively whereas the average time of patient type 3 under the seventh scenario can be reduced as 9.26 per cent. Since the decreased average times of the fifth and seventh scenarios are very similar. However, the seventh scenario could be further developed and immediately implement into an operation. Therefore, the seventh scenario has been proposed for improving the efficiency of service in this study.

Conclusions

Through an application of the Lean tools, the Value Stream Mapping could be used to identify wasteful activities in the service process such as the waiting times for medical treatment and medical diagnosis. The Cause and Effect Diagram was also used to identify the causes of problems and solutions. Three guidelines for solving the problems were suggested. These guidelines were also taken to determine the seven scenarios of improvement which were approved by a computer simulation. The comparison between the actual and the

simulated data of such scenarios indicated that the fifth and seventh scenario could nearly reduce similar average times for three type patients. Due to the flexibility, The seventh scenario, which could reduce the average times for the typed-1 patients from 97.83 to 79.87 minutes (18.36%); the typed-2 patients from 250.50 to 220.60 minutes (11.94%); the typed-3 patients from 243.40 to 220.87 minutes (9.26%) respectively, was therefore chosen.

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