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Queuing Management Simulation Using Lean in Pharmacy Department of Hermina Yogya Hospital: Exploiting the Potential of Reducing Cycle Time

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Abstract: Pharmacy is responsible for providing all the prescribed drugs and advising patients about the use of the medication. This unit is important for the hospital economically because it accounts for 40-50% of hospital revenues. Lean is implemented in pharmacy to reduce the cycle time using sequencing job analysis. Prior to implementing lean method, the team has conducted training for all staff, including measurements and audits to monitor the performance metrics in line with lean implementation. The team promoted the involvement of staffs, including in committing and engaging in totality of implementation activities. The measurements used were: (1) Average cycle time, (2) Job Delay and (3) Percentage of Job Delay. The time is calculated from the patient submitting the prescription to receiving the drug in minutes. The pharmacy cycle time of the selected sample was 110 respondents divided into 3 categories: (1) red for subscription containing 1-3 items with target of 5 minutes, (2) yellow for subscription containing 4-6 items with target 10 minutes and (3) green for subscription containing more than 6 items with a target of 15 minutes. The pharmacy cycle time one month after the implementation of lean on the selected sample was 110 respondents divided into 3 categories. The cycle time of red category on average was 6 minutes, yellow 9 minutes and green 20 minutes. When compared to the target, the red category that exceeds the target is 31.46% (28/89), 21.43% yellow (3/14) and 14.29% green (1/7). The above results show that lean implementation is successful in reducing the waiting time for certain items in the pharmacy. Finally, lean can directly reduce the cycle time. In addition, the change of conventional service model which was in the order of arrival can be changed into SPT (Shortest Processing Time) model. Therefore, there is a significant decrease in service time for red by 46.96%, yellow 52.57% and green 62.07%.

Keywords: Pharmacy, Lateness, Lean Implementation, Cycle Time

I. INTRODUCTION

Background

One of the most important challenges faced by hospital in achieving cost efficiency is reducing the queue time in pharmacy department. The pharmacy department receives medicine order and suggests doses and new drugs. About 40-50% of hospital revenue comes from drug sales in the pharmacy department [1]. In China for example, hospital revenue even reaches more than 50% from drug sales [2]. Therefore, the pharmacy department is very important for the sustainable hospital business economically.

However, the pharmacy department is often faced with efficiency problems due to many factors. The pattern of prescription arrival, the percentage of pharmacy department staff, work order, and interactions between fellow pharmacy employees as well as between pharmacy employees and patients often inhibits efficiency [3], [4]. The decrease in efficiency is reflected in the length of the queue for drug purchasing, which in turn causes dissatisfaction of the patients [5] - [7]. A number of studies confirm how the service in the pharmacy department affects the overall patient satisfaction on hospital services [3], [8], [9].

There are several quality improvement methods proposed to improve the efficiency of drug sales in the pharmacy department. The common method is queuing theory [10]. However, this method uses a complex mathematical approach and statistical assumptions that do not reflect reality [11]. The application of this theory often involves a high cost redesign solution and could reduce efficiency even further during the renovation process [12].

A simpler approach offered by lean methodology. The lean methodology is “an organization’s cultural commitment to applying the scientific method to designing, performing, and continuously improving the work delivered by teams of

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people, leading to measurably better value for patients and other stakeholders" [13]. Lean aims at efforts to reduce eight types of waste: overproduction, human resources, transportation, inventory, motion, corrections, over-processing, and waiting [14]. The lean method is known to be very suitable for collective cultural setting such as in Indonesia because of the collective character of lean implementation [15]. The application of lean is known to give positive effects on employee performance [16] and overall organizational performance [17], [18].

Lean methodology is effective for refining the flow of patients without redesigning the space, but to redesign the layout for a smooth flow of patients without going through long queues [19]. Specifically, we use the lean method to organize the pharmaceutical jobs in order to achieve the most possible efficiency.

II. METHOD

Lean is implemented in a pharmacy department of Hermina Yogya Hospital, Yogyakarta, Indonesia. The target is to reduce the cycle time using sequencing job analysis. Prior to implementing lean, the team has conducted training to all staff, including in the conduct of measurements and audits to oversee performance metrics in line with lean implementation. The team has supported the involvement of staff, including in committing and engaging in totality implementation activities.

The team then review the situation and held a meeting to propose solutions to the problems, attended by the pharmacy department staff. The team decided to hold three activities, namely 5S, *kanban* system, and reduction of lot size. First, the 5S procedure, which is sort, straighten, sweep, standardize, and self-discipline was implemented. Next, the team used the *kanban* system for drugs order from the receptionist to officers in the racquet room so that they did not need to go to and fro. The officers only need to send orders and receive products through a kanban line. Finally, the team reduces the lot size so it would truly represent the needs at the time of ordering without any inventory build-up.

III. DATA ANALYSIS

To measure the effect of lean on reduction of cycle time, we measured: (1) Average cycle time, (2) Job Lateness and (3) Percentage of Job Lateness. This time is calculated from the patient give prescribing to receiving the drug in minutes. The pharmacy cycle time of the selected sample is 110 patient respondents divided into 3 categories: (1) red for recipes containing 1-3 items with target of 5 minutes, (2) yellow for recipes containing 4-6 items with target 10 minutes and (3) green for recipes containing more than 6 items with a target of 15 minutes. One month after the implementation of lean, the pharmacy cycle time of the selected sample is measured again. We use independent-sample t-test to test the significance of the difference before and after lean implementation. This test is quite commonly used in the analysis of lean performance [20].

IV. FINDINGS

We measured the cycle time two days before the implementation of lean and three days a month after lean implementation. Before the implementation, 66 subscriptions in the red category, 32 in the yellow category, and 12 in the green category were obtained. After the implementation, the obtained sample consisted of 89 red categories, 14 yellow categories, and 7 green categories.

Red Category Subscriptions

Subscription in red category include the subscriptions containing 1-3 items of drug. This subscription is targeted to have a cycle time less than 5 minutes. Data from the situation before lean implementation was 66 subscriptions with an average cycle time of 12.98 minutes. The minimum value is 3 minutes while the maximum reaches 82 minutes. The standard deviation of the data was 11.18 minutes. Meanwhile, the data after lean implementation of 89 samples obtained an average cycle time of 6.89 minutes, meaning reduction of 46.96%. Meanwhile, the minimum value decreased from 3 minutes to two minutes. Similarly, the maximum time of 82 minutes drops to only 28 minutes. The standard deviation also decreased to 5.29 minutes. In addition, delay, defined as the number of subscription produced exceeding the time target of five minutes, obtained 81.82% subscription in pre-implementation. Post implementation, the target time of five minutes was reached by 68.54% subscriptions, meaning that the delay was only 31.46%, much lower than the pre-implementation.

To find out whether the differences were significant, an independent sample t-test was conducted. The data shows an abnormal distribution based on the Kolmogorov-Smirnov test, so that the t-test used was the Mann-Whitney U test. The

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Mann-Whitney test produced a Z value of -5.64 with a significance level of 0.000 <0.050, indicating that there was a significant difference before and after lean implementation.

As the red category covers subscription with 1-3 items, it is possible that the number of items affects the results of the analysis. The results of Kendall's bivariate correlation test yielded a value of 0.113 with a significance level of 0.080> 0.050. Although the number of items did not significant influence the cycle time, a standard value of cycle time was made to increase the confidence level by dividing the cycle time by the number of items. The results of the Mann-Whitney test again produced a significant value (Z = -4.31, p = 0,000 <0.050) indicating that the differences are real even if the sample is differentiated based on the number of items.

Yellow Category Subscription

We conducted the same test for the yellow category subscription. The subscription in yellow category includes the subscription containing 4-6 items of drug. It is targeted to have a cycle time of less than 10 minutes. The data from situation before lean implementation was 32 subscriptions with an average cycle time of 20.78 minutes. The minimum value is 5 minutes while the maximum reaches 47 minutes. The standard deviation of data reached 10.08 minutes. Meanwhile, post-lean implementation data from 14 samples obtained an average cycle time of 9.86 minutes, which means a reduction of 52.57%. Moreover, the minimum value decreased from 5 minutes to three minutes. Similarly, the maximum time from 47 minutes was only 37 minutes. The standard deviation also decreased to 8.41 minutes. In addition, delay, defined as the number of subscription exceeding the target time of 10 minutes, were 90.63% of subscription in pre-implementation. After implementation, the target time of 10 minutes was reached by 78.57% subscription, meaning that the work delay was only 21.43%, much lower than the pre-implementation.

To find out whether the differences were significant, an independent sample t-test was conducted. The data shows a normal distribution based on the Kolmogorov-Smirnov test (Z = 1.02; sig 0.251> 0.050), so that the comparative test used was the t-test. The Levene test produced a significance value of 0.102> 0.05 indicating that the variant was homogeneous. The t-test resulted in a significance value for the homogeneous variant of 0.001 <0.050, indicating that there were significant differences before and after lean implementation in the yellow group of subscription.

Since the yellow category covers subscription with 4-6 items, it is possible that the number of items affects the results of the analysis. The results of Pearson correlation test produced a value of 0.478 with a significance level of 0.001 <0.050. It shows that the number of items significantly affects the cycle times. Therefore, the t-test needs to be repeated to increase the confidence level using the standard value of variable of the cycle time. The results of the t-test produced a significant value (Levene = 0.490> 0.050; Significance = 0.002 <0.050) indicating that the differences are real even if the sample is differentiated based on the number of items.

Green Category Subscription

The green category includes subscription containing more than 6 items of drug. This subscription is targeted to have a cycle time of less than 15 minutes. The data of situation before lean implementation were 10 subscriptions with an average cycle time of 35.40 minutes. The minimum value is 10 minutes while the maximum is 54 minutes. The standard deviation of data reached 11.31 minutes. Meanwhile, the data of post-lean implementation of 7 samples obtained an average cycle time of 13.43 minutes, which means a reduction of 62.07%. Meanwhile, the minimum value rises from 10 minutes to 11 minutes. However, the maximum time increased from 54 minutes to only 20 minutes. The standard deviation also decreased to 3.05 minutes. In addition, delay, defined as the number of prescriptions exceeding the target time of 10 minutes, were 75.00% of subscription in pre-implementation. After the implementation, the target time of 15 minutes was reached by 85.71% subscription, meaning that the work delay was only 14.29%, much lower than the pre-implementation.

To find out whether the differences were significant, an independent sample t-test was conducted. The data shows a normal distribution based on the Kolmogorov-Smirnov test (Z = 0.919; sig 0.379> 0.050), so that the test used was the t-test. The Levene test produced a significance value of 0.123> 0.05 indicating that the variant was homogeneous. The t-test resulted in a significance value for the homogeneous variant of 0,000 <0,050, indicating that there were significant differences before and after lean implementation in the green group of subscription.

Since the yellow category includes subscription with more than 6 items, it is possible that the number of items affects the results of the analysis. The data shows that the maximum number of items was 9 items. The results of the Pearson correlation test produced a value of -0.208 with a significance level of 0.424> 0.050. It shows that the number of items does not significantly affect the cycle time. However, to increase the confidence level, the t-test was repeated with

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standard value of variables of the cycle time. The results of the t-test produced a significant value (Levene = 0.022 <0.050; Significance = 0,000 <0.050) indicating that the differences are real even if the sample is differentiated by the number of items.

Table 1. Research Results

Category	Red (1-3 items)		Yellow (4-6 items)		Green (7-9 items)	
	Pre-	Post-	Pre-	Post-	Pre-	Post-
N	66	89	32	14	10	7
Cycle Time						
Mean (min)	12.98	6.89	20.78	9.86	35.4	13.43
Min. (min)	3	2	5	3	10	11
Max. (min)	82	28	47	37	54	20
SD (min)	11.18	5.29	10.08	8.41	11.32	3.05
Target (min)	5	5	10	10	15	15
Late (%)	81.82	31.46	90.63	21.43	75.00	14.29
Difference						
Test	Mann Whitney		t-Test		t-Test	
Sig.	0.000		0.002		0.000	
Reduction						
Cycle Time	46.96%		52.57%		62.07%	
Lateness	61.55%		76.35%		80.95%	

V. DISCUSSION

This study is to assess the effectiveness of service efficiency improvement of the pharmacy department using a number of lean interventions. The results of one month after the intervention was performed showed a dramatic decrease in cycle time, indicating that the expected effectiveness is achieved.

In addition, this study is in line with previous studies which demonstrated the effectiveness of lean in improving the performance of hospital pharmacy department [21] - [23]. The biggest effect appears in green category since the standardized system allows the drug to be taken faster and faster because one subscription usually has a relatively similar drug pair and is located adjacent on drug shelves. Overall, the lean systems developed in the pharmacy department allow the improvements on the cycle times because of the acceleration resulting from the combination of various lean techniques. In this case, 5S allows medicines to be sorted according to the speed of retrieval by taking into account the drug class, clean room from dirt and items that are no longer needed, all pharmaceutical indicators that have been organized neatly and clearly, and rules that have been set so that this excellent condition can be maintained. Kanban allows the speed of ordering and delivery of drugs along with reduced waste of motion. Lot size reduction decreases the waste of time from of the patients because one order is guaranteed to be completed before other order is arrived.

There are many kinds of tool for lean implementation besides 5S, *kanban*, and lot reduction. These tools for example, include value stream mapping, poka-yoke devices, visual control, etc. [24]. All of them can be used according to the needs other than merely reducing the cycle times for queueing management. Value stream mapping, for example, can be used to improve the work system as a whole, especially in a larger pharmacy department or related to cross-departments. Poka-yoke can be applied to reduce errors in doing tasks. Meanwhile, visual control can be used for monitoring and evaluation activities. In this study, we have shown that the combination of 5S, *kanban*, and lot reduction is useful in reducing the cycle time of pharmacy department.

CONCLUSION

The application of lean method using 5S, *kanban*, and lot reduction was successfully conducted in the case of pharmacy department at Hermina Hospital Yogyakarta. This process was started with training and brainstorming sessions which facilitate common understanding on the problems and the right tools to be produced to overcome the cycle time problems. We learned that cycle time can be reduced by implementing a good housekeeping with smart mobilization techniques and strong discipline. It is not only effective to reduce the cycle time, but also to improve the overall efficiency of the hospital as well as promote patient satisfaction.

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