Lean Service and Application of MRI-Tomography Imaging Center

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Abstract: In this study, Magnetic Resonance (MRI) and Tomography Imaging Center of an Education and Research hospital was investigated from a system development point of view, and processes causing waste were identified. During analysis phase, it was found that waste-causing processes arise from waiting of patients due to deficiencies of the appointment system. Starting with the lean management philosophy and using tools and techniques of lean service notion, these processes were redesigned and waste was prevented by also taking the resistance and critical success factors encountered during lean application process into consideration. For this purpose, differences of incoming patients, types of operations, preparation periods and cycle times were analyzed and a new appointment model was proposed.

Key Words: Lean Management Systems, Lean Service, Lean Healthcare, MRI-Tomography Imaging Center

Introduction

In the recent years, organizations attach as much importance to service and customer satisfaction as they attach to profitability, and they benefit from various techniques, technologies and points of view in order to meet expectations of dynamic demand, short operation/delivery period, high quality and low cost and to maintain their existence. Lean production and Lean Thinking in this regard are deemed as a nearly indispensable approach. Lean Thinking is a way designed to define the value, to line up the actions that create value in a manner that will give the best result, to implement these activities uninterruptedly and in an increasingly efficient fashion. In brief, Lean Thinking is lean, since it shows the way to derive more with increasingly lower efforts, less equipment, less time and less space, and thereby it converges more to the exact wishes of the customer. (Womack, Jones, 2003). Today, service-oriented sectors gain more significance and growing enterprises aim at profit maximization by eliminating waste. Lean Thinking essentially focuses on defining activities that do not create value in the services and production sectors and removing waste (Womack, 1990).

Lean service is use of basic principles of lean production in the services sector. Lean production philosophy that provided successful results in the manufacturing industry has started to be used in the service sectors in the recent years. Application of Lean Thinking is new and being adopted by health, logistics and enterprises that sell fast services at the first stage (Efe, 2011).

Lean Management in the Hospitals

Existence of organizations, their survival and boosting of their market shares in today's competitive conditions is possible by responding to customer demands in the fastest and accurate way possible, above everything else. Hospitals, which carry out activities on humans that add value, cannot always respond to the demands of patients or cannot respond immediately and this gives rise to plenty of waiting time. Major reasons of these waiting times are bottlenecks and waste in the system. When one considers that people expecting service from hospitals are mostly patients, it is natural that they easily get dissatisfied as they do not have the endurance and time to wait. For these reasons, bottlenecks in the system should be quickly fixed, efficiency of so expensive resources should be increased and waste should be eliminated. Here, lean tools and techniques come to the help of hospitals, which are used in lean production but today receive interest in the services sectors as well. In our country, use of Lean Thinking philosophy in the service sectors (especially the health sector) is not so common, whereas in the world, especially in the United States, the years when applicability of Lean Thinking to the health sector was discussed are left behind and many hospitals implemented lean transformation successfully and obtained positive results. That is because, Lean Health can turn from a goal into reality owing to the need to do "more work" with "less resources" in parallel to the economic change in the world and increased focus on raising safety and quality along with performance (Graban, 2008).

It may be useful to have a common terminology in identifying waste. 7 types of waste defined for the production sector can be used as a useful framework in identifying the waste in the hospitals. However, since hospitals involve processes that focus on humans, human potential is added as an eighth type of waste (Melton, 2005). There are eight types of waste defined for hospitals. These are:

- ✓ Defects
- ✓ Overproduction
- ✓ Unnecessary Movement of Materials
- ✓ Waiting
- ✓ Excessive Stock
- ✓ Unnecessary Movement of People
- ✓ Over processing
- ✓ Human Potential

Materials and Method

Site of the study is the MRI and Tomography imaging center of an Education and Research Hospital. The number of patients is high, since the imaging center offers services in a state hospital, which is a full-fledged hospital. The center offers services 7/24 in three shifts of 8 hours. Full service flow of patients that come to the imaging center, from registration to the discharge, was analyzed. During analysis, problems were identified, and reasons of the problems were investigated by going down to the root causes. A system that would provide a solution to these problems was designed and application results were discussed.

Identification of the problems

Process of identifying and resolving problems is tough job due to complexity, difficulty of choosing alternatives, ambiguity and the risk it involves. Due to these difficulties, best way to solve a complex problem is to use an effective decision-making process (Engin, 2005). At this stage, method of face to face meeting with the employees and patients was used. Work flow maps were studied, and upper management, employees and patients were met to identify the problems. But, the biggest problem seen was waiting of the patients. Patients had to wait a lot for the operation even if they come at the time of appointment, which caused dissatisfaction and problems.

Waiting time can in general be defined as the time during which no operation is done. It is easy to identify a lack of action as waste, but it is difficult to differentiate waiting times. Patients usually wait in the clinics due to bad work flow or bad programming. For patients, waiting time is the time they waited to reach the step that adds value in the patient tour. In a hospital, it is not only patients who wait, at the same time many materials wait during much of the time instead of being used in value-adding works. The reason for the waiting times is that work is done aggregately within the service and that the workflow does not comply with the first in-first out rule (Graban, 2008). In Table 1, appointments in a period of one month is investigated and average delays (average waiting time of the last patient) can be seen. Appointments given by the center during a one month time was investigated and waiting time of the last patient at the end of the day was calculated using these appointment lists.

Table 1. Monthly appointment delay periods

Delay Period (Hours)	Number of days	Percentage (%)
1	4	13
1-3	8	27
3-5	16	53
> 5	2	7

As seen in the table, last patient waits for 1 hour during 4 days, for 3 hours during 8 days, for 5 hours during 16 days and for more than 5 hours during 2 days. When average of these figures is taken, daily average waiting time is 188 minutes.

Identifying the reasons for the problems

In order to identify the reasons for waiting problems of patients in the imaging center, Fish Bone Diagram (Cause-Effect Analysis) used in the decision-making and problem-solving stages of Lean Production applications was used.

Fish bone diagram

A fish bone diagram shows the relationship between causes and effects. In general, it is used to reduce a problem to a few basic problems and focus on these potential basic problems. Fish bone diagram was first used in 1953 by Professor Kaoru Ishikawa in the quality applications in Japan (Şengül, 1997). In Figure 1, one can see the fish bone diagram prepared to find a solution to the question “Why do patients wait for a long time?” with the employees of the imaging center and to go down to root causes of this problem.

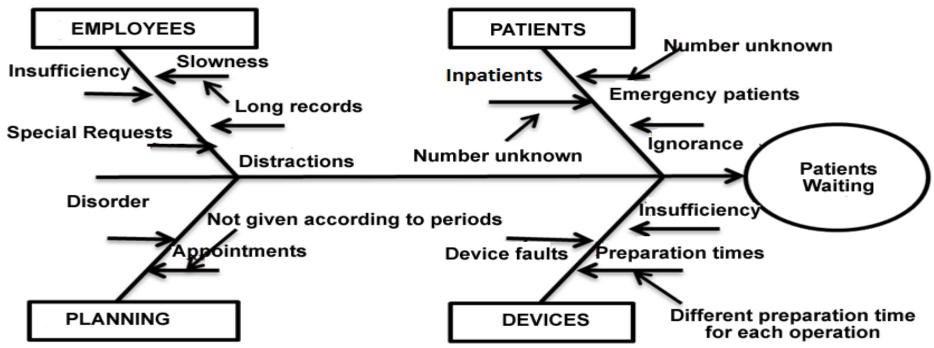

Figure 1. Fish Bone Diagram

According to the fishbone diagram created, reasons for waiting of patients are elongation of registration times, the fact that appointments are not given according to the time needed for imaging and according to the types of imaging, the fact that inpatients and emergency patients are not separated, insufficiency of number of staff, insufficiency of number of devices, the fact that patients are not sufficiently informed, special requests of the doctors, patients keeping technicians busy and lengthy preparation times. Elimination of these identified problems will contribute to lean transformation. But, trying to solve all of the problems will lead to failure to identify the root causes and allow repetition of these problems. For this reason, it should be determined solving which problems will contribute more to the lean transformation. Pareto analysis was conducted for this purpose.

Pareto analysis

This approach laid out by Italian economist Pareto in 1897 and later implemented by M. C. Lorentz was originally developed to show the income distribution. It is J. M. Duran who adapted this to quality problems by making it a significant minority-insignificant majority principle and gave it the name "Pareto analysis" (Özcan, 2001). Pareto analysis data table based on total weights, cumulative weights, percentages and cumulative percentages according to the votes of the employees is shown in Table 2.

Table 2. Pareto analysis data table

Problems	Number of votes	Percentage	Cumulative Number of Votes	Cumulative percentage
Little time reserved for emergency patients/inpatients	6	0.28571	6	0.285714
Imaging times of appointments	5	0.2381	11	0.52381
Imaging types of appointments	4	0.19048	15	0.714286
Lengthy preparation times	2	0.09524	17	0.809524
Insufficiency of number of staff	1	0.04762	18	0.857143
Insufficiency of number of devices	1	0.04762	19	0.904762
Patients insufficiently informed	1	0.04762	20	0.952381
Special requests of doctors	1	0.04762	21	1

According to the pareto diagram, there are 4 problems that differentiate from others and constitute 80 % of all problems. Making improvements in these 4 problems will affect results of lean transformation more.

Solution of Problems and Application

According to the pareto analysis, of the problems of allocating little time to emergency patients and inpatients, failure to give appointments according to imaging times and according to imaging types and length of preparation times, first three seem to arise from bad planning. Investigation was conducted to identify the root cause of the problem of lengthy preparation times, and at the end of measurements it was found that measurement times were not long but preparation operations were overly repeated. So the real problem is not the length of preparation period but repetition of preparation stages. If similarities can be identified in the preparation phase and similar works (imaging) can be done successively, waste will be minimized. Eventually, the reason behind the fact that preparation periods are lengthy in total is still the bad planning of the appointments. The solution that will eliminate all 4 identified problems is to redesign the appointment system.

Group Technology (GT) is a production philosophy based on grouping of products according to their similarities in product design and production, by making use of similarities among products. While implementing GT, similar parts are grouped in "part groups". Each group will have similar design and production features. Thus, processing of each member of a group will be similar (Özçelik, 2011). Starting with the GT definition, preparations can be grouped based on similarities. Works (imaging) that have similar preparation phases will belong to the same group. There are 40 different MRI types that can be handled in the imaging center. Preparation of the device for imaging consists of changing the coil. 40 different types are imaged using 7 different coils. Therefore, grouping works that use the same coil together will remove the process of changing the coil and reduce the preparation time. There are 7 different imaging groups. It was aimed to redesign the appointment system based on these groups. In order to avoid repetition of preparation, appointments will follow one another in the same time range during the day for MRI types within the same group, which will eliminate the need to change the coil. Also, emergency patients will be reserved time within the day, which will reduce the time arising from emergency hospitals. Patients coming to the imaging center were observed for 30 days. And when data of 30 days was analyzed, following was found.

Imaging center provides services for 24 hours. 2478 patients came for MR imaging in 30 days. Imaging is performed for 82 patients daily on average. But, average of 100 patients are given appointments, and appointments of remaining patients are cancelled by phone. Distribution of 2478 by groups is shown in Table 3.

Table 3. Group distributions

Groups	Total patients	Percentage(%)
1st Group	131	0,05
2nd Group	1119	0,45
3rd Group	384	0,15
4th Group	624	0,25
5th Group	189	0,08
6th Group	15	0,01
7th Group	16	0,01

After analyzing the number of incoming patients by group, in order to avoid waiting resulting from emergency patients, incoming emergency patients and the group of these emergency patients were investigated. During 30 days 148 emergency patients/inpatients came. 58 % of these emergency patients belong to 4th group, 24 % belong to 2nd group, 10 % belong to 5th group and 6 % belong to 3rd group. No emergency patient came for 1st, 6th and 7th groups. Distribution of emergency patients by group is as follows: emergency patients constitute 3.2% of 2nd group, 2.3 % of 3rd group, 13.7 % of 4th group and 7.9 % of 5th group. No emergency patient came for 1st, 6th and 7th groups. Average cycle time for each group was calculated. These periods are 17 minutes for 1st group, 14 minutes for 2nd group, 20 minutes for 3rd group, 11 minutes for 4th group, 19 minutes for 5th group, 15 minutes for 6th group and 25 minutes for 7th group. Daily time to be allocated by group, and number of patients on appointment and number of emergency patients calculated based on cycle times, according to the information at hand, are shown in Table 4.

Table 4. Number of patients on appointment and periods

Groups	Emergency patients	Number of patients to give appointments	Number of patients	Average service time (min)	Average preparation period (min)
1st Group	0	4	4	17	2
2nd Group	2	43	45	14	1
3rd Group	1	9	10	20	2
4th Group	5	27	32	11	2
5th Group	1	5	6	19	1
6th Group	0	1	1	15	2
7th Group	0	1	1	25	1

Since the preparation process will be performed once only, total time needed for groups:

Average set up time: T_{su}

Average service period : T_c

Average Number of Appointments: RHS

Total time for i'th group: A_i

$A_i = T_{su} + (RHS_i \times T_c)$ (1)

If total times needed for groups are calculated using the formula (1); 70 minutes is needed for 1st group, 603 minutes for 2nd group, 182 minutes for 3rd group, 299 minutes for 4th group, 96 minutes for 5th group, 17 minutes for 6th group and 26 minutes for 7th group. Total 1293 minutes should be programmed for appointments based on the number of people in the groups and remaining 147 minutes should be distributed within the day for emergency patients. This way, even if emergency patients come one after another, the patient who will wait most will wait for 147 minutes, which is a nearly impossible probability. Also, even in such case, average waiting time will be reduced from 188 minutes to 147 minutes, which means a reduction of 21.80 %.

In the current situation, number of patients who can be served daily is 82. By reducing the total preparation time, number of patients that can be served daily increased to 99, which is an increase of 20.73 %. This increase will considerably boost the profits. Even when no emergency patients come, 90 patients will be served, and this will still mean an increase of 9.95 %. But, it is almost impossible in a hospital, a dynamic system, that any process will remain unused.

Time ranges arranged by groups, when appointment schedule is arranged according to groups, is shown in Table 5.11, omitting the emergency patients. Highest number of patients comes for 2nd group. Giving the appointments for groups with the highest number of patients during daylight will allow easier communication with the doctors. For this reason, 24 hours is scheduled in the order of 2nd group, 4th group, 3rd group, 5th group, 1st group, 6th group and 7th group. If the period of 127 minutes allocated for emergency patients can be distributed according to patient numbers of groups, waste will be minimized. Appointment schedule that involve the emergency patient periods is shown in Table 5.

Table 5. Appointment time ranges

Group	Starting Time	Ending Time	Number of patients
1st Group	08:00	19:01	43
2nd Group	19:01	00:31	27
3rd Group	00:31	03:52	9
4th Group	03:52	05:39	5
5th Group	05:39	07:15	4
6th Group	07:15	07:33	1
7th Group	07:33	08:00	1

Conclusions

Present situation and situation after the redesigned appointment system are compared in Table 6.

Table 6. Comparison Data

	Current Situation	Future Situation	Comparison
Average Number of Patients	82	99	20.73 % increase
Total Preparation Period (min)	121	11	90.90 % decrease
Waiting period (min)	188	< 147	> 21.80 % decrease

With the new appointment system that is designed on the basis of reducing preparation times and waiting periods arising from emergency patients by dividing the works into groups, average number of imaging operations has increased by 20.73 %. An increase of 20.73 % will substantially boost the profits. Total preparation time has been reduced by 90.90 %. Reduction in the waiting periods will be 21.80 % at the lowest. With this new system, flow of patients improves, imaging times speed up and capacity is used in the best way. Also, cost, waste, waiting times and periods patients kept in the process are reduced, and it became possible to do more imaging and efficiency has improved. Movement of the technicians who kept repeating the same process was minimized, which boosted their motivation.

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