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Lean Process Improvement of First Case Scheduling in Operating Rooms

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Abstract

Maximizing operating room (OR) utilization requires effective scheduling of surgical cases. Ineffective schedules result in costly overtime and decreased patient satisfaction. The impact is magnified when the first surgical case is delayed which causes the other cases to be delayed as well. Moreover, scheduling first cases late results in low utilization of hospital resources and may impact the quality of care for patients. This paper investigates the first case scheduling process in a tertiary hospital in Pennsylvania, USA. Lean techniques and data analysis are utilized to analyze the scheduling inefficiencies and propose process improvement strategies. The proposed strategies resulted in significant improvement in the number of cases scheduled by 7:30 AM which reduced the amount of overtime and improved OR utilization.

Keywords
Lean, process improvement, first case scheduling, operating rooms, healthcare

1. Introduction

Application of process improvement in operating rooms (ORs) is gaining more attention because of the increasing market pressures on hospitals from competitors (e.g., other surgical suites including office based surgery) and from payers seeking lower prices. ORs are considered one of the major profitable hospital units because they generate two thirds of all hospital revenues (Jackson, 2002). Furthermore, ORs comprise an important fraction, about 40%, of hospital budget spending (Pham et al., 2016). Both underutilization and over-utilization of OR time are costly for hospital management and provide a negative experience for both OR staff as well as their patients. The total cost of these OR time inefficiencies is the amount of underutilized time multiplied by the cost of underutilized time in addition to the amount of over-utilized time multiplied by the cost of over-utilized time (McIntosh et al., 2006). Furthermore, over-utilization and under-utilization of OR resources can result in lower quality of care and poor patient feedback (Does et al., 2009). As resources are often limited in the OR by the number of rooms available and surgeon availability, improving the utilization of these resources is of utmost importance.

Across the nation, many hospitals are facing both budget and reimbursement cuts. These financial constraints are forcing hospitals to improve the efficiency of their ORs, which is their primary source of income. There are several key factors that impact the overall OR efficiency. Two key factors to improve efficiency are reducing the probability of a first case start (FCS) delay as well as reducing turnover time. OR first surgical cases are the cases with no prior case in the same OR suite of the same hospital on a given date of the case. The wheels in time, when the patient physically enters the operating room, is a metric used to determine the FCS delay. An FCS delay is defined as any time where the wheels in time is later than the scheduled start time for the operation (Glover et al., 2009). Since ORs are costly to keep open, there are several consequences to having FCS delays. The main consequences consist of financial matters and both patient and staff dissatisfaction. A FCS delay can result in further delay for all scheduled

cases after, leading to both the hospital paying employees' overtime and decreasing the patients' overall satisfaction. An increase in overtime also results in higher operating costs required to keep the operating room open longer (Lin et al., 2006). It is estimated that for a scheduled eight hour operating day, each additional minute in a FCS delay causes 1.2 minutes in overtime (University of Michigan Health System, 2006). Taking into account each minute of overtime for each staff member required, the annual overtime expenses quickly become significant.

OR scheduling allocates hospital resources to individual surgical cases and determines the time for the surgery. OR scheduling is one of the main factors that directly impacts OR utilization and quality of care. OR surgery scheduling determines the start time for the surgery as well as the hospital resources that should be allocated to the surgery. The common method for OR scheduling is called block scheduling by which a block of OR time is reserved for surgery. The OR scheduling is not an easy task because of the nature of the healthcare environment. Among the factors that make OR scheduling a hard task are: no-shows, emergency cases, surgeon unavailability, and room unavailability.

Lean tools and techniques are used in industry to improve efficiency and quality while controlling costs. In 2000, healthcare industry started adopting these tools and techniques to improve the quality of care and reduce the wastes in the healthcare processes. However, Lean healthcare is still in its first stages and many opportunities exist to apply it in healthcare industry. Lean process improvement can be used to improve FCS by identifying and eliminating the root causes of the delays and providing countermeasures to overcome the delay problem. Lean tools and techniques can also be used to study the first case scheduling process and make it more efficient.

This paper focuses on applying Lean and statistical techniques to improve the scheduling process of first surgical cases in a tertiary hospital in Pennsylvania, USA. A process improvement framework is proposed and implemented. The goal is to increase the first cases scheduled by 7:30 AM from 62% to 75% by implementing countermeasures and standardizing the scheduling process.

When this study was started, the hospital had only 62% of first cases scheduled by 7:30 AM while 100% of the anesthesia and day shift OR staff are on site and available by 6:30 AM. In order to improve its processes, the hospital has started implementing process improvement strategies and established a collaboration the research team. Students and faculty are working on different process improvement projects.

The main objective of this study is to implement process improvement strategies to increase the percentage of cases scheduled by 7:30 AM. As a result of late case scheduling, the OR is required to be staffed later into the day, which leads to increasing labor costs and underutilizing the staff available in the morning shifts. The process for calculating the "Percent of Cases Scheduled by 7:30 AM" is shown in Figure 1. First cases are defined as those with no prior case in the same OR suite of the same hospital on a given date. Any case schedule to start on or before 7:30 am is considered "early" scheduled case. Any case scheduled to start after 7:30 am is considered "late" scheduled case.

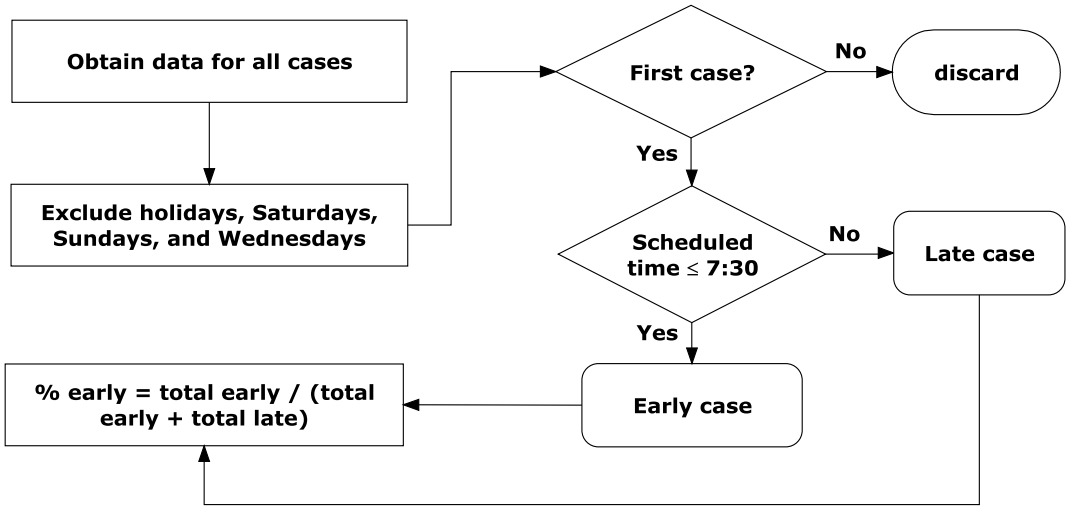


Figure 1. Process used to calculate the percentage of early scheduled cases

2. Related Literature

Effective management of hospital ORs is a key driver for minimizing operating costs while accomplishing patients' satisfaction. OR scheduling is an important operational problem in most hospitals. Scheduling of surgical cases involves allocating hospital resources to the individual surgical cases and determining the time to perform the surgeries. OR scheduling must take into account the availability of resources including doctors, nurses, rooms, and equipment as well as the availability of patients. Many authors in the literature have studies the OR scheduling from different perspectives. For example, Molina-Pariente *et al.* (2015), discussed the case of integrated OR planning and scheduling when surgical teams composed by one or two surgeons and surgery durations depend on the experience and skills of the surgeons. An optimization model, mixed integer linear programming, was developed and used to solve the scheduling problem. M'Hallah and Al-Roomi (2014) discussed the stochastic off-line planning and on-line scheduling of OR at the operational level. A simulation model was developed to test different strategies to reduce the overtime and optimize the OR schedule. . Ferrin *et al.* (2004) also developed a simulation study to analyze incentives and scheduling in operating rooms. Xiao et al. (2016) performed an analysis of the stochastic operating room scheduling problem and developed a three-stage resources model that considers scheduling cancelations and can be used to predict future uncertainties. Xiang et al. (2015) developed a heuristic optimization approach to solve OR surgery scheduling problem.

Other studies discussed the use of process improvement strategies to increase the OR efficiency and decrease delays and overtimes. Robinson and Kirsch (2015) discussed the application of Lean strategies in the ORs and how they can be used to eliminate waste from the system to leave only value-added steps in patient care. Mullaney (2010) implemented Lean methodology to improve process of supplying instruments to the operating room. An interprofessional approach that utilizes Lean and Six Sigma methodologies to improve the efficiency of operating rooms was presented in Bender et al. (2015). In a similar study by Cima et al. (2011), Lean and Six Sigma methodologies were used to improve OR efficiency and financial performance across an entire operating suite.

This study applies Lean process implement methodologies to improve the scheduling process of first cases in a tertiary hospital in Pennsylvania, USA. Process mapping and root cause analysis are utilized to understand the current scheduling process and identify the root causes of late scheduling. Several countermeasures are suggested and prioritized based on their impact and ease of implementation.

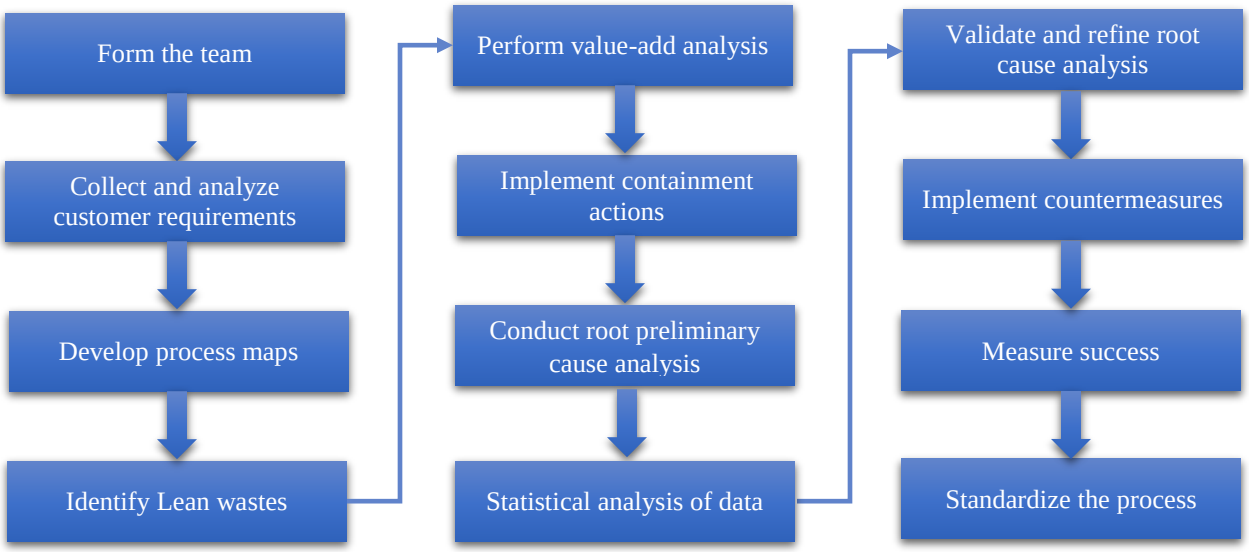
3. Methodology and Findings

Shown in Figure 2, the process improvement framework consists of multiple steps that focus on eliminating Lean wastes and causes of first case delay. The first step was to identify the team who will work on the project. Customer requirements were then collected and analyzed using Kano model. The customer requirements analysis was conducted to identify the problems and clarify the expectations of the project. In order to understand the current process, the team collected data and information about the current processes and developed process maps to help understand the process. Lean wastes were then identified and a value-add analysis was performed to identify the opportunities for improvement. Several containment actions were implemented as a temporary solution to reduce first case delays. A preliminary root cause analysis was than conducted to identify the potential root causes of the delays. Statistical analysis of data was then performed to identify delay trends and the effectiveness of the containment actions. The statistical analysis was also used to validate the identified root causes. Countermeasures were suggested and discussed with the OR leadership. The countermeasures were prioritized and selected based on their impact and ease of implementation. Further data analysis was performed to measure the success and, finally, the process was standardized to sustain the gains.

Once the team was formed, customer requirements were collected and analyzed. Kano model was used to divide customer requirements into 3 categories: delighters, primary satisfiers, and must-be. The first step of customer requirement analysis is to collect the verbatim of customer requirements. Table 1 shows the statements obtained from the customers regarding the first case delays and OR utilization. After identifying the critical customer requirements (CCR), the customers were asked to answer the following two questions:

- Question 1 - How would you feel if attribute A was available in your product, service or software?
- Question 2 - How would you feel if attribute A was not available in your product, service or software?

Based on the answers to the two questions, the CCR are categorized into delighter, primary satisfier, and must-be. Table 2 shows the summary of the customer answers. Based on the results in Table 2, the team decided to work on the two primary satisfiers. This study discusses the second CCR, "At least 75% of the first cases are scheduled to start



by 7:30 AM", which is classified as a performance need (or primary satisfier). Scheduling the first case to start early in the morning, at 7:30 AM in this case, will improve OR utilization and reduce the amount of overtime.

Figure 2. Process improvement framework

Table 1. Voice of customer statements for Kano analysis.

Voice of Customer & Kano Analysis	***VOC Affinity Category***	***Critical Customer Requirement (CCR) (Specific and Measureable Needs)***
"The hospital typically has 50% of the ORs active by 9AM"	Early Start	*At least 75% of the first cases are scheduled to start by 7:30AM*
"Essentially 100% of the anesthesia and day shift OR staff are on site at 6:30 AM"	Early Start	*At least 75% of the first cases are scheduled to start by 7:30AM*
"The hospital has some of the slowest/latest on time starts in the system "	On-time Start	*At least 75% of the first cases start on their scheduled time*
"There is great drive to improve the percent of cases scheduled by 7:30, on time starts and rooms running by 8 AM"	Early Start	*At least 75% of the first cases are scheduled to start by 7:30AM*
"The causes of delay are multifactorial and not particularly well understood"	On-time Start	*At least 75% of the first cases start on their scheduled time*
"We want to optimizes anesthesia and OR staff labor dollars/time"	Efficiency	*Decrease the amount of OT by 50%*

Table 2. The Kano analysis results for customer requirements

Critical Customer Requirements (CCR)	***Question 1*** Response	***Question 2*** Response	***Kano Analysis***
At least 75% of the first cases start on their scheduled time	Very Satisfied	Dissatisfied	Performance Needs (Primary Satisfiers)
At least 75% of the first cases are scheduled to start by 7:30AM	**Very Satisfied**	**Dissatisfied**	**Performance Needs (Primary Satisfiers)**
Decrease the amount of OT by 50%	Very Satisfied	Neither	Excitement Needs (Delighters)

The next step in the framework is to develop process maps in order to understand the process. The flowchart in Figure 4 shows the process of scheduling the first surgical cases. The scheduling process starts when the doctor collects

patient's information and sends reservations to the main scheduling office where the case is analyzed and sent back to the proper department in the hospital.

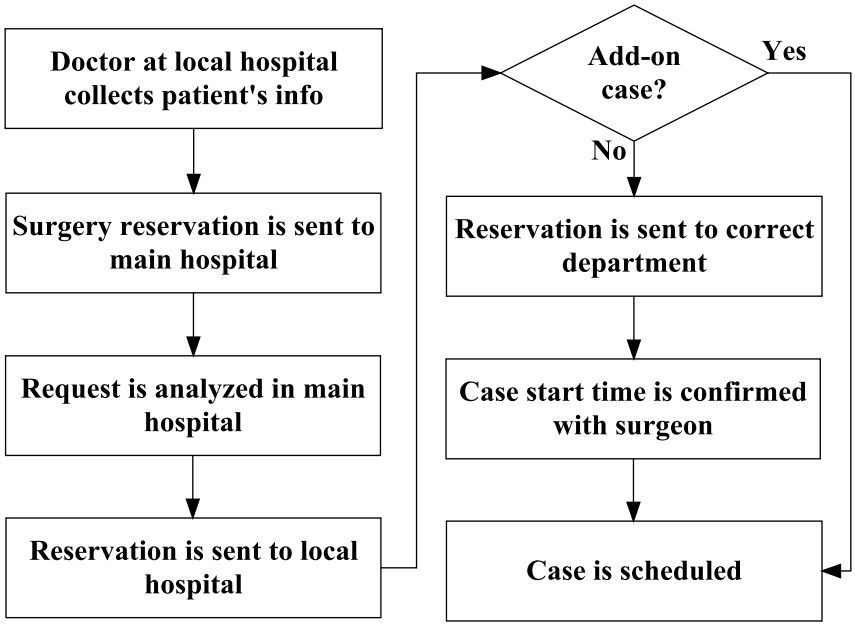


Figure 4. First case scheduling process

In order to identify the scheduling process deficiencies, Lean wastes identification and value-add analysis were performed. Table 3 shows the identified Lean wastes which includes defects, waiting times, non-value add processes, and transportation. Table 4 shows value add analysis for the first case scheduling process. It can be seen that only 16% of the activities are value add where as 56% are non-value add and 28% are non-value add essential. Value-add activities are those activities that adds value to the service. Non-value add activities are those activities that do not add any value to the service and they can be eliminated. Non-value add essential activities do not add any value to the service but they are necessary for the delivery of the service and they cannot be eliminated but they can be minimized.

The following step is the implementation of containment actions which are strategies to stop the loses due to late scheduling of first cases. Several containment actions have been implemented by the hospital in order to improve the scheduling process and reduce the delays of the first cases. An example of these containment actions is a "Delay Form" which identifies the late case and provides the reason(s) for the case that started late.

Root cause analysis is then performed to identify the potential causes of late scheduling of first cases. The fishbone diagram for the root cause analysis is shown in Figure 5. The main categories of the root causes are communication, man power, equipment, environment, patient, and documentation.

- Communication: Several problems were observed due to communication issues in the case scheduling process. The observed issues were: no communication between surgeon and scheduler, surgeon provides wrong availability, and the scheduler misinterprets the surgeon's needs. Each of these issues creates a problem for the scheduler who cannot properly schedule any case, or in this circumstance cannot determine a proper first case start time.
- Man power: Unavailability of the surgeon, anesthesiologist, and remaining members of the surgical/anesthesia team is another possible reason why there is a first case start time scheduling issue. The sub-cause for each of these reasons is that the person(s) may have outside commitments which prevent them from being available to work a first case of the day.
- Equipment: Block scheduling may be a potential cause due to not enough time being available for a specific surgery and there may be not enough ORs offering block time for an office's needs. One other issue is the use of flip rooms. These rooms may improve efficiency for a surgeon, but causes problems with overall OR utilization and scheduling.

- Environment: In the present environment several problems exist. After communicating with the schedulers at the different offices, it was noticed that there is denial that the problem exists. A result of this, the scheduling staff was unwilling to give the proper procedures and information about their scheduling process. A sub-cause of this would be that the staff is trying to avoid being at fault for the problem.
- Patient: Possible causes for first case scheduling issues may be due to the patient not being able to arrive for a first case start time and their personal preference may also have an impact. This may be due to the patient not being able to arrive for a first case start because of transportation issues and that the patient may want to have their surgery time later in the day is possible.
- Documentation: The transfer of documents (surgery reservations) travels through the UPMC system, which may cause scheduling problems. The reservation can be sent with the wrong information from the patient's doctor/specialist. Once processed, the reservation may be sent to the wrong hospital.

Table 3. Lean waste identification for first case scheduling process

Lean Wastes Identified								
Process Stage	D	O	W	N	T	I	M	E
Before Local Hospital	Wrong Information Sent		Wait while being analyzed	Reservation analyzed at multiple points	Information sent to Main Hospital then Local Hospital			
At Local Hospital			Wait to hear from surgeon					

Table 4. Value-add analysis for first case scheduling process

Value Add Analysis					
Process Step	**Activity**	**Time (min)**	**Value Add**	**Non-Value Add**	**Non-Value Add Essential**
Before Local Hospital	Doctor/Specialist sends survery reservation	5	X		
	Reservation is analyzed in Main Hospital	60		X	
	Reservation is sent to correct hospital	10			X
At Local Hospital	Scheduling department analyzes reservation	10		X	
	Reservation sent to correct department	5			X
	Scheduler checks surgeons schedule	20			X
	Verify start time with surgeon	5	X		
	Schedule procedure	10	X		
Total Time		**125**	**20**	**70**	**35**
Percentage			**16%**	**56%**	**28%**

In order to validate the identified root causes, historical data was collected and analyzed. It was found that the three main root causes for the scheduling problem are:

(1) no standard method for case scheduling,
(2) surgeons hold office hours in the morning, and
(3) surgeons sometimes assist other surgeons in pre-op steps.

Once the root causes have been validated, countermeasures were created to eliminate or reduce the impact of these causes. For this step, countermeasures were documented and then presented to OR leadership in the hospital. The OR leaders then rated the level of impact and ease of implementation for each countermeasure. These metrics were rated on a scale from one to ten, with one being low and ten being high for the impact, and one being difficult and ten being easy to implement the countermeasure. Table 5 shows the average rating and standard deviation for each countermeasure. The averages of the two metrics were then used to place each countermeasure on a 2x2 matrix that categorizes each into either "Quick Major Wins", "Make a Business Case", "Quick Minor Wins", and "Money Pit". Quick major wins and quick minor wins are the most desirable categories followed by make a business case. Any countermeasure that falls under money pit is undesirable. The matrix for first case starts is shown in Figure 6. The "Quick Major Wins" countermeasures are the ones selected because they are relatively easy to implement and will have higher impact on improving the scheduling process of first cases. The three countermeasures selected are" 1) standardizing the scheduling process, 2) creating a list of consequences for late scheduling or rewarding early scheduling, and 3) documenting the reasons for late scheduling.

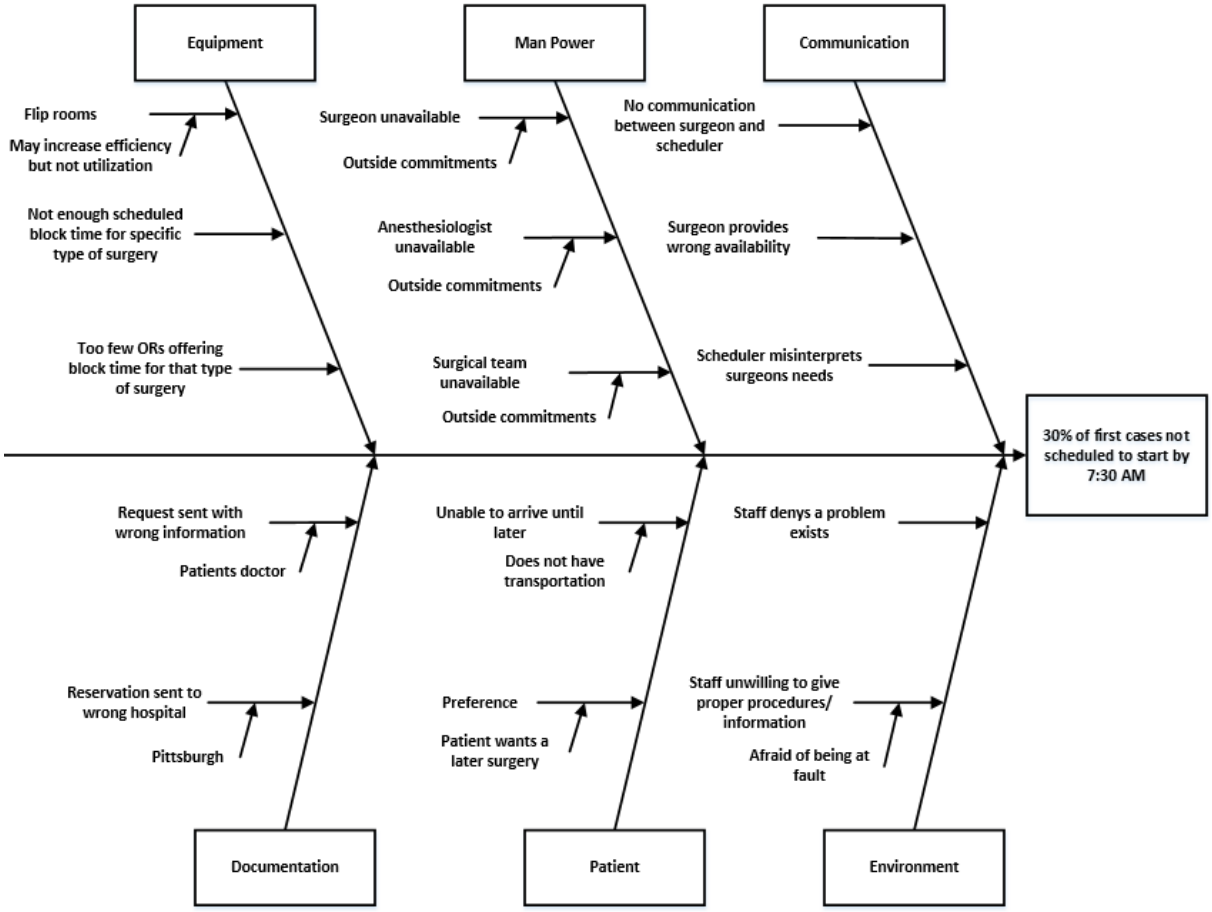


Figure 5. Root cause analys of late scheduling of first cases

Table 5. Countermeasures for the late scheduling of first surgical case

Countermeasure	Impact		Easy to Implement?	
	Std Dev	Mean	Std Dev	Mean
Create a standard method for case scheduling	**0.50**	**6.50**	**1.00**	**6.00**
Incentivize consistent on-time scheduling before/at 7:30 (reward by office)	2.17	7.25	0.68	3.25
Create a list of consequences for late scheduling (increasing in severity)	**1.48**	**7.75**	**1.86**	**5.75**
Require documented reason for late scheduled first case	**1.64**	**6.25**	**3.12**	**7.00**
Hold monthly Kaizen events	2.06	6.50	1.47	4.25
Doctors hold office hours at the end of the day	1.04	4.64	0.65	2.25
Hire assistant to help with pre-op (students)	1.79	4.75	2.49	3.75

In order to measures the effectiveness of the countermeasures and improvement strategies, data were collected and analyzed. Figures 7 shows the process improvement trends for the hospital. The figure shows the percentage of first cases scheduled by 7:30 AM. When the improvement strategies were first implemented by the hospital, the percentages were 62%. The current value for the percentage of first cases scheduled by 7:30 AM is 71%. In order to achieve the goal of 75% of first cases scheduling by 7:30 AM, continuous process improvement strategies and standardizing the scheduling process should be implemented.

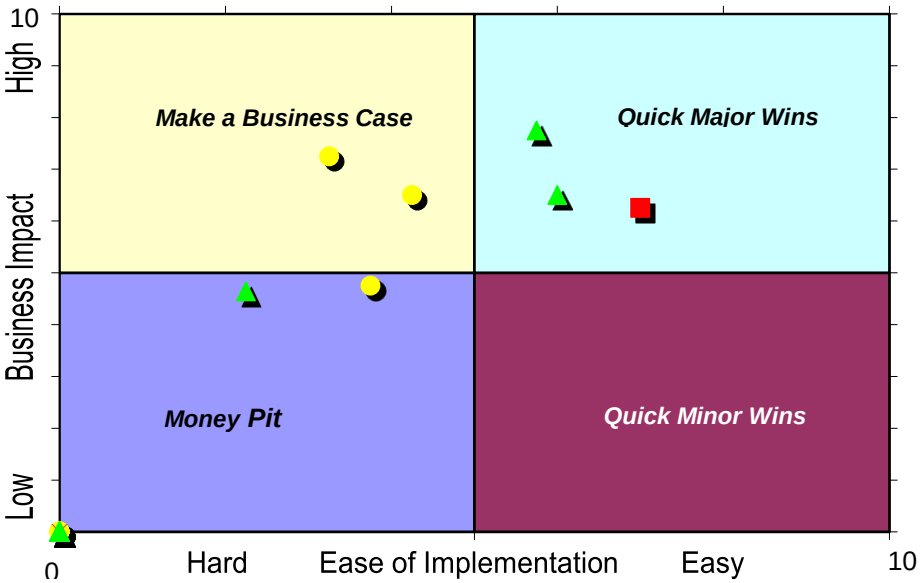


Figure 6. Selection Matrix for the countermeasures

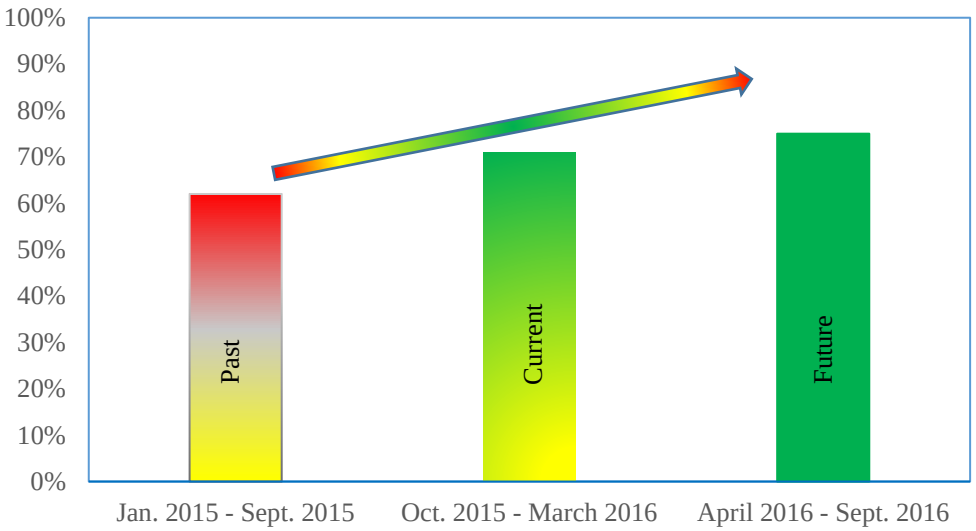


Figure 7. Process improvement trend for main hospital

4. Conclusions

Lean process improvement has been successfully applied to the healthcare process in the last few years. Many hospitals are applying Lean methodologies to achieve improvements in patient safety while reducing costs. This paper discussed the application of Lean process improvement to first case scheduling process at local hospital. A structured problem solving framework was presented. The main root causes for the late scheduling of first cases are: no standardized process, surgeons hold office hours in the morning, and surgeons sometimes assist other surgeons in pre-op steps. Several countermeasures were suggested and prioritized. The selected countermeasures are: standardizing the scheduling process, rewarding the early scheduling, and documenting the late scheduling reasons. Analysis of the current data shows an increasing improvement trend and it is expected that the goal of having at least 75% of first cases scheduled by 7:30 AM will be achieved in the next three months. Future research will focus on investigating the sustainability of the proposed countermeasures and implementing process improvement initiatives in other divisions of the hospital such as emergency department and outpatient clinics.

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Biography

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