Process Improvement Approach to Investigate Low Block Utilization of Operating Rooms: A Case Study

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Abstract

Lean principles and statistical analysis have been successfully implemented to hospitals and healthcare systems. These principles among other process improvement principles aim to detect and eliminate wastes in the system and its processes. In this paper, lean and statistical analysis were applied to systematically investigate the causes of low operating room (OR) block utilization and recommend solutions to improve the utilization. The study was carried out at a tertiary hospital in Pennsylvania. Root cause analysis has identified the main reasons of delays that impact utilization, i.e., waiting in OR after surgery is done due to bed unavailability, delays in preoperative process due to IV insertion difficulty and unavailable beds, and scheduling problems such as late first case starts and unrealistic surgery schedules. Countermeasures were developed, reevaluating the current scheduling practice and developing a scheduling tool are believed to be the best countermeasures in terms of ease of implementation and impact.

Keywords
Operating Room, Block Utilization, Process Mapping, Root Cause Analysis, Statistical Analysis

1. Introduction
Operating Rooms (ORs) generate around two thirds of the hospital revenue (Jackson, 2002) while the OR costs account for 40% of hospital resources costs (Macario et al., 1995). Furthermore, 60% of all admitted patients are treated in ORs (Eijkemans et al., 2010). With the implementation of the Affordable Care Act (ACA), approximately 32 million people will have medical insurance (Peters and Dean, 2011). Therefore, the number of patients increases as well as the demand for surgery services. Aging population and advances in surgery also increase the demand for surgical services (Marjamaa et al., 2008). Since surgical services share of costs is 40% combined with reimbursement reductions, the impact of the ACA could be the biggest in this area (Peters and Dean, 2011). Demand is not the only concern that ORs management has to worry about, variability in processes, procedures, and demand, and limited resources of expensive areas in OR suite such as intensive care units (ICUs) are among many other factors that make surgical case scheduling a complex process (Marjamaa et al., 2008).

Under this context, hospital surgery departments are pressured to control and reduce costs while providing quality care in timely manner. For decades, lean manufacturing and process improvement principles have been implemented by industry to provide high quality products with minimum cost. Lean management is being adapted by many healthcare systems to detect inefficiencies and create efficient processes and systems (Kim et al., 2005). A new study that implemented lean principles in OR to improve utilization, on-time starts, turn over time, and same day cancellation resulted in improved performance in all of the measures except same day cancellations (Castaldi, et al., 2016). Other process improvement principles and methodologies were used to improve the performance measures of ORs, such as

variability methodology to improve operational performance (Smith et al., 2013), constraint management to improve OR efficiency (Kimbrough, et al., 2015), and many others.

The paper is part of an ongoing project. The main objective of this paper is to investigate the root causes of low block utilization of ORs at a tertiary hospital in Pennsylvania. A systematic process improvement methodology is followed to identify and validate root causes of low block utilization, develop countermeasures to improve OR block utilization, and sustain improvement gains.

The paper is organized as follows: Section 2 presents the methodology that was followed to systematically analyze OR processes. Section 3 clarifies the problem and identifies the processes that affect block utilization. Section 4 analyzes the current system to identify lean wastes and root causes. Section 5 provides and explains the developed countermeasures. Section 6 presents an update of the improved situation. And finally, section 7 provides the conclusions and recommends future work.

2. Methodology

This section describes the approach that was adapted to investigate the problem of low OR block utilization. It also defines the process improvement techniques that were utilized throughout the study. The approach followed the steps that are shown in Figure 1.

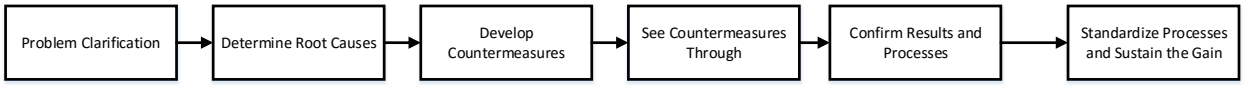

Figure 1. Methodology

Firstly, the problem should be defined clearly; the difference between the current situation and the standard represents the problem. The standard in this case represents the best practice. After that the problem should be broken down to determine the point of occurrence and prioritize sub-problems. Next step, root cause analysis is carried out to identify the potential root causes of the prioritized problems and validate them. Potential countermeasures are then developed and ranked. Countermeasure with high impact are implemented and monitored. Successful countermeasures are then used as new standard. Finally, the process should be repeated continuously. The following sections provide the details of the methodology steps as applied to the case study.

3. Problem Clarification

At the beginning of the study, the hospital's OR block utilization was hovering around 58%. As a result of underutilization, the OR's efficiency was low as well. OR efficiency was around 43% for 7:30am to 3:00pm, 27% from 3:00pm to 5:00pm, and 27% from 5:00pm to 7:00pm. The hospital aims to reach their internal target of 80% utilization. Figure 2 shows the monthly OR block utilization along with the internal target (2015-2016). The utilization was consistently below the target.

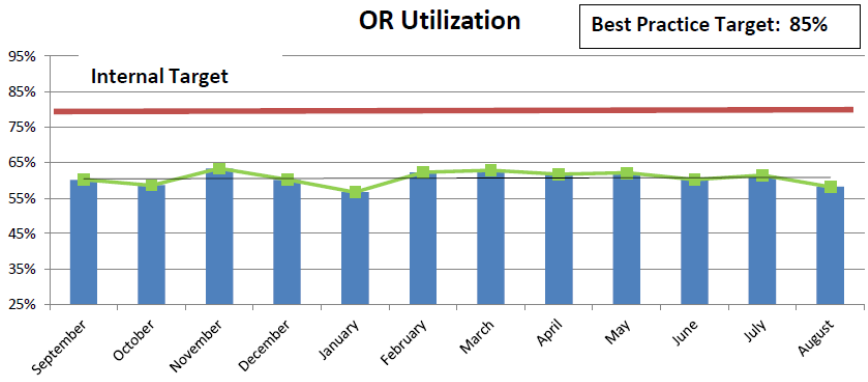

Figure 2. The monthly OR block utilization

Figure 3 shows the processes that should be investigated to identify the causes of low block utilization. In this paper, we focused mainly on preoperative, perioperative, and postoperative processes. The following section provides the analysis of the current system.

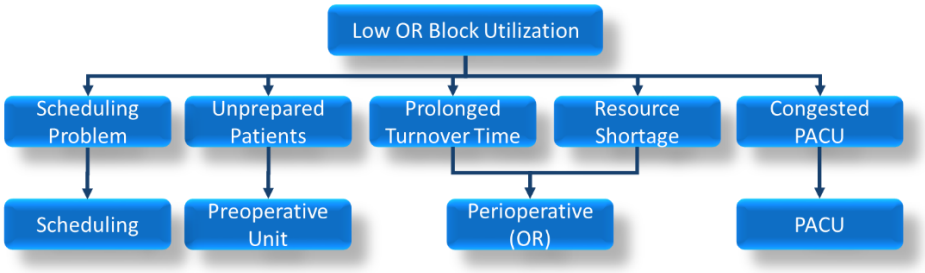

Figure 3. Processes that impact OR block utilization

4. Analysis of Current System

To analyze the current situation, process mapping was used to understand patient flow. Patient flow through different OR processes was analyzed. As shown in Figure 4, there are three main stages: preoperative, perioperative, and postoperative stage.

In the preoperative stage, patient is brought from nursing units to the preoperative holding unit (PHU) when he/she is ready for OR. In the perioperative stage, the patient is anaesthetized for surgery and then operated on. Once done, the patient is moved to postanesthesia care unit (PACU) to recover from anesthesia. Some critical patients are moved to intensive care unit (ICU). After PACU, patients either discharged or admitted to the hospital based on their situation. At this hospital, the preoperative and the postoperative processes take place in the PACU area. Figure 5 shows the preoperative process.

The hospital uses block system to schedule their surgical cases. Block scheduling is a type of scheduling that schedules by chunks of time called "blocks". Block time allocation can be set aside for a specific surgeon, surgical group, or stay open to all services on a first-come-first-served (FCFS) basis (Pham and Klinkert, 2008). The OR suite runs Monday through Friday from 7:30 am to 5:00 pm. The suite consists of a total of 20 ORs, 15 main ORs and 5 ORs in the Women's Hospital. The hospital's current scheduling system uses whole-day blocks that allocates the times to a surgical group. Thus, each group is assigned a block for the entire length of the workday. Block time inefficiencies can lead to problems in costs, profitability, organizational effectiveness, and surgeon satisfaction (Dahl, 2013).

The utilization rate is calculated by "Prime Time Used Minutes" divided by the "Available Minutes". The "Available Minutes" is the number of operating rooms multiplied by equivalent weekdays in the month multiplied by 9.5 (hours) multiplied by 60 (minutes per hour). The "Prime Time Used Minutes" is the sum of the 30 minutes of turnover time plus the amount of time between patient in room time and patient out of room time. At this hospital, the utilization rate is only calculated for 7:30am to 5:00 pm.

Since the turnover time affects the utilization, process mapping was used to understand the turnover process as well. Figure 6 shows the flow diagram of the turnover process. The total turnover time is broken down into three different categories: patient exit to cleaners in, cleaners in to room sterile, room sterile to next case patient in.

4.1 Lean Wastes

Identifying wastes in the system can help identify what areas need improvement and can provide insights when determining the appropriate solution. Value added activities are activities that physically change the shape or character of a product or assembly. In the operating room, a value added activity would be steps in the process that involve the surgery itself. A non-value added activity involves steps that are not essential or necessary to the procedure.

Cleaning the preparation room, paperwork, OR cleaning, restocking of surgical equipment, and preoperative interviews are all non-value added activities (Ballard and Kuhl, 2006). There are 8 main wastes that can be present during any process: defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion and extra processing.

The processes were broken down into value added, non-value added essential, and non-value added activities. Table 1 shows an example of the value and non-value added activities in the preoperative process. The following describes the non-value added activities.

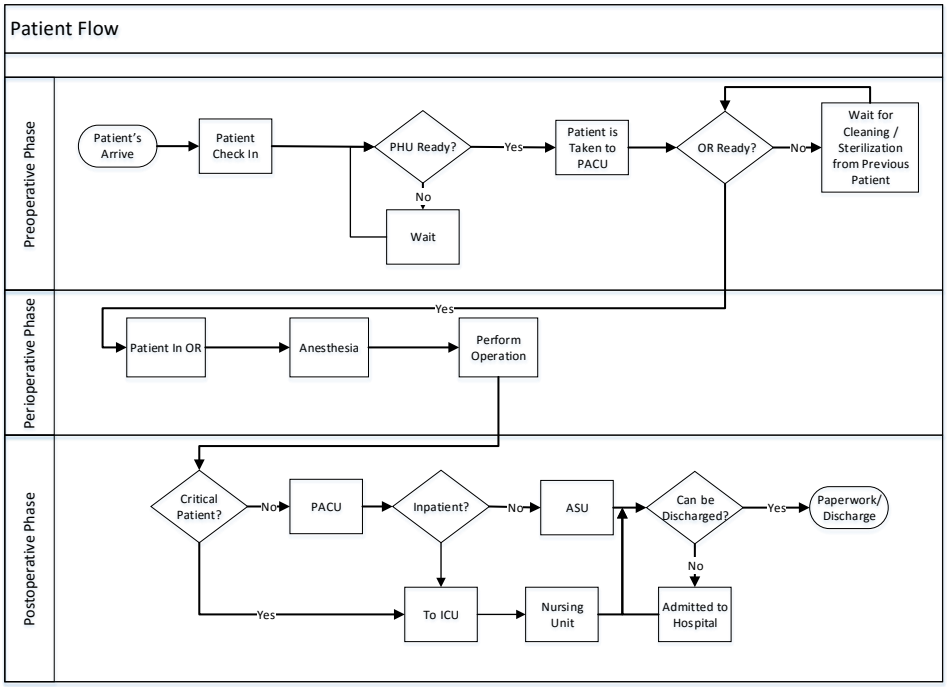

Figure 4. Patient flow in the OR suite

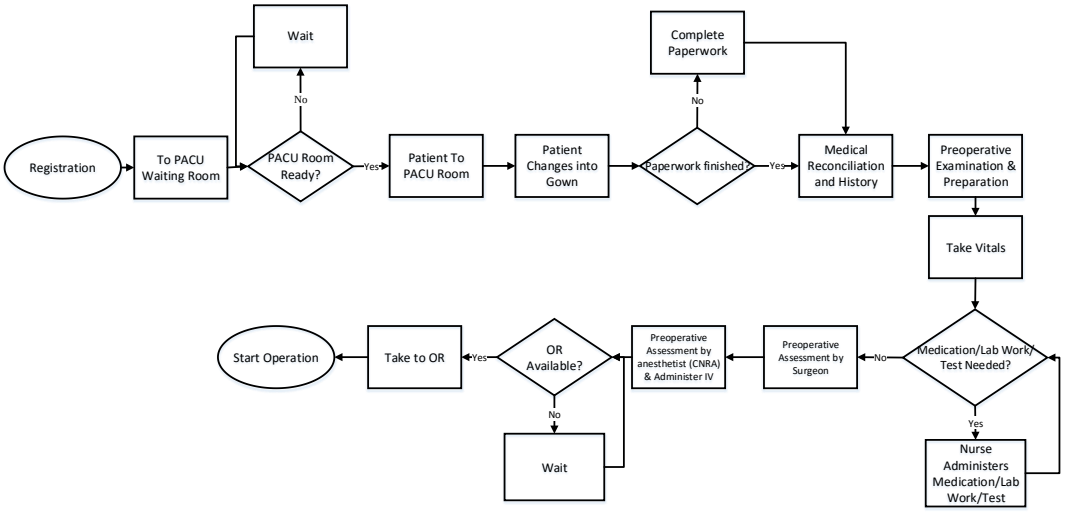

Figure 5. Preoperative process flow diagram

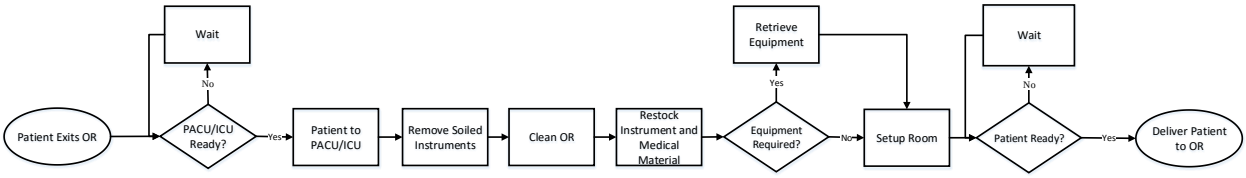

Figure 6. Turnover process flow diagram

Table 1. Preoperative process broken down into value added, non-value added essential, and non-value added activities

Preoperative Process				
Process Steps:	**Time (minutes)**	**Value Added Activity**	**Non-Value Added Essential Activity**	**Non-Value Added Activity**
Patient registration	8		✓	
Patient waiting in waiting room	35			✓
Patient changes into gown	5		✓	
Nurse examination/assessment	6		✓	
Paperwork	10		✓	
Collecting vitals	4		✓	
Medication administered	2		✓	
Lab work	4		✓	
Waiting for lab results	5			✓
Surgeon assessment	10	✓		
Anesthesia assessment	4	✓		
IV administration	25		✓	
Transfer Patient to OR	5		✓	
Total Time:	123	14 (11.5%)	69 (56%)	40 (32.5%)

Waiting
The patient and nurses experience waiting wastes multiple times throughout the general operating room process. Waiting wastes occur during the following steps: patient registration, patient waiting in the waiting room, paperwork, and lab results. The patient first waits about five minutes to be called upon for personal information verification and then waits again to be directed to the pre-operating rooms until the staff finishes preparing and filing the paperwork.

Non-Utilized Talent
Between patient registration and the pre-operation room, the staff experiences non-utilized talent wastes. The registration clerk asks the patient general demographic questions and what surgery they are getting that day, then once the patient is back into the pre-operating rooms the same questions are asked by the nurses.
The staff for turnovers consists of 8 patient care technicians (PCTs) and two housekeepers. Each PCT is assigned to multiple OR suites and are responsible for completing the turnover process. Two PTC's are runners which means they are not designated to a specific OR and help out anyone who needs help. The turnover times are better on busier days. Whereas on slower days, the staff aren't as productive and the turnover times are longer.

Preparing the charts consists of making sure all forms and lab materials needed for the patient are in the charts. Currently, the charts are only prepared for the first cases while charts for the surgical cases later in the day are not prepared, therefore, the nurses have to go through them during the preoperative process and retrieve the forms and lab materials needed. By having one person prepare all the charts, time wasted by retrieving these documents will be eliminated.

Extra processing
Nurses do not always have access to a computer while in the patients pre-operating room. This causes the nurses to gather the information manually and then find a nurses' station to input the new information into the computer system.

Motion
While all of the pre-operating rooms have computers, there are only a few nurses' stations with computers. Multiple nurses work with a single patient and there are times when the nurses are overlapping each other in the pre-operating room causing one of the nurses to find another computer. Also, the nurses prefer not to use the computers in the patient's room, but instead gather the information and then find a nurse's station to record the data. Whenever they could input their information into the computer in the patient's room, they choose to either right down the information or remember it until they get to a nurses' station.

Delays
The preoperative process begins with the patient checking into admissions or registration which is located in the lobby of the hospital. The patient checks in and receives paperwork and a wristband. From there, they go to the OR family waiting room and re-register there. The nurse asks for the patient name, family members present and type of surgery being performed. The admissions desk in the lobby is for all patients coming to the hospital so this causes the patient to be late if they are stuck waiting behind other patients at the admissions desk. If the patient is late due to waiting for other patients at the desk, it could cause a delay in their scheduled start time.

Very frequently the anesthetist spends a decent amount of time trying to insert the IV stick into the patient. This is primarily because the patient is dehydrated and/or students are inserting the IV's. Patients are not allowed to eat or drink before a surgery so they become dehydrated which causes the veins to constrict and makes IV insertion difficult, especially for a student.

4.2 Root Cause Analysis
Observations and expert opinions can be used to identify root causes of the lean wastes. Five-why analysis and fishbone diagrams were used to identify the root causes of the common waste in the processes, i.e., delays.

4.2.1 Root Causes Identification
The 5-why analysis was performed in order to find the actual root cause of the underutilization. The 5-Why analysis asks "Why is this a problem?" until a root cause is identified. It is important to find the actual root cause of the problem so the problem can successfully be resolved or improved and so that time and resources are not wasted. For delays in the PACU, there were four main causes that were analyzed. 5-why analysis for delays in the PACU is shown in Figure 7 and for delays in the turnover process in Figure 8. Also, fishbone diagrams were created to display causes of delays and inefficiencies which lead to underutilization. Fishbone diagrams are shown in Figures 9 and 10.

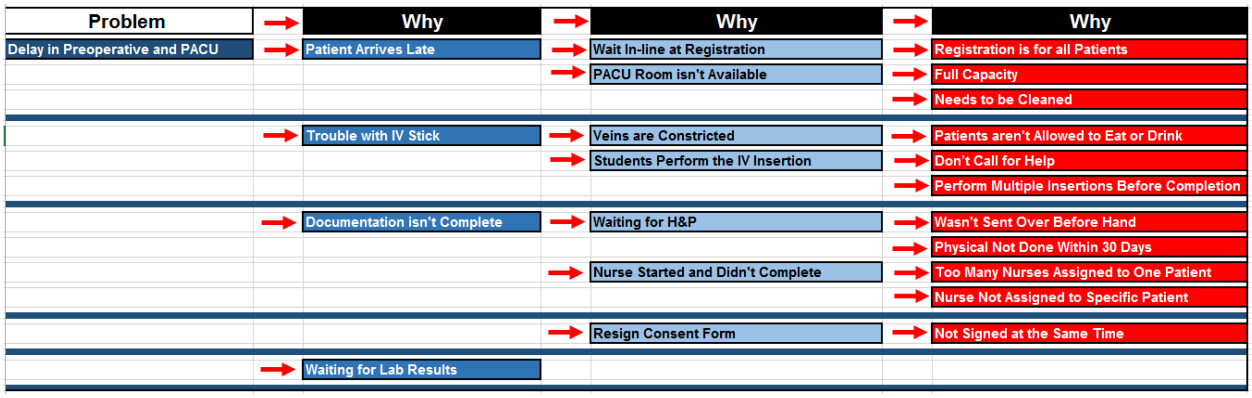

Figure 7. 5-why analysis for delays in PACU and preoperative processes

After analyzing the 5 why's for the Preoperative/PACU process, it was found that the two most influential causes for delays are the PACU rooms are not available, and trouble inserting the IV into the patient. The root causes for the PACU rooms not being available are either the room needs to be cleaned from the previous patient and/or the PACU is at full capacity. Preoperative only has nine beds available, while the PACU has 12 beds available. Because preoperative has less beds than the PACU and is connected to the PACU, the nurses will utilize beds in the PACU in order to get ahead on the preoperative process. However this causes the number of available beds to decrease. While it helps increase the efficiency of the preoperative process, it delays the PACU process. This is not calculated in the utilization, because it is not considered a part of the turnover process, but instead is viewed as a part of the surgery time.

The root causes for trouble inserting the IV into the patient are dehydrated patients and/or students are preforming the IV insertions. Due to the patients not being able to drink or eat after midnight the night before, the patients tend to be dehydrated and have constricted veins. Another issue preventing the preoperative process from running efficiently and with full utilization is that students are inserting the IV's. While inserting IV's is needed for the nurses' education and the delay is not preventable because they are still learning, the protocol for whenever the nurse in training cannot complete the insertion is causing more delays. The two main reasons that the IV insertion is taking longer than

necessary, is that the nurses in training will perform multiple insertions before getting it correct and/or they do not call for help when needed.

The 5-why analysis was also performed on the turnover process. The main root cause for the turnover process is the delay in patient delivery to the OR. The turnover process consists of three phases: patient leaving for the PACU to the cleaning staff arrival, the cleaning process, and then waiting for the next patient to arrive. Same root causes for delays in the preoperative/PACU process impact the turnover process, i.e., the IV insertion and documentation errors.

Fishbone diagrams were created for the low utilization and turnover process delays and are shown in Figures 9 and 10, respectively. The root causes were categorized into four different sections: policy, people, procedure and technology.

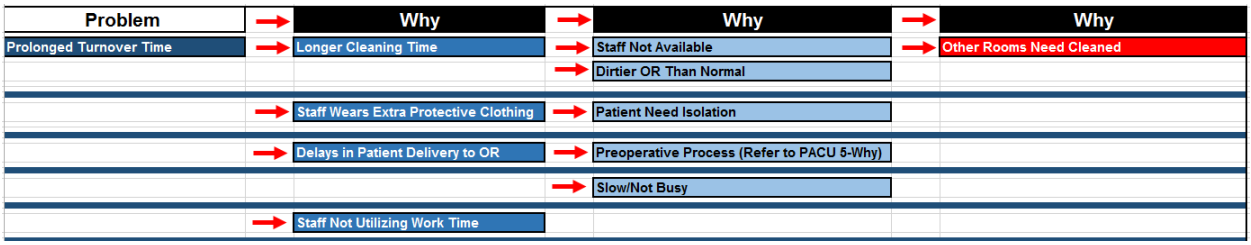

Figure 8. 5-why analysis for delays in turnover process

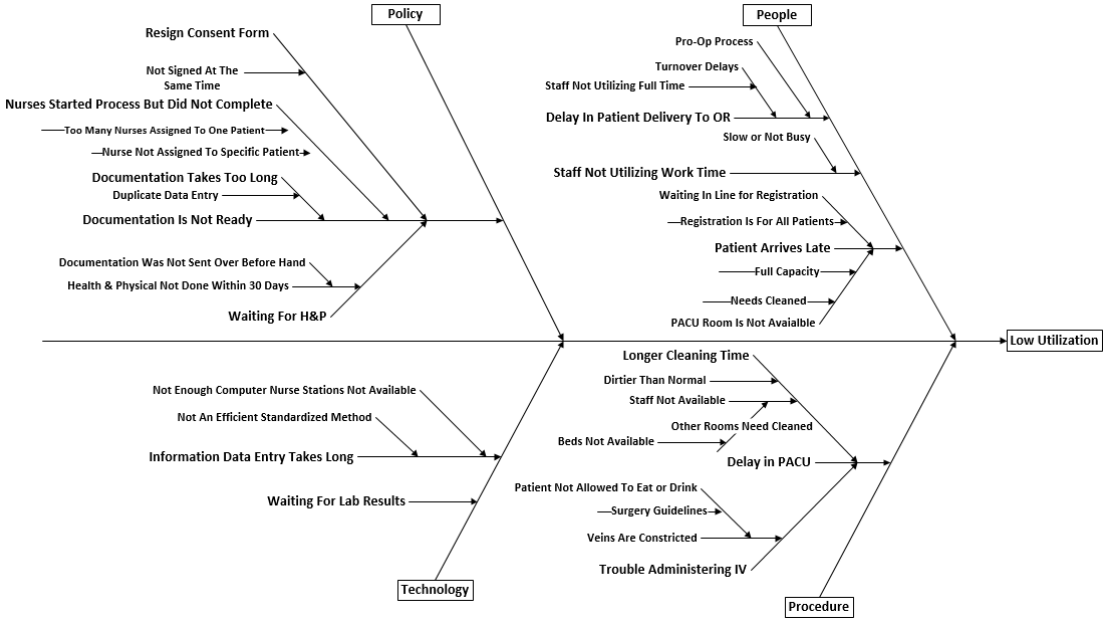

Figure 9. Fishbone diagram for low utilization

4.2.2 Root Causes Validation

Interviews and historical data were used to validate the identified root causes. The average amount of time the case is late was calculated for December 2015. Surgical cases are considered late if the surgical case starts later than the scheduled time. As indicated in Figure 11a, the average time for the late starts in December 2015 was 71.3 minutes. This validates that there is a delay in the preoperative process and also shows that it is correlated to the prolonged turnovers. It is correlated to the turnovers because this is the time that the room is waiting for the patient to enter. The time procedure start to procedure stop is the actual procedure time which was found to be 72.9 minutes on average. Often in the OR, there is no space available to put the patients after surgery, so they leave them in the OR until a space becomes available. This wastes away OR time and delays next surgeries as well. The time when the procedure stops to wheels out is the time that the patient waits in the operating room after the surgery is completed. The average time the patient waits was 12.4 minutes in December 2015. This data validates that there is a problem with the amount of

space available because the patients are waiting in the operating room rather than being taken immediately to the PACU for recovery.

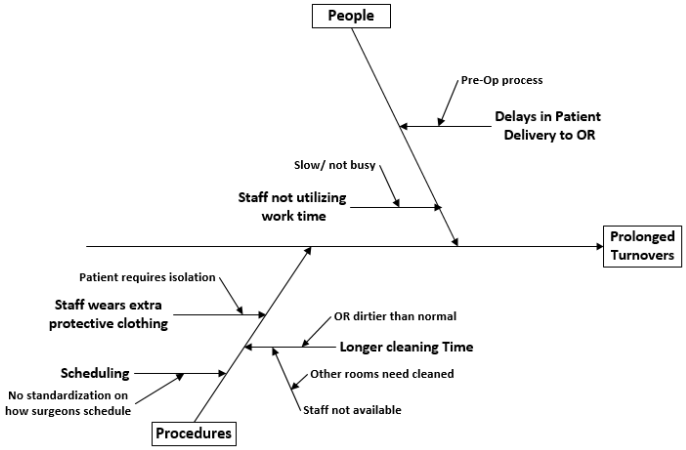

Figure 10. Fishbone diagram for prolonged turnovers

The historical data for turnover times were also analyzed. The average turnover time was above the target of 30 minutes. The turnover time involves three stages: the patient exits the room to the cleaners, cleaners in to room sterile, and room is sterile to next patient in. the actual cleaning time was within the target limits which is 8 to 9 minutes. The other two stages were long and they validate the PACU delays.

Figure 11b shows a Pareto chart for the frequency of late starts, the time the patient waits in the OR after surgery, the room sterilization that exceeds 8 minutes, and the turnover times that exceed the 30 minute target. The main causes are the time the patient waits in OR after the surgery, and the delays in preoperative process.

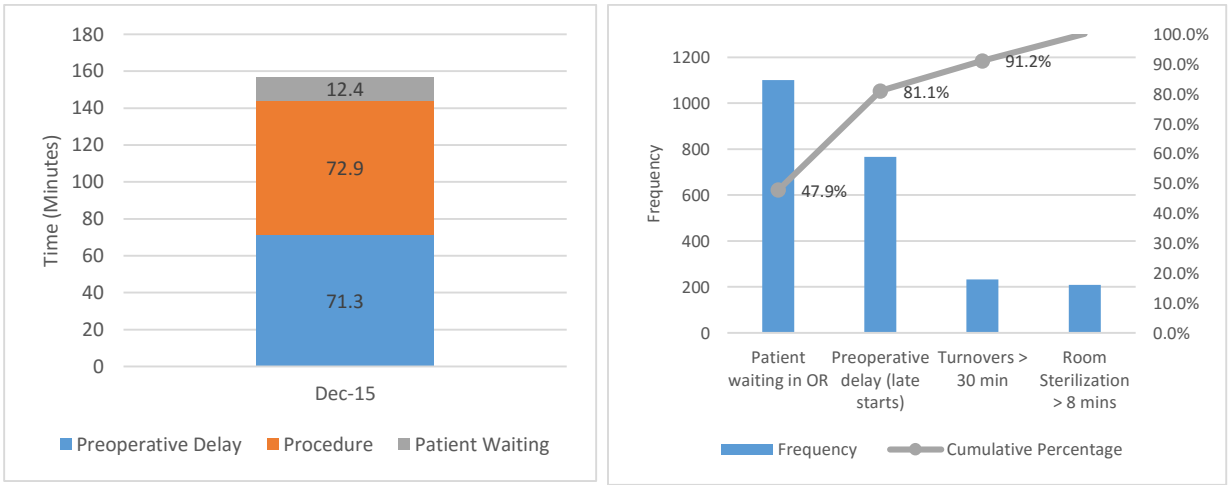

Figure 11. a) Delays and actual procedure times in OR, b) Pareto chart analysis

5. Countermeasures

Some problems can be easily solved, such as the IV insertion problem. Patients can be advised to drink water on the day before the surgery to stay hydrated so that their veins are less constricted. This will help the students administer the IV and decrease waiting time. Another solution would be to provide incentives to turnover staff. It was found that the busier the turnover staff was, the more efficient they were. In order to increase efficiency during slower days, incentives for the staff can be introduced.

Possible countermeasures are shown in the impact vs. ease of implementation matrix in Figure 12. One possible countermeasure is to mobile tablets or individual computers to use while on duty. This solution can eliminate extra-processing waste. This can be costly, however, it will eliminate the extra process steps performed by the nurses. Another possible solution is to eliminate any written paperwork and convert it to electronic form. However, this countermeasure might be very hard to implement but would have a high impact because all information will be in one system.

The preoperative process begins with the patient checking into admissions or registration which is located in the lobby of the hospital. The patient checks in and receives paperwork and a wristband. From there, they go to the OR family waiting room and re-register there. The nurse asks for the patient name, family members present and type of surgery being performed. The admissions desk in the lobby is for all patients coming to the hospital so this causes the patient to be late if they are stuck waiting behind other patients at the admissions desk. If the patient is late it could cause a delay in the scheduled start time. By merging these two steps together and having one registration specifically for the OR would eliminate waiting and non-utilized talent wastes and would be fairly easy to implement and have a medium impact.

Another countermeasure would be to expand the PACU or have a separate area for the preoperative process. By having more space and beds available, the delay waste would be eliminated or reduced. However, this countermeasure have a very high impact but it would be costly to implement.

Another countermeasure could be to improve the scheduling process. The authors have investigate the first case start delays in another study and provided countermeasures to solve that problem. First case start delays would impact other cases throughout the day and would adversely impact the utilization. Two separate scheduling processes for the add-on cases and regular cases would impact preoperative delays; the data shows that the add-on cases have a higher preoperative delay than the regular cases. By doing this the utilization rates may increase.

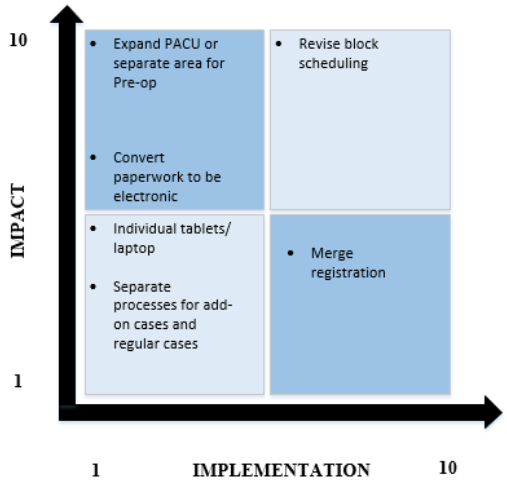

Figure 12. Impact vs. implementation matrix for countermeasures

Along the same lines, a countermeasure would be to revise the block scheduling. Currently, the hospital doesn't have guidelines or a standardized process for how the specialty units schedule their cases. The specialty unit is allocated its designated block time and their office calls and schedules the surgeon's case(s) and gives a specified amount of time for each surgical case. By analyzing historical data and determining the average time each surgeon spends on a case, they could be able to schedule his/her case more accurately. This would be the best possible countermeasure to implement because it has a high impact and a moderate implementation.

6. Ongoing Progress

Since the start of this project in January 2016, several improvement strategies, such as improving the first case starts, were implemented. Figure 13 shows a 22.6% (55.2 minutes) decrease in preoperative delays compared to 71.3 minutes

in December 2015. The utilization was increased from 62% to 66% in January and February 2016 and April 2016, respectively.

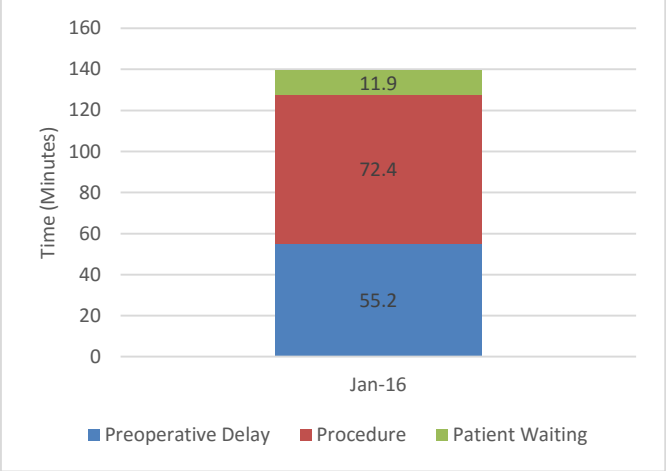

Figure 13. Delays and actual procedure time in OR (January, 2016)

7. Conclusions and Future Work

This paper investigates the causes of low OR block utilization at a tertiary hospital in Pennsylvania and suggests some solutions. It was determined that the two main root causes were procedure related: IV insertion and unavailable beds due to scheduling issues. Through the root cause validation, patients waiting in the OR after surgery and preoperative delays are the main forms of delay. Countermeasures were then created and rated based on ease of implementation and impact. It was found that the countermeasure with the highest ease of implementation and impact is to "revise patient scheduling". Currently patients are scheduled by their doctors, who have been allotted block times. However, when the patients arrive to their scheduled surgery, the collection of unrealistic schedule times, preoperative delays, waiting in OR after surgery, and not enough beds in PACU can lead to many problems such as increasing in overtime costs, late surgeries, unsatisfied surgeons and patients, etc. As a future work, scheduling process will be investigated thoroughly to identify root causes of scheduling problems and a more effective, data-driven tool for patient scheduling will be developed.

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Biography

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