Improving operating room efficiency through the use of lean six sigma methodologies

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Abstract

This green belt project looks at operating room efficiency metrics from an angle other than measuring improvements in first case starts and turnovers decrease. Following the systematic approach of the Lean Six Sigma training, the DMAIC pathway, the project has focused on improving access to the operating room through recuperating the time unutilized by surgeons whose block cannot start until after 8 am. The project demonstrates that improvement can be achieved through the number of minutes recuperated as well as the total number of cases additionally done over three months. It also showed increased satisfaction of operating room staff and patients.

Ultimately, and more importantly, the project proved so successful that the body governing the operating room approved, as new policy, the automatic use of the unutilized time for the purpose of increasing access to the operating room and decreasing the operating room burden of add-on cases.

Keywords: OR efficiency measures, OR downtime, room utilization, case opportunity, LSS

1. Introduction

Lean six sigma (LSS) methodologies, while recently having garnered more attention in the healthcare industry, have been in use for over two decades in the car and cell phone manufacturing industries. The underlying philosophy is that any process has inputs that, if controlled through a systematic approach, provide good outputs. Since this aligns perfectly with the cybernetic model that the parent of quality, Avedis Donabedian (1) has proposed, it follows that the healthcare industry lends itself perfectly to such methodologies. While there are multiple areas within healthcare that can benefit of the application of LSS, the areas most suited and targeted have been those of throughput, namely the operating rooms.

Historically, operating rooms have set goals for improvement efficiency metrics such as first case on time start and turnover. While first case time starts not only have a direct effect on downstream operations, it is also a patient and operating room (OR) staff satisfaction boost. It is a known fact however, that turnovers, while still a satisfaction assessment tool for OR staff in particular, are less descriptive of real efficiency gains, and more often case opportunity, defined as the ratio of unutilized minutes in an OR/average minutes of a case length, that can be additionally done in a room. Unrecognized or not, there is a lot of downtime, defined as total number of minutes an OR is not working outside of the 45 minutes allowed for turnover. The amount of downtime can be quantified to provide real case opportunity numbers, and can also better describe efficiency in operating rooms. The LSS methodologies that are geared directly toward decreasing waste in OR's (namely number of unutilized minutes), are specified for decreasing variance (namely striving for standardization of gains made from waste decrease) and providing a platform for continuous improvement. This green belt project has looked at increasing room utilization through recuperating the time that is unutilized due to surgeons that cannot start their cases until after 8am. The project proves that not only was room utilization increased, but it actually translated to increased patient and OR staff satisfaction, as well as increasing the numbers of cases that were able to be done. The project only underscores the impact of other areas outside the OR, such as increased patient access to the OR and decreased length of stay (LOS) for inpatients.

The transition from volume to value based delivery has come to the forefront of the improvement agenda of healthcare leaders, particularly in the arena of operating rooms, the source of both major revenue and expense. Physicians, administrators, operating room personnel and anesthesiologists are examining avenues that will enable them to deliver the best quality of care and attain required metrics by CMS, while decreasing costs. Two aspects of any process are particularly important to a smooth operational flow: efficiency and effectiveness.

Since by definition efficiency, borrowed from engineering, is the ratio of inputs to run the operation/outputs gained, the healthcare industry has attempted to find the best descriptors that might fit the existing definition, and so efficiency was measured by metrics such as first case starts and turnover times.

While those metrics are used widely and are considered gold standard, little attention has been paid to other potential efficiency metrics that healthcare clinics, for example, may use but are not used by the OR. Such corresponding metrics look at response time, backlog and opportunities. By the same token, effectiveness metrics such as quality or patient access to operating

rooms are at the forefront of any OR dashboard, yet have not been looked at in any detail.

The work of Alex Macario (2) has brought a wealth of information on the decrease in turnover efforts. Turnover decrease is a patient and operating room personnel goal and increases satisfaction, however, it has little effect on backlog or OR access. As Macario says, "rushing around the OR to decrease turnovers can be dangerous, stressful and have little financial impact" A five-ten minutes decrease of turnover for an average OR size with 20 OR's each with a load of three cases, for example, ultimately translates into a an OR finish time of 30 minutes earlier. That will not allow for an extra case to be done, although it might be more satisfactory to all OR personnel.

More importantly, examining lengthy turnovers usually uncovers hidden causes of the delays such as PACU holds or missing equipment or instrumentation that will need to be addressed, and those may actually be the rate-limiting steps for OR efficiency. Since LSS methodologies focus on both elimination and decrease in variance, identifying areas of waste outside of first case starts or turnovers that seemed to have a higher impact on quality of care, more patient access and better OR efficiency have been the goals of our green belt project. As opposed to the historical approach and based on the efficiency definition of eliminating process waste, the LSS methodologies bring in a fresh view on waste and metrics that help to better assess it. The data was collected for 7 consecutive months and was obtained from our GE system electronic medical record.

2. Materials and Methods

Downtime in the operating room presents in multiple ways including, surgeons that want to start their day later, too many cases scheduled concurrently that compete for the same equipment or instruments, patients not ready on time due to previous case under-scheduling or holding area inefficiencies, among others. The downtime however can have a real time metric that assesses both the number of cases that the OR cannot overcome, and the financial loss that accompanies it. Downtime is quite dissatisfying to all OR personnel. Our green belt project focused on the downtime associated with first cases not started on time, and as a metric we used case opportunity.

Case opportunity (case numbers that could be done in a room that is not fully utilized or is poorly utilized) seems like a new approach that would describe patient access, best practice utilization and quality of care.

Our team started with the assumption that an OR should have only start times of 7, 7:30, and 8am. Any case starting after 8am was considered a delay in first case start. Lean six sigma methodologies utilize an organized and sequential approach to achieve improvements that start with defining a problem, measure the metric to be improved, analyze the causes of the problem, improve and finally insure that the improvement is maintained and under control. This DMAIC (define, measure, analyze, improve, control) approach is the mainstay of any LSS project.

3. Research

In our define phase, we identified our problem as being lost time due to delayed case starts, which was, by definition, any case that started after 8am. We used the electronic medical record to assess the amount of lost time monthly and targeted an 8% improvement in lost time. Our end points were increased patient satisfaction and access, OR personnel satisfaction and increased prime time

utilization (defined by OR time between 7am-3pm).

A S(upply) I(nputs) P(rocess) O(utputs) C(ustomer) diagram was designed in order to determine all steps of the process as well as the stakeholders at each point.

Table 1. SIPOC diagram

SIPOC						
SUPPLIER	INPUT		PROCESSES		OUTPUTS	CUSTOMER
SCHEDULING OFFICE	X1	Schedule times (Times before 12PM)	Preparing operating room and materials	Y1	Primary Metric: Operating rooms delivery time	Patients
	X2	Add-On times (Times after 12PM)		Y2	Secondary Metric: Patient Satisfaction	OR Personnel
NURSES	X3			Y3	Secondary Metric: OR Personnel Satisfaction	Hospital Administrators
OPERATING ROOM	X4	OR Last Case Finished Times				

We looked at the savings the project would accomplish by calculating the costs recuperated by utilizing the hours that would have been otherwise lost and we estimated a 760% return on investment ROI for our project.

3.1 Benefits and Value to the Project

Average Cost of Operating Room
$75 per minute
Total Hours Lost per Month
225 hours (16,875 minutes)
Total Average Cost
=$1,265,625 per month

Reduction in Late Delivery Time
45 hours per month (2,700 minutes)
Total Cost Savings each month
=2,700 minutes X $75 = $202,500

Revenue per ICU Patient
$1,500 per day
Additional Patients
=45 hours / 24 = 1.875 patients per month
Marginal Revenue Generated
=1.875 X 1500 = $2,812.50

Average Cost of Time and Energy
$200 per hour
Number of Time and Energy Hours Used
135 hours per month
Investment in Process Change
=$27,000

Return
205,312.5
Investment
$27,000
ROI
=760.4%

3.2 Notes

We estimated the Number of Time and Energy Hours used by tripling the number of hours that we saved (hours that we saved per month = 45). Our team then moved to the next step and measured the lost hours of delayed first case starts for the three months we conducted our experiment and

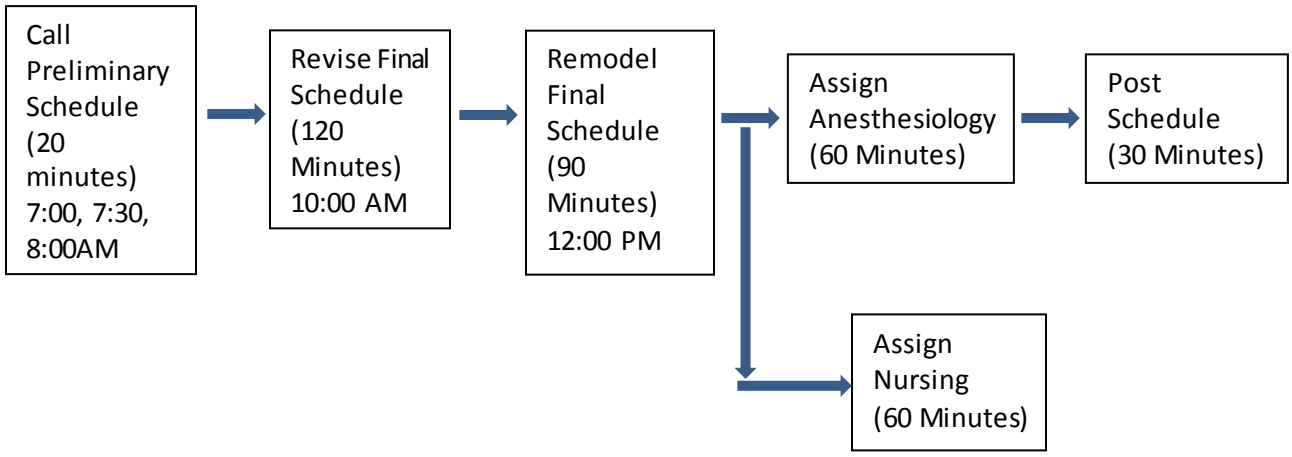
the results are displayed below. The information was obtained through the use of two electronic medical records and averaged, one from the anesthesia EMR and one from the hospital-based nursing operated EMR. The mean and standard deviation is derived from the 2015 lost hours column. The current state begins from July 1 and ends September 30.

Table 2. Number of lost hours due to first cases late starts (2014, 2015)

	2014				2015			
Month	**Hours Lost**	**Average Hours Lost**	**Total Hours of Surgery (M-F)**	**Proportion Hours Lost to Total Hours**	**Hours Lost**	**Average Hours Lost**	**Total Hours of Surgery (M-F)**	**Proportion Hours Lost to Total Hours**
Jun	207.82	9.9	2727	7.62%	143.12	6.5	2894	4.95%
Jul	212.4	9.2	2899	7.33%	225.75	9.8	3079	7.33%
Aug	130.87	6.2	2900	4.51%	154.63	7.4	3089	5.01%
Sep	240.08	10.9	2774	8.65%	252.45	11.5	2738	9.22%

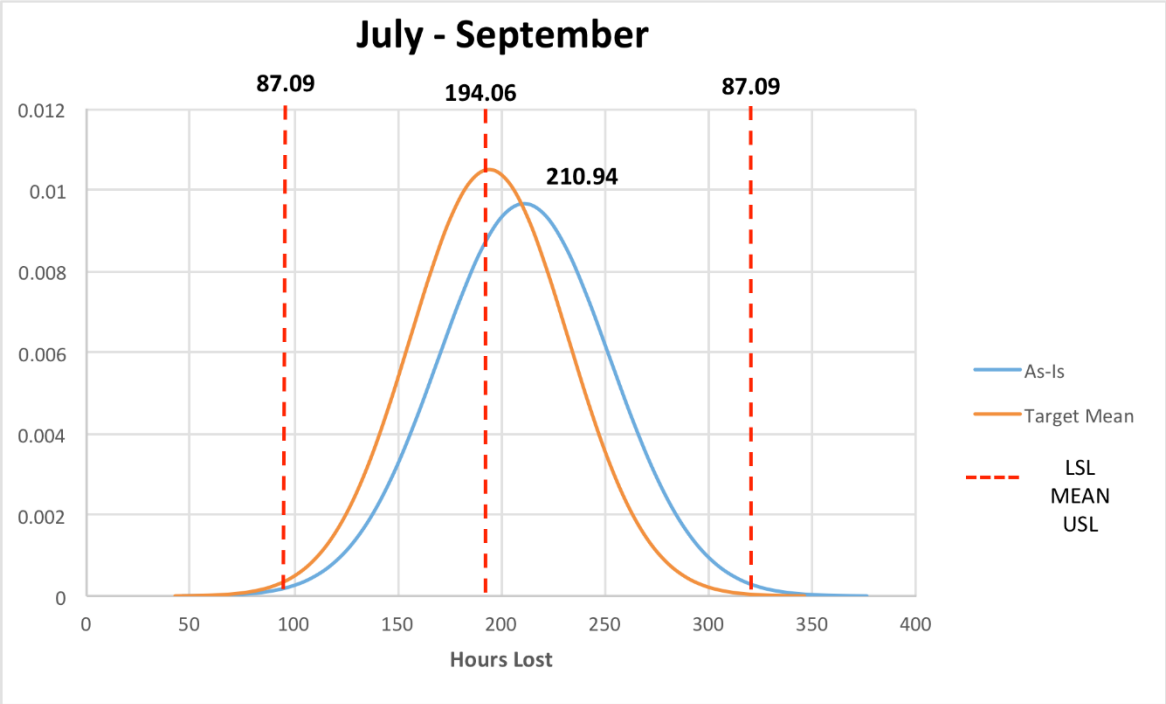
During the measure phase, the team also depicted the value stream map of the process. Value stream maps are graphical depictions of any process allowing for quick identification of time wasted vs. time that is valuable to the customer, in this case the patient. From the patient's standpoint the only value of being in a hospital is having the needed surgery. Waiting for transport to the OR or waiting as an inpatient to have surgery are of no value to the patient. Based on this concept, the value stream map as is was constructed to help to improve targeting the decrease of waste.

Figure 1. Value stream map "as is"



The raw data from Table 1 is mapped on the curve below. The As-Is mean and standard deviation is 210.94 and 41.28, respectively. Further, the upper standard limit is 334.80 and the lower standard limit is 87.09. The target mean, which represents an 8% reduction in total lost hours, is 194.07, and the target standard deviation is 37.98

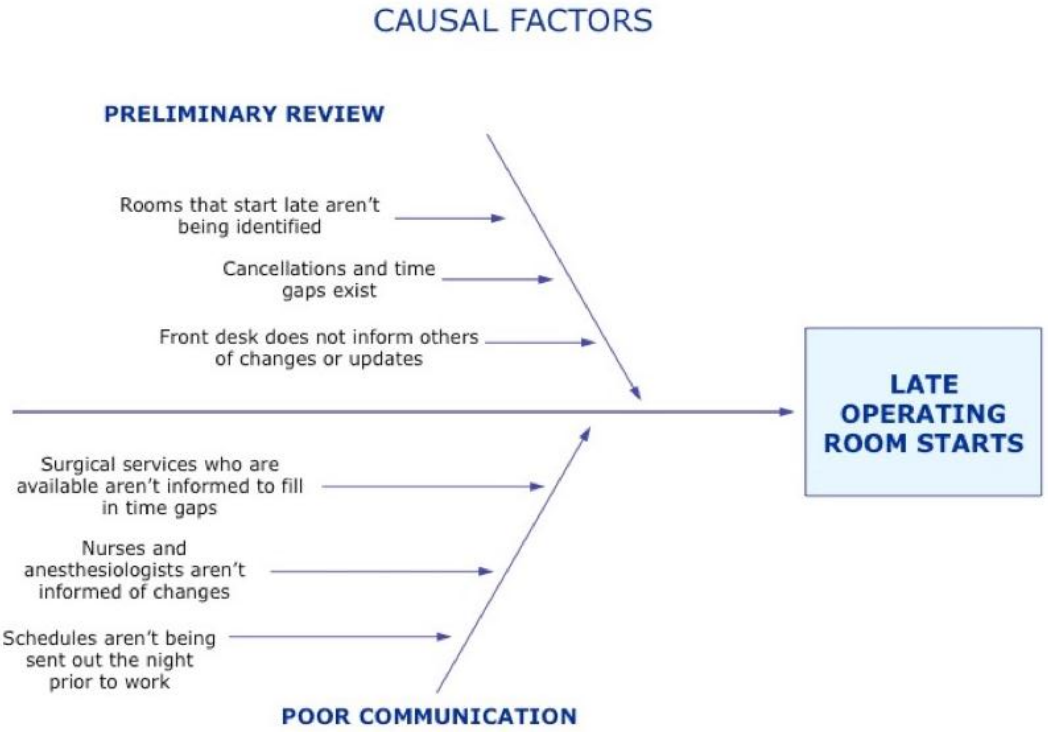
Figure 2. Distribution of lost hours June-Sep 2015



Late start times in the operating room represent a large portion of the overall OR waste and are highly dissatisfying to patients. Since one surgeon's delay in start can represent another surgeon's opportunity to provide timely care for a patient who might otherwise experience a delay in his/her care, all the stakeholders in the process believe that utilizing those time windows appropriately should be the goal. This will also increase the surgeon, anesthesiologist and OR nursing satisfaction, since more cases will finish on time rather than late.

The team then moved to the next step, the analyze phase, in order to determine causes that are obstacles to improvement and more importantly rank them in the order of the severity and impact on the process. The fishbone diagram is one of the most frequently used tools for that purpose, so the team constructed one such diagram with the results of root cause analysis.

Figure 3. Fishbone diagram derived from root cause analysis



3.3 Identification of Related Issues

1. Surgeon Overhead:
   Surgeons are frequently tasked with responsibilities that supersede scheduled surgery block time.
2. Surgeon miss-estimates:
   Surgeons underestimate surgery time, which results in staggered surgeries becoming delayed as a result.
3. Cultural Avoidance:
   Staff avoids confrontation with surgeons about OR Utilization; surgeons are perceived as "customers" in hospital's mind.

3.4 Verify and Prioritize Root Causes

In this step, the team prioritized the most important targets for the improvement to be deployed. Those were determined to be in the order of importance:

1. Schedules are not finalized earlier
Clarification: Surgical block could be released earlier, however surgeons are hesitant to Release this information for fear of losing their guaranteed time.

2. Front Desk, Nurses and Anesthesiologists, and Surgical Services are not being informed effectively or periodically of any schedule changes that surgeons may make.

3. Cancellation and time gaps exist. The "ghosting" practice (scheduling in a block for a patient, usually an inpatient not cleared at the time of scheduling for surgery in order to keep the block time from being released) is well known in the operating room environment.

3.5 Improve phase

The team then proceeded to the improvement phase by first selecting approaches and tools and starting a small scale pilot that targeted the various stakeholders through different avenues. Surgeons, the most resistant to change group were educated on the potential benefits of

the trial. Schedulers were trained to identify opportunities to insert cases in front of later ones, in rooms starting after 8 am, and to create visual alerts such as EMR alerts when a room is not scheduled before 8 am. The front desk was trained to use visual alerts (highlighting the opportunity rooms on the schedule) in order for the schedule makers to readily address those items.

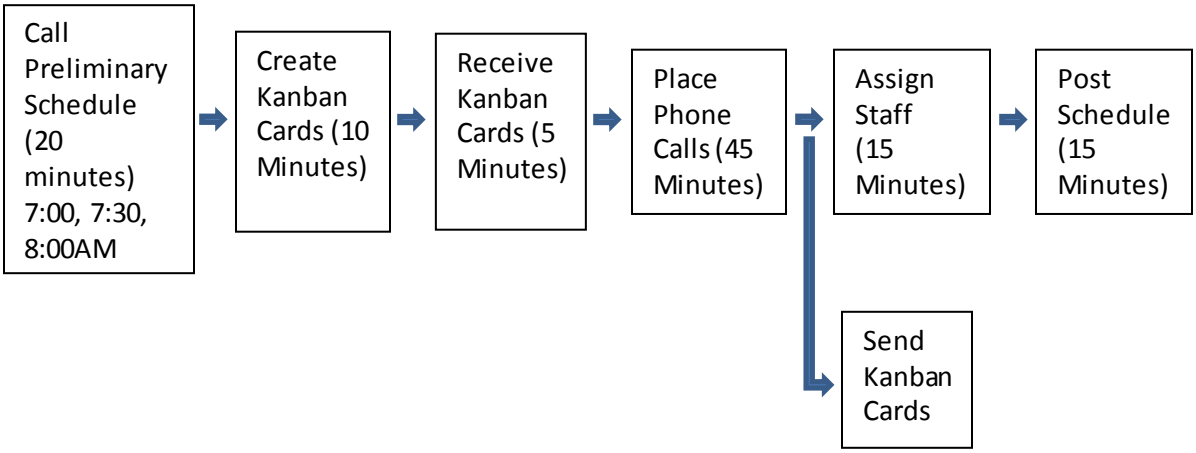
Those approaches were followed through with step by step training.

- Educate surgeons and hospital staff about benefit
- Schedulers were educated to identify and create visual alerts, cueing schedule adjustments
- Front desk was to receive alerts, then follow through by placing phone calls to surgeons to ask if about operating in specific window
- Surgeons were to confirm availability
- *Kanban cards (alert cards to attract attention to a change in schedule) were created and organized to move with carts transporting instruments to room
- Once the front desk finalized all arrangements, they then informed the scheduling office of all changes in order to be able to reflect those on the final schedule.
- At the same time assignments were made for nursing/anesthesiology based on the final schedule.

*****Kanban Cards-Visual Alerts for Schedulers and Front Desk Personnel

A future value stream map was then produced which depicted how the process would change and how the wasted time would be better utilized.

Figure 4. Value stream map-future state



Our improvement plan would consist of the following steps;

1. Front desk (nurse in charge/anesthesiologist medical director) would review their preliminary schedule at 10am
2. Late starts are identified and schedulers are advised to fill in those spots by looking at the preliminary schedule, and seeking a case of a duration that would fit into the identified gap. Schedulers will then inquire into surgeons' availability-is the surgeon in the OR? In clinic?
3. Surgeons are then contacted to see if they are available to fill in any available spots
4. Surgeon confirms or rejects inquiry

5. If the surgeon confirms, their confirmation time and case information is sent to the scheduler to include it in the final schedule
6. Assignments are made by nursing and anesthesiology departments
7. If there are available time slots remaining after 12pm, schedulers are advised to fill in the time slots that they can, following the same steps.
8. Process repeats itself

The improved data for Oct- Dec. 2015 is depicted in Table 1.

Figure 5. Normal distribution for lost hours Oct-Dec 2015 (post treatment)

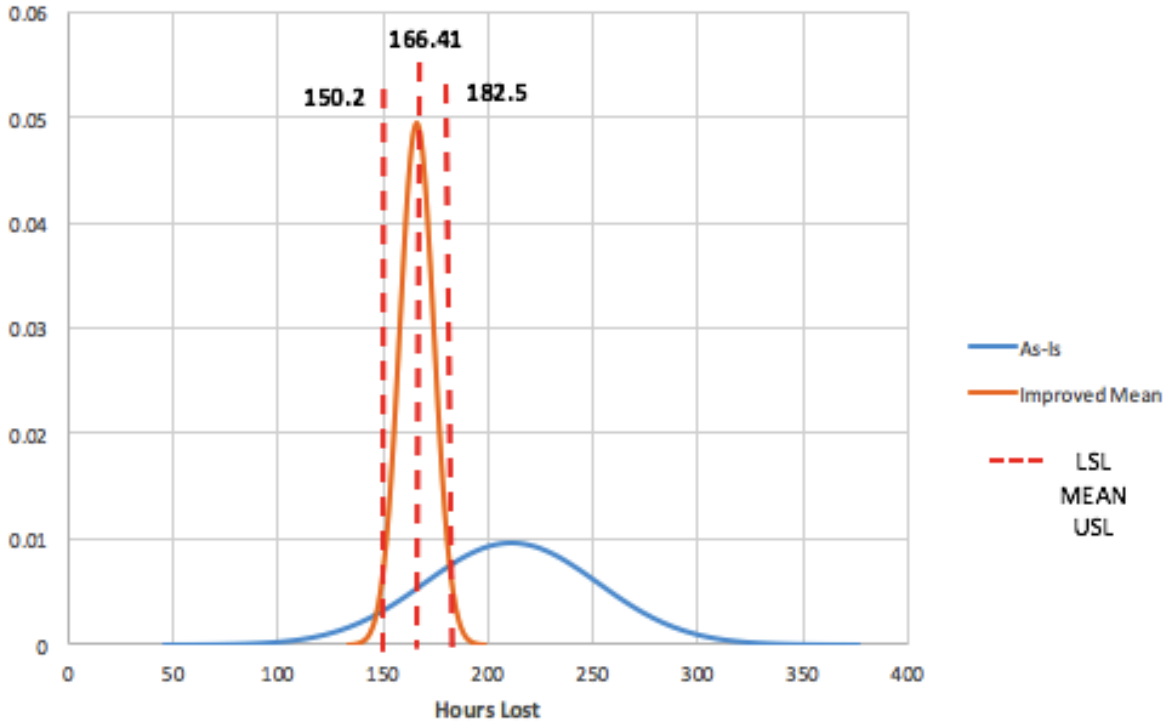


Figure 6. Lost time of improved months

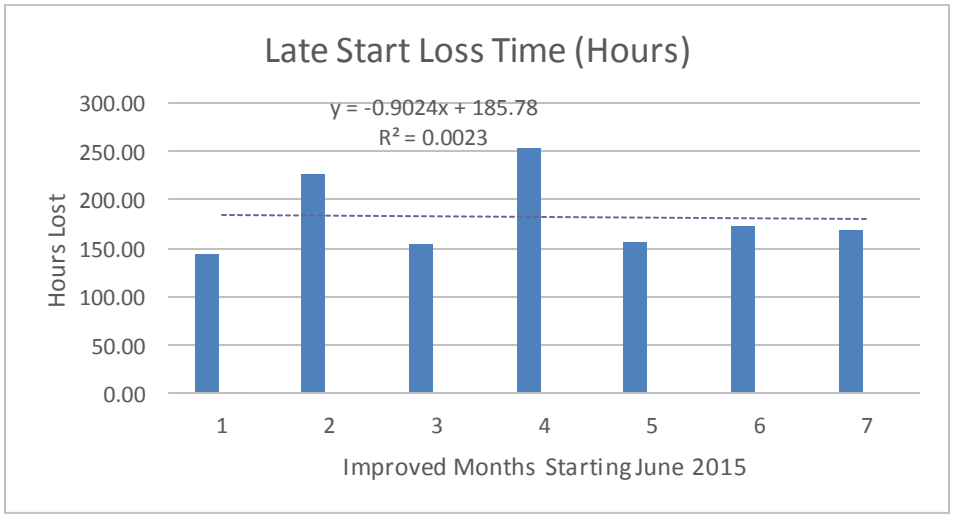
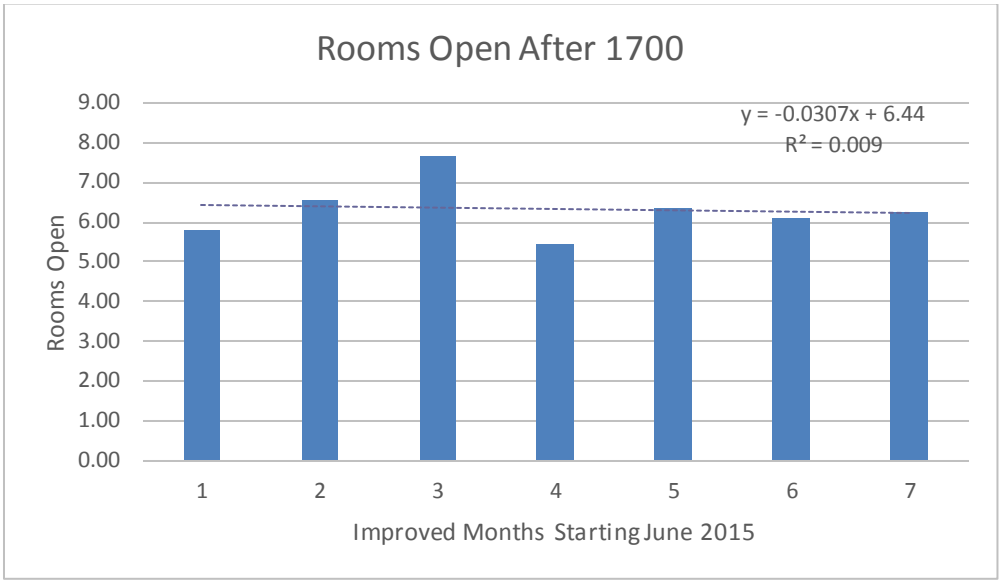


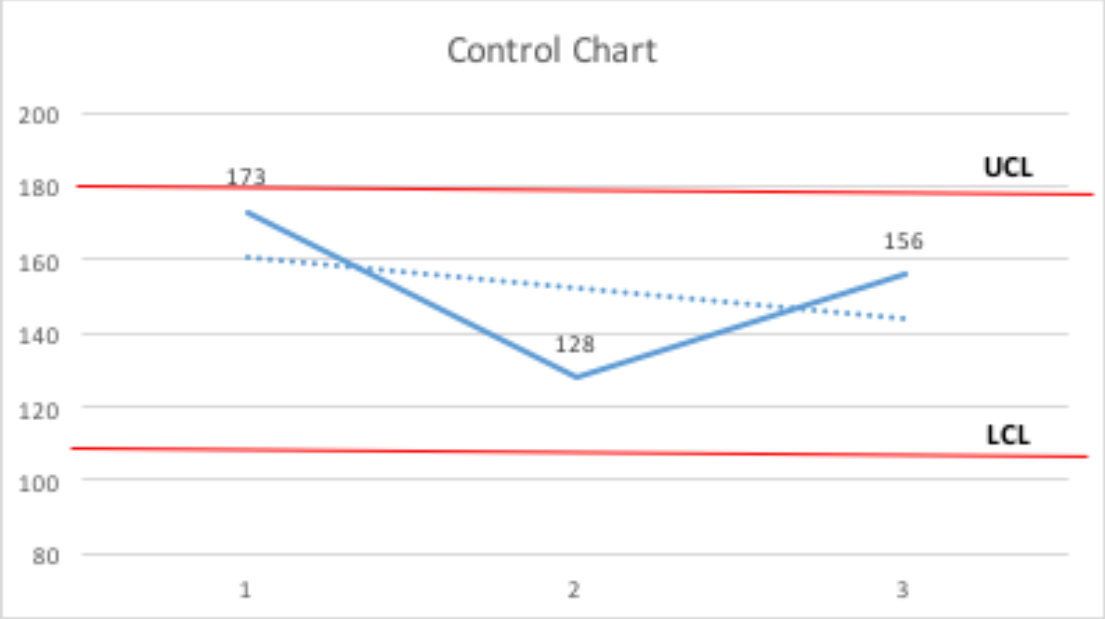
Figure 7. Time recuperated, less rooms running late

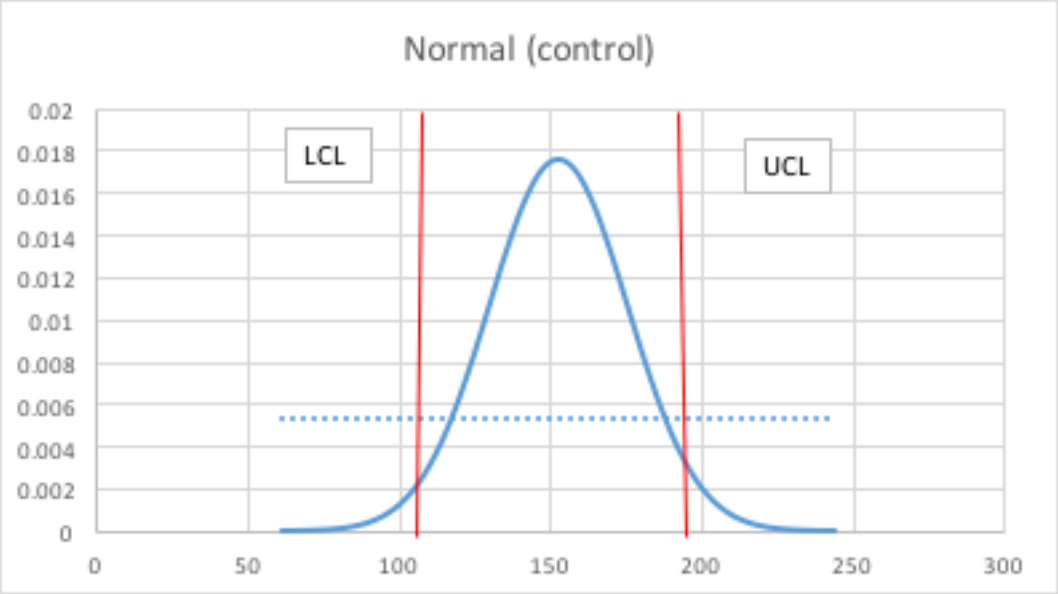


3.6 Control phase

With the improvement phase successfully completed, the team moved to the control phase, which is meant to sustain any process improvement. The control phase shows the degree to which the process is sustained and also helps to determine the sources of variance if the process is deemed unstable (poorly controlled). Control charts are based on metrics from the month of April 2016.

Figure 8. Process control chart for April 2016





Once the control phase was deemed sustained, the team moved to validate all parameters of improvement starting with the savings accomplished.

Table 3. Validated improvements through the calculation of the ROI

ROI Calculation	
Mins saved each day	30
Days in a month	30
Minutes saved per month	900
Months	12
Total Minutes Saved	10800
Cost per Minute	75
Total Cost Savings Per Year	**810,000**
More Cases done	36
Hours Per Case	2
Additional Time Utilized (for 1 month)	72
Factor (To annualize this number)	12
Total Hours **PER YEAR**	864
Revenue Per Hour	62.5
Marginal Revenue	**54,000**
Total Return	864,000
Investment Per Month (Took from 1.6)	27,000
Total Months to Learn New Process	3
Total Investment	81,000
ROI	**1067%**

Table 4. Final Achieved ROI

	Before				After		
	July	August	Sept.		October	Nov.	Dec.
Lost hrs.	207.82	130.87	240.8		157.35	172.78	148.02
Mean		193.1633				159.3833	
Std. Dev.		56.41156				12.50461	

With all mechanisms to achieve and sustain improvements we mapped the new strategy for the scheduling process presented below:

- A dedicated OR front desk person is assuming the task of identifying and filling the necessary schedule slots.
- An OR metrics analyst is then reviewing all information monthly and builds control charts which analyze and detect the source of variation.
- The analyst reviews that all rooms have an early start defined as 7, 7:30, 8 and 8:30am.
- If a point lies outside those limits it is analyzed for the source of variation.
- This permits both process monitoring as well as ensuring stability of the new process.
- Upper limits and lower limits are decided based on observed data, assuming a realistic process capability.

No LSS project finishes without reviewing other opportunities for improvement. It is also becoming part of the culture of continuing improvement that is more apparent in numerous organizations nationwide.

3.7 Steps for Ongoing Improvements

- In January, 2017 the new policy was approved by the governing body of the operating room, and is now in place.
- The success of the project has triggered interest in developing a policy that requires mandatory filling of all late start cases. This had buy-in from all parties: surgeons, allowing them more flexibility in scheduling cases; anesthesiologists in utilizing prime time resources, as well as nurses.

Identify and Record other improvement opportunities:

Ongoing improvement will entail efforts to decrease starts that are later than 8 am. The project recuperated 101 hours over three months, an average of 33 hours per month. Our case opportunity with a three-hour case length and a turnover of 45 minutes was a rate of approximately eight cases per month. That would translate into improved OR access, more timely quality of care for patients and better OR personnel satisfaction to mention only a few efficiency/effectiveness metrics. The financial implications for the organization are quite significant as well, particularly when savings are calculated over a year.

Without detracting from the overall satisfaction that short turnovers have for all

OR personnel, the metric historically has not demonstrated a superior outcome in terms of improving patient access, increasing case numbers or decreasing costs significantly. In that respect, first case starts as a metric seems to have a much larger impact on overall OR efficiency. Lean six sigma has opened the door to other areas of identifying waste and decreasing variance that are the most important determinants of OR time, which represents the most valuable OR resource.

4. Discussion

The operating room is a complex environment, and defining the best efficiency metrics is difficult. Historically, first case starts and turnover times are considered the best descriptors of what can be done to improve the OR efficiency, however, the healthcare environment is changing. New determinants are emerging, such as patient access, as well as financial metrics which put value in quality above volume, thereby imposing more constraints on regular OR workflow. The aviation industry, which parallels the healthcare industry the closely, considers far more performance metrics. Examples of such metrics include operations and customer scheduling effectiveness, pilot availability rate and pilot readiness.

Translating those into the operating room, we would look at patient scheduling effectiveness and surgeon availability, for example, thereby lending opportunity for both improvement and change. Tom Peters (3), an aviation metrics pioneer has said, "What you don't measure you can't control." By focusing on only two metrics we lose much opportunity for improvement. Inaccurate scheduling is one of the leading causes for delay in patient access. Surgeon unavailability, for various reasons is also a cause of delay, particularly in busy academic centers where surgeons fulfill other missions, such as the educational one in addition to their practice. Measuring the impact of those delays and attempting to improve them is best evidenced by applying the LSS methodology. Not only does it expose workflow bottlenecks but it also has a bottom up approach, thereby engaging OR team members, enhancing communication and collaboration and promoting culture change. The OR of the future may start using different performance metrics for efficiency and effectiveness in order to control patient access and patient satisfaction while at the same time keeping costs under control.

Our project proved a successful initiative that turned into an OR policy. The hospital administration also became interested in expanding the project through a black belt project (currently ongoing) that would address all downtime this time defined as minutes unutilized (aside from the 45 minutes allowed for turnover) on any room between 7am-5 pm, regardless of the cause. Using LSS uncovers a magnitude of hidden causes thereby allowing opportunities to analyze and address.

5. Conclusion

The LSS methodologies offer a tremendous opportunity for improvement, and are slowly starting to make their way into the healthcare industry. The applications are still not utilized to their full potential mostly due to lack of knowledge, infrastructure and hospital leadership buy-in. They are, however, essential in building a culture of safety and one of continuous improvement. With CMS actively now pushing the utilization of such methodologies more than ever, it is expected that more organizations will adopt and use them. At the same time, due to need for cost control and better quality of care, an opportunity to look into and challenge efficiency measures in a new way is

presenting itself to healthcare organizations. Integrating efficiency and effectiveness measures (such as better patient access to the OR) seems to become more possible than ever through LSS approaches.

The future may see a complete set of metrics for the OR dashboard that are more patient centric (better access and satisfaction), but that can also best increase revenue (more cases done) and cost savings (decrease waste). Training more OR staff in the LSS methodologies changes the way a process is viewed and approached. More importantly, in order to show more value for hospital administration, anesthesiologists must invest in training in LSS and promote the incorporation of the methodologies into the resident curriculum, all as part of a cultural change and increased patient safety efforts.

Conflicts of Interest: None

Funding Sources: None

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