Case Study

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Reducing Patient Waiting Time in Outpatient Department Using Lean Six Sigma Methodology

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This article addresses the issue of longer patient waiting time in the outpatient department (OPD) of a super specialty hospital attached to a manufacturing company in India. Due to longer waiting times at OPD, employees need to be away from the workplace for a longer duration. This problem was addressed through the Lean Six Sigma (LSS) methodology. The process, starting from registration of a patient to dispensing of medicine, was included in the project. The non-value added steps in the process were identified, and actions were initiated. A cause and effect diagram was prepared for high patient waiting time, and causes were validated with the help of data collected from the process. Statistical tools such as Kruskal–Wallis test, Box – Cox transformation, Control charts, normality test, etc., were used within the LSS methodology not only to identify the causes but also to sustain the improvements. As a result of this project, the average waiting time reduced from 57 min to 24.5 min and the standard deviation was reduced to 9.27 from 31.15 min. This will help the hospital to serve patients better and faster, which, in turn, will lead to a reduction in delay of treatment and a faster recovery of patients. The productivity loss due to absenteeism of employees from the workplace could be reduced. Generally, in an Indian health care scenario, most of the activities were dependent on individual doctors rather than processes. This project has helped the clinicians and the hospital management to identify the weak areas in the process for improvement. Because of the implemented solutions, understanding the history of past treatments and medications of the patients was easy for the doctors. Also, the practical validity of deploying LSS in a healthcare scenario was justified with this study. Copyright © 2013 John Wiley & Sons, Ltd.

Keywords: case study; healthcare; Lean Six Sigma

1. Introduction

Lean Six Sigma (LSS) is the latest generation of improvement approaches.[1] It is a business improvement methodology that aims to maximize shareholder value by improving quality, speed, customer satisfaction and costs. It achieves these by merging tools and principles from both lean and Six Sigma.[2] The lean improvement projects, executed using Define-Measure-Analyze-Improve-Control (DMAIC) methodology, are termed as LSS projects.[1,3] While lean is all about speed and efficiency, Six Sigma is about precision and accuracy: lean ensures resources are working on the right activities, while Six Sigma ensures things are done right the first time.[4] The lean also aims to increase the speed of operations and simplify the process flow.[5] LSS uses tools from both toolboxes in order to get the best of the two methodologies, increasing speed while also increasing accuracy.[6] It focuses on improving processes, satisfying customers and achieving better financial results for the business.[7,8] The concepts Six Sigma and Lean have evolved and changed the way that many people view improvement work.[9–11] A number of organizations in the healthcare sector also have been implementing Lean and Six Sigma initiatives for the last ten years for improving their processes. In previous years, several hospitals have adopted LSS, not only for quality improvement, and not just to deal with clinical and medical issues, but more generally for business improvement and in all areas of operations.[12] LSS projects in hospitals focus on different aspects of the workings of the hospital, including, length of stay, appropriate use of medication, better use of operating rooms and nursing efficiency, etc.[13]

The purpose of this paper is to demonstrate the power of LSS methodology in a hospital environment to reduce 'patient waiting time in outpatient department (OPD)' of a large hospital attached to a manufacturing company. The next section provides the readers with the details of the case study.

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2. LSS in OPD

This article presents a case study on LSS in a super-specialty hospital attached to a manufacturing company in India. This hospital provides healthcare services to 12,000 current employees and their families along with the retired employees. This is a hospital with approximately 80 specialist doctors working with other committed staff to provide quality services to the patients. Each day, 700 to 800 patients visit the hospital for various types of treatments. Since the number of patients visiting the hospital for treatments and routine health checkups is very high, the waiting time for people at the OPD was as high as two hours. This longer waiting time was having a cascading effect on other hospital processes, including the admission of patients to various in-patient departments and the different tests to be performed in the pathology department. Another important issue was that whenever the waiting time was longer at the OPD, there was a general tendency that operators in the processes did not report back to the factory on that specific day. During the rainy season, different types of influenza were very common in this area, and this led to very high level of absenteeism. Hence, timely and quality service was of the utmost important here as any delays in treatment to the patients would lead to increased absenteeism in the company, causing production stoppages and other operational inconveniences resulting in customer dissatisfaction.

The OPD has three major processes, viz, registration, consultation and medicine dispensing. This process is defined as follows: The patients arrive at the hospital and take a token from a token distributing machine that records the serial number and arrival time of each patient. Then, the patients wait in front of the registration counter. After registration is complete, they are directed to various OPDs for consultation. The patients wait in the respective OPDs for their appointment. Those patients who have to collect medicines after consultation are directly sent to the pharmacy for dispensing medicines. In some cases, the doctor decides that the patient needs to be sent for further investigation in the pathology department. The process of patients being directed to the pathology department for various investigations is not covered under the scope of this project. The hospital management decided to consider the improvement of the pathology department process as a separate project. During this study, the processes considered for improvement were registration, consultation and medicine dispensing. Because of the interfaces between doctors, nursing assistants, pharmacists and registration clerks, the complexity of the process increases further. Lean strategy helps in eliminating waste and other non-value added (NVA) activities from the processes and the streamlining of the operations of the hospital. A more streamlined operation would assist in reducing the stress of doctors and clinicians in the hospital and thereby improving their performance. LSS has been shown to produce improved quality, and at the same time reduce costs, on both the clinical and operational side of health care.[14,15] This approach to quality benefited both the patients, the health care providers and the bottom line.[16,17] Hence, it was decided to adopt LSS methodology (DMAIC) to make process improvements as it was essential to have a deeper analysis of the process to reduce the mean and variation in patient waiting times.[18,19]

2.1. *The define phase*

During the define phase of a LSS project, the problem was defined clearly and allocated to a team for execution. In this project, a team was formed with the Head of General Medicine Department as the leader. The team members included doctors from Cardiac, ENT, General Medicine and Ophthalmology departments. One pharmacist and a clerk from the registration counter were also included in the project team. The champion for the project was the Medical Director of the hospital. The champion was responsible for reviewing the project periodically for its progress, providing support to the team in terms of infrastructure and other resources, including manpower for execution of the project. The champion also reported the progress of all projects during the monthly business review meeting of the company. The project leader was trained as a Black Belt and had overall responsibility of managing the team, completing the project as per the schedule and communicating with the champion about the status of the project. The team members were trained as Green Belts and were responsible for contributing towards the project by participating in team meetings, collecting data from the respective processes and acting as change agents within the process. The organization hired a consultant as Master Black Belt (MBB). In this case, the arrangement with the MBB was that, as and when needed, the team would conduct meetings/discussions with the MBB. The team, after detailed discussion with the champion, prepared a charter with all the necessary details of the project. A project charter provides a preliminary delineation of roles and responsibilities, outlines the project objectives, identifies the main stakeholders and defines the authority of the project leader.[20] The project charter prepared in this study includes a project title, the background and reasons for selecting the project, a goal statement, the team and a schedule for the project. The project charter thus prepared is presented in Figure 1.

The critical to quality characteristic defined in this case was the 'patient waiting time at the OPD' measured in minutes. The team defined this further as the time taken from issue of token to disbursement of medicine from the pharmacy. The team had an initial meeting with a few outpatients, and they gave feedback that the waiting times in some OPDs were more than two hours. Hence, after discussion with the champion of the project, the goal statement of this project was defined as 'reducing the patient waiting time at the OPD to within 60 min'. The time frame given by the management to achieve this target was approximately five months. Based on this understanding, the team decided to perform a Supplier-Input-Process-Output-Customer (SIPOC) analysis for this project, so that every team member had good clarity in the process steps and project scope.[20,21] During the preparation of SIPOC, people from all the processes in OPD were actively participating. As a first step in preparation of SIPOC, a high level process map was created by identifying the broad steps in the process. This SIPOC helped the team to have a clear idea about the scope of the project. Since this was a cross functional project, which involved various medical departments of the hospital, an understanding of the project scope by every team member was necessary. The SIPOC, thus prepared, is presented in Figure 2.

Project Title: Reduction in Patient waiting time in outpatient department		
Background and reasons for selecting the project: The patient waiting time at various OPDs was very high, even going beyond two hours, with an average of 57 minutes. The delay in treatment to the patients will lead to increased absenteeism in the company, causing production stoppages and other operational inconveniences.		
Aim of the project: Reduce the average patient waiting time at the OPD to less than 60 minutes.		
Project Champion:	Medical Director	
Project Leader:	Head - Department of General Medicine	
Team Members:	Doctor – Cardiac Department Doctor – ENT Department Doctor – General Medicine Department Doctor – Ophthalmology Department Pharmacist, Registration Clerk.	
Characteristics of product/process output and its measure		
CTQ	Measure & Specification	Defect Definition
Waiting time	Time in minutes & within 60 minutes	Any waiting time more than 60 minutes is considered as a defect
Expected customer benefits:	Reduced waiting time for patients at the outpatient department.	
Schedule	Define: 2 Weeks Measure: 2 weeks Analyse: 4 weeks Improve: 3 weeks Control: 4 weeks	

Figure 1. Project charter

Supplier	Input	Process	Output	Customer
Patient	Patient Information	OPD Process	Report / Prescription	Patient
Central Stores	Medicine		Medicine	Patient
Central Stores	Instruments		Updated Medicine stock register	Stores
Registration counter staff	Information on Availability of Doctor			

OPD Process

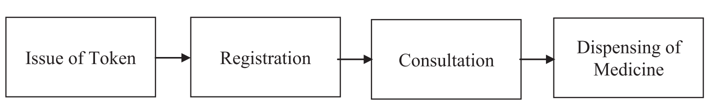

Figure 2. SIPOC for the OPD process

2.2. The measure phase

The measure phase in the LSS method involves evaluation of the baseline performance of the system that exists prior to any changes that the team might suggest.[22] During the team discussion, it was observed that there was a possibility of variation in waiting time for different OPDs. Hence, a data collection plan was prepared with different OPDs as a stratification factor. As per the plan, a sample of size 200 was collected on patient waiting time. The data was tested for normality and found not to be following the normal distribution.[23] The probability plots of original, as well as transformed data, are presented in Figure 3. To get an understanding of the overall performance of the process, a process capability analysis was performed with Minitab software by giving 60 min as the upper specification limit. Any patient waiting time of more than 60 min was considered as a defect. Since the data was not following any known distribution, even after transformation, the observed performance from the Minitab software output was considered for

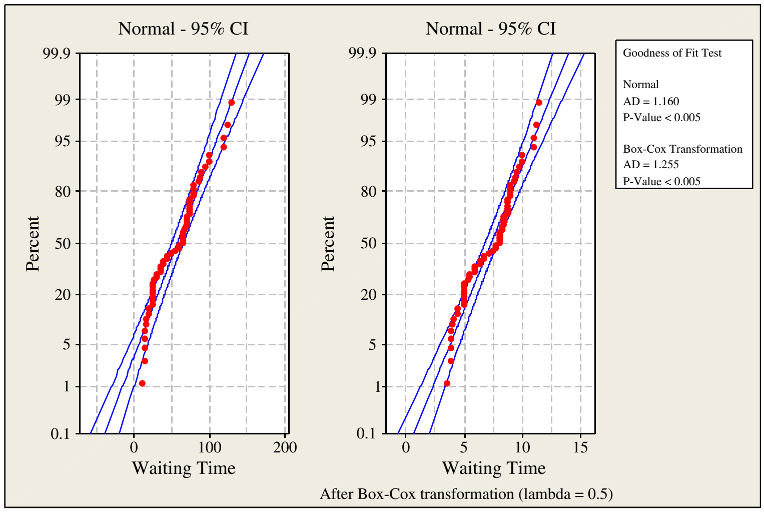

Figure 3. Probability plot for waiting time

baseline status evaluation. Figure 4 presents the Minitab software output of process capability analysis. The defects per million opportunities (DPMO) found from this analysis was 508196 with a mean of 56.95 min and standard deviation of 31.15 min. This was considered as the baseline of the process.

2.3. The analyze phase

In any LSS project, the objective of the analyze phase is to identify the root causes that create variation in the process.[24,25] Since this study deals with reduction of waiting time of the process, a two-stage approach was adopted in this project. During the first stage, a process analysis was performed to identify the NVA steps, bottlenecks and inefficiencies of the process. During the second stage, a cause and effect diagram was prepared to identify the potential causes for longer waiting time, so that root causes can be identified through data-based validation of causes. The activities performed during both of these stages are presented in the remaining part of this section.

During the process analysis, a detailed process map was prepared for the process starting from the collection of a token to dispensing of medicines at the pharmacy. There were a total of 35 steps in the process map, including decision points and waiting times. After studying these process steps in detail, the team concluded that out of the 35 steps, 14 of them were NVA. While deciding about the NVA, the team considered the seven kinds of waste according to lean principles. These are: overproduction, inventory, motion, waiting, transportation, over-processing and defects.[4] The team revisited each step in the process map based on these seven points, and the decision about NVA was made. The team had further discussions to study the possibility of eliminating these NVAs

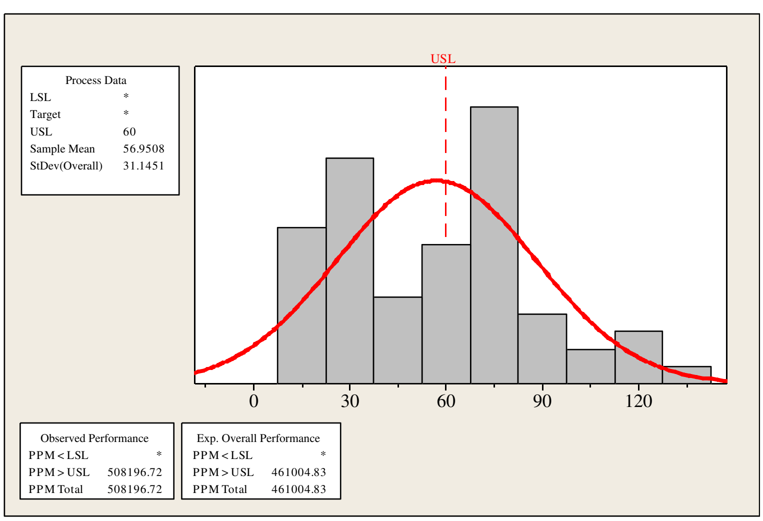

Figure 4. Process capability analysis for waiting time

from the process. Due to the nature of the process, some of the NVAs were not possible to eliminate from the process, whereas actions could be initiated for the others. Table I presents a list of actionable NVAs identified through this analysis. The solutions for these NVAs are discussed later in the improvement phase of this article.

Furthermore, the team performed a brainstorming session with the involvement of senior doctors, nursing assistants and pharmacists working with the process to identify the potential causes of longer waiting times. The potential causes related to the registration, consultation and medicine dispensing processes were identified. There were a total of 18 potential causes identified at this stage. These causes are presented in the form of a cause and effect diagram.[26] The cause and effect diagram is presented in Figure 5.

The root causes for longer patient waiting time at the OPD were to be identified through data-based validation of these causes. The team, along with the MBB and champion, had a further detailed discussion concerning the type of validation possible for these causes. Based on this discussion, a cause validation plan was prepared and is presented in Table II. This validation plan summarizes the details of data to be collected on each cause and the type of analysis to be performed for confirming the root causes. One such analysis used was a Kruskal–Wallis test for validating the cause of variation between OPDs with respect to waiting time.[23] There were multiple OPDs, such as Cardiac, General Medicine, Ophthalmology, ENT, etc. Hence, the waiting time data was collected separately for all these OPDs, and the Kruskal–Wallis test was performed to test the significance of waiting time with respect to these OPDs. The p-value from this test was found to be less than 0.05, confirming that there is a significant variation in waiting time between these OPDs.[23] A box plot for the same data was prepared and is presented in Figure 6. A sample of size 200 was used for these analyses. Hence, this was considered as a root cause to be addressed during the improvement phase.

Wherever direct measurable data was not possible to collect on the causes, the GEMBA method was used to validate such causes. In the GEMBA method of validation, the process was observed for a specified period of time, and the presence or absence of the specific cause was recorded.[27] In this case, the team decided to observe the process for a period of one month, and the occurrences of specific causes were recorded. Based on these observations, a conclusion was made regarding the root cause. The summary of all those validations is also included in Table II.

Table I. The list of non-value added activities identified for further action

Sl. no.	Non-value added activities
1	Correcting the wrong personal information entered during registration
2	Going back to the consulting room because not able to read prescription
3	Going back to the doctor due to medicine not available in the pharmacy
4	Doctors wait for stationary, such as a writing pad, etc., in the OPD
5	Patient reporting to wrong OPD
6	Patient not able to locate the OPD

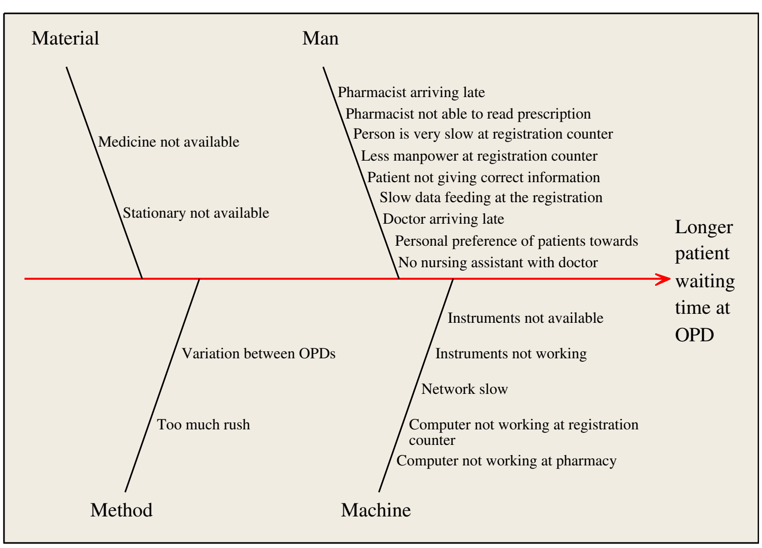

Figure 5. Cause and effect diagram for longer patient waiting time at OPD

Table II. Cause validation plan

Sl. no.	Causes	Validation method	Observation/Conclusion
1	Person is very slow at registration counter	GEMBA	Not observed
2	Too much rush	GEMBA	Observed on cardiac and diabetic OPD days
3	Less manpower at registration counter	GEMBA	Not observed
4	Computer not working at registration counter	Number of complaints reported to system department for a month	Not reported during the month
5	Network slow	Number of cases reported in a month	Not reported during the month
6	Stationary not available	Number of cases reported in a month	14 times it was reported from various OPDs
7	Patient not giving correct information	GEMBA	Observed almost all days
8	Slow data feeding at registration counter	GEMBA	Not observed - The persons were found to be proficient in job
9	Doctor coming late	Collecting data on OPD starting time for a month	Observed on all days
10	Instruments not working	Number of cases reported in a month	This was not reported during the observation period
11	Instruments not available	Number of cases reported in a month	Not observed
12	Personal preference of patients towards any doctor	Through an interview of patients	24 out of 30 persons interviewed showed personal preference
13	No nursing assistant with doctor	Number of cases reported in a month	Not observed
14	Variation between OPDs	Kruskal–Wallis test/Box plot	The p-value for Kruskal–Wallis test is less than 0.05, indicating a significant difference between OPDs
15	Pharmacist coming late	Collecting data on pharmacy starting time for a month	Not observed
16	Computer not working at pharmacy	Number of complaints reported to system department for a month	Only once it was observed during the month.
17	Medicine not available	Number of cases reported in a month	Observed on all days
18	Pharmacist not able to read prescription	Number of prescriptions going back to doctor for clarification in a month	Observed on most of the days

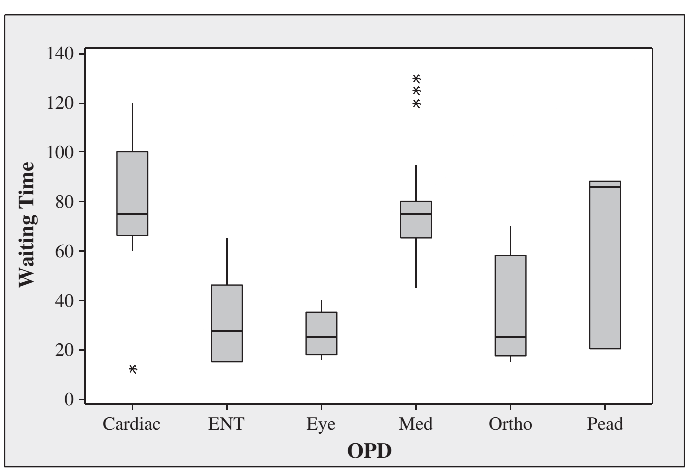

Figure 6. Box plot for patient waiting time for various OPDs

2.4. The improve phase

During the improve phase of this project, the solutions were identified for the root causes.[19,20] Actions were also identified for taking care of the NVA activities listed in Table I. A risk analysis was performed for all the selected solutions/actions to identify possible negative side effects of these solutions before they were implemented. A few of the selected solutions for the root causes and NVA activities are as follows.

- For the root cause - medicine not available, software was prepared with real-time updating of medicine stock in the pharmacy. This stock status was made available online at all of the doctors' consulting rooms. The nursing assistant with the doctor checks the availability of medicine online and hands over the prescription to the patient. Once the pharmacist dispenses the medicine and scans the barcode corresponding to the medicine listed in the prescription, the system automatically updates the stock status of the medicine. Previously, the patients waited at the pharmacy until the medicine was brought from the central store or returned back to the doctor for different medicine. As a result of this solution, the inconvenience caused to the patients was reduced to a large extend.
- Another root cause was - unable to read the prescription. To resolve this problem, instead of a handwritten prescription, a printout of the list of medicines was given to the patient. In this process, the medicine was selected from a dropdown menu in the software. This ensures that the prescription is readable for the pharmacist and doctor prescribes only those medicines that are available at the stores.
- One NVA activity identified was that the patient was not giving correct personal information, and this required corrections at a later stage. For this, with the support of the Information Technology (IT) department, software was developed, and the details of each employee and their family members were captured with a unique identification number as the ‘employee number’. In this process, if any employee or their family member quoted the employee number, all personal details, including history of past treatments, were available in the system. This has helped in reducing time taken at the registration counter and consulting room. This software was integrated with the stock updating software. Since in-house manpower was not available for this data entry, three persons were hired on a temporary basis for two months to complete the computerization of the personal information of all employees and family members. After these details were keyed in, individual's information was verified in the presence of respective employees.
- Another NVA identified was that patients are not able to locate respective OPDs. To resolve this problem, a detailed sketch of the layout of the hospital was prepared and displayed near to the registration counter. Also, directions to all the OPDs and pharmacy were displayed at appropriate places. In this display, the name of the OPDs and pharmacy were written in both English and Hindi languages so that everyone could understand and follow.
- Patients were showing some preference towards a few of the doctors and, hence, their respective consulting rooms were crowded. This cause was addressed by allocating junior doctors to all such identified consulting rooms to support the senior doctor. These include the OPDs of cardiac and general medicine.
- Doctor arriving late to the consulting room was resolved by rearranging the plan of activities for the day. Generally, the doctors would first make a ward round where patients were admitted and then start the consultation. Now, it was planned that the doctors first sit in the consulting room, and once the crowd has reduced, they go to observe the patients admitted into the ward.

The summary of all such actions is presented in Table III. An implementation plan was prepared with target date and responsibility to apply all of these actions. During implementation of the solutions, the software was developed with the support of the IT department of the company. This software was helpful in maintaining stock level updates online, updating patient details and

Table III. Cause and solution

Sl. no.	Causes	Solution
1	Too much rush	Allocating junior doctors in OPDs with senior doctors
2	Stationary not available	A list of required stationary was prepared and available at the registration counter, and OPDs were verified daily evening.
3	Patient not giving correct information	Software for entering all personal details of the employees and their family, linking to their employee number.
4	Doctor arriving late	Re-planned the doctor's schedule for the day. Instead of visiting the ward first in the morning, doctor visits the ward once the crowd in the OPD is reduced.
5	Personal preference of patients towards any doctor	Allocating junior doctors in OPDs with senior doctors where there is a huge crowd
6	Variation between OPDs	Allocating junior doctors in OPDs with senior doctors where the doctors require more time for consulting
7	Medicine not available	Software for real-time update of medicine stock
8	Unable to read prescription	Printing the prescriptions, based on the software

creating prescriptions. Hence, even though this was started as a project limited to doctors and other paramedical staff of the hospital, eventually it turned out to be a cross-functional project involving many areas and departments of the company.

Under the direct supervision of the team, all the solutions were implemented, and results were observed. The data on patient waiting time was collected from the process to study the level of improvement in the process. Based on a sample of size 180, the process capability analysis with a target of 60 min yielded DPMO of zero. The Minitab software output of the same is presented in Figure 7. The average waiting time was reduced to 24.5 min from 56.95 min and standard deviation was reduced to 9.27 from 31.15 min. Thus, there was a reduction of 57% on average and 70% in standard deviation for patient waiting times. A box plot was prepared to compare the waiting time before and after the project and is presented in Figure 8. The sample sizes used for making the box plot were 200 and 180, respectively, before and after the study.

2.5. *The control phase*

The application of the LSS methodology not only improved the process performance but also process improvement in ensuring sustainability of results in the long run. The biggest challenge in any improvement initiative is the sustainability of the achieved results.[1,28] For this, the following were planned:

- A monthly review was planned to discuss the status of implementation by the Medical Director of the hospital. The problems cropped up during the implementation were discussed in this review meeting, and actions were planned for taking care of the same.
- Standard operating procedures (SOP) were prepared/modified for all the processes and displayed near to the workplace. The people were trained on the SOPs so that they could implement them without any difficulty.

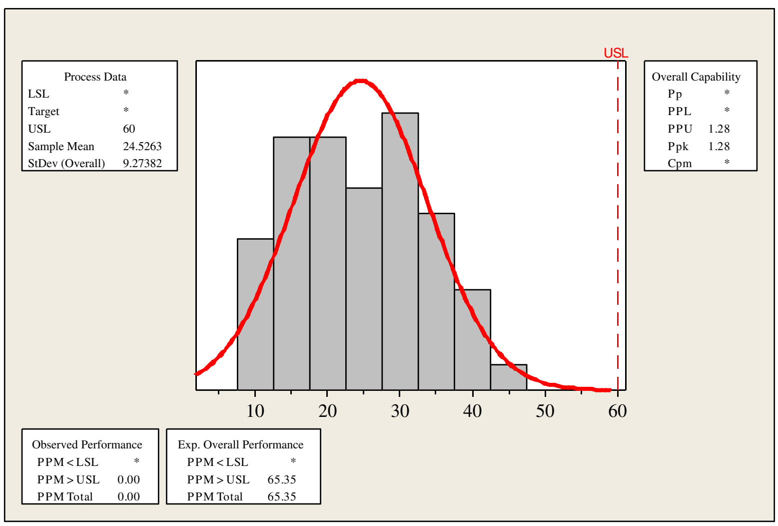

Figure 7. Process capability analysis for waiting time after the study

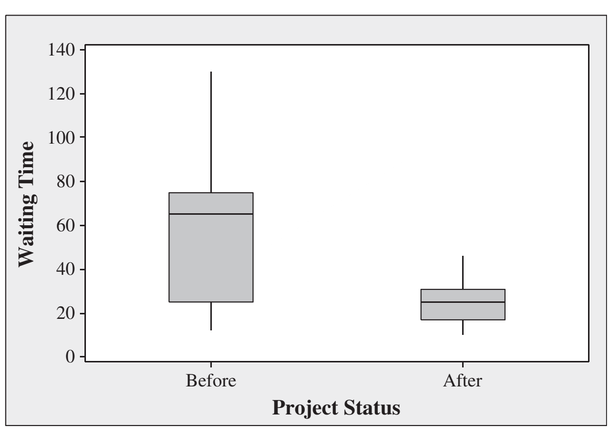

Figure 8. Box plot for waiting time: before and after the study

- Since this hospital was certified to ISO 9001: 2008, all the process changes made were brought under document control of the quality management system.
- The internal audit check list was modified after adding the check points related to this project. This has even helped verification of the implemented solutions and control mechanisms under the scrutiny of internal auditing system of the organization. Thus, all the actions initiated were institutionalized and practiced.
- Daily data was recorded on patient waiting time on a sample basis, plotted on a Run chart and variations were studied.[29,30] A sample Run chart is presented in Figure 9. A reaction plan was prepared along with the Run chart for taking immediate corrective actions on the process, whenever signals for assignable causes were observed.[29] The summary of all these actions was presented at the monthly review meeting.
- The above data was used to calculate the DPMO, average and standard deviation of the process on a monthly basis and was displayed in Medical Director's office as a trend chart.

All of these actions with the support from top management have helped to sustain the achieved results of the project.

3. Lessons learned

This was started as a simple project with a few doctors and paramedical staff as members, but later it turned out to be a cross functional project with the involvement of quite a few departments and areas of the organization. Through this project, the people understood the power of working in cross functional teams, which was a first experience for the hospital staff. Since this was the first project executed in this hospital, the objective of the management at this stage was to ensure that people understood how to complete a LSS project. This study has demonstrated to the hospital staff how an LSS project can be successfully completed by involving a cross functional team. This project also has proven that some of the solutions require redesigning of the existing process flow and current practices that were followed in the hospital for decades. Another important point was that generally there was a feeling among the doctors and nurses that there was nothing to improve in the hospital, which was proven to be wrong. The usage of Minitab statistical software for analysis of the data and making meaningful conclusions also was new to the hospital staff.

4. Managerial implications

The healthcare-related activities in India are mainly dependent on individual doctors rather than defined processes. Even in super speciality hospitals, all activities are driven by very few senior doctors. Their activities were never monitored through any metric. Most of the hospital management did not have any control over such processes. As a result of this project, it was established that for improving the quality of service, the activities had to be process dependent rather than individually driven. This study helped the management to review the metrics related to the process performance. Data and its analysis gave confidence to the people and the top management for taking decisions about the process. After observing success in this project, the management decided to implement LSS throughout the organization. During the next year, a total of 23 projects were planned in the hospital.

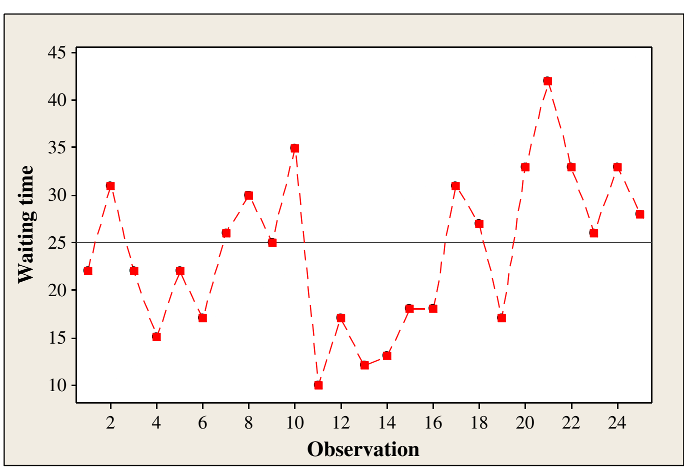

Figure 9. Run chart for waiting time

5. Conclusions

The hospital had attempted to reduce the waiting time of patients at OPDs for several years through the application of recommended practices with no significant differences detected. This case study illustrates the application of LSS methodology to resolve the problem of longer patient waiting times in the OPDs of a hospital. The objective of this study was to explore the practical propensity of implementing a lean anchored Six Sigma model in a real-time healthcare scenario.

The implementation of a lean sigma framework in the organization provided an impetus for establishing best practice within the organization. The methodological implementation accomplished the reduction in waiting time. Moreover, the reduction in waiting time led to an increase in patient satisfaction. A significant improvement was observed in the key performance metrics after the implementation of the LSS strategy. The average patient waiting time was reduced by 57%, and the standard deviation was reduced by 70%. The study enabled the inculcation of creative thinking as well as improved employee morale towards attaining the strategic goals of the organization. By focusing on eliminating waste, identifying the truly value adding activities and using the DMAIC tools for problem solving, it is possible to achieve significant improvements in the levels of customer service provided. Also, the practical validity of deploying LSS in a healthcare scenario was justified with this study. The authors hope that this case study will encourage managers to use the LSS method to deal with difficult problem in the hospital.

Even though the case study was successful in improving the process, the team encountered quite a few challenges during the project execution. The most important challenge was that for implementing the solutions, support was required from various other departments of the company. This included the support for developing software for various activities. The timely intervention of the champion helped to resolve these issues. Another challenge was the collection of data, analysis and interpretation of the results. Since the team members were not familiar with these activities, constant support from the MBB was required during the project.

After the completion of this project, the team was convinced of the following points: Extensive data collection was essential to the success of the project, but this had to be focussed on the key areas identified in the study. Statistical software was essential for the analysis. However, these packages required use by people with the correct training. LSS succeeded in a process where previous improvement attempts had failed. This is attributed to the structured data collection that focussed attention on the true causes of the problem.

There were quite a few areas in the hospital, such as medicine procurement planning, inventory management, high attrition of hospital staff, equipment breakdowns, etc., that required further improvement. All these areas were considered as future projects to work with. Since the Six Sigma organization in this hospital is still expanding, it is expected to achieve greater substantial improvements in the near future.

A further survey of the hospital patients can be conducted to understand the effectiveness of the achieved results. During this survey, the managers of various departments can also be included to understand the after-effect of this research in terms of productivity improvement and reduced absenteeism.

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E. V. Gijo is a member of the faculty at the Statistical Quality Control and Operations Research Unit of Indian Statistical Institute, Bangalore, India. He is an active consultant in the field of Six Sigma, quality management, reliability, Taguchi methods, time series analysis, and allied topics in a variety of industries. He is a certified Master Black Belt and trainer in Six Sigma and guided more than 500 projects in Six Sigma in various organizations. He has published around 20 papers in reputed international journals. He is a reviewer for more than seven international journals related to statistics and quality. He also teaches in the academic programs of the institute.

Jiju Antony is recognised worldwide as a leader in the Six Sigma methodology. He founded the Centre for Research in Six Sigma and Process Excellence (CRISSPE) in 2004, the first research centre in the field of Six Sigma in Europe. He is a fellow of the Royal Statistical Society (UK), fellow of the Institute for Operations Management (UK), fellow of the American Society for Quality (USA), and fellow of the Institute of Six Sigma Professionals and was recently elected to the International Academy of Quality, the first to be elected from the Scottish Higher Education sector. He is a certified Master Black Belt and has demonstrated savings of over £10m pounds to several organisations throughout Europe. He has authored over 225 journal and conference papers and 6 text books, and published over 75 papers on the topic of Six Sigma. Over the past 8 years Professor Antony has provided Lean Six Sigma training to over 800 people from UK-based companies. He is currently coaching and mentoring over 20 Lean Six Sigma projects from various companies in the UK, ranging from manufacturing and service to public sector organisations, including NHS, City Councils and the University sector. He was the past editor of the International Journal of Six Sigma and Competitive Advantage and is currently serving as the editor of the First International Journal of Lean Six Sigma, launched in 2010 by Emerald Publishers. He has been a keynote speaker for various conferences around the world and is a regular speaker for ASQ's annual Lean Six Sigma Conference in Phoenix, USA. He is on the EAB of nine International Journals. Professor Antony has worked on a number of consultancy projects with several blue chip companies such as Rolls-Royce, Bosch, Parker Pen, Siemens, Ford, Scottish Power, Tata, Thales, Nokia, Philips, GE, and a number of small and medium sized enterprises.