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Application of Lean and Six Sigma for Intestinal Obstruction Patients-A Case Study

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Abstract

The purpose of this paper is to apply Lean and Six Sigma techniques in Indian hospital to investigate the barriers in length of stay (LOS) period of Intestinal obstruction patients. The Six Sigma's DMAIC (Define-Measure-Analyse-Improve-Control) procedure is being applied along with standard Lean tools. The detailed data of patients are observed over a period of eight months. The mean LOS is computed to be 11.55 days with standard deviation of 3.34 days. The value stream mapping is used to find various non-value added activities and Fishbone diagram is utilized to determine root causes of the process. Patient's feedback and GEMBA observations are used to validate the possible causes for the problem. It is observed that nearly 70% of total LOS is non-value added time and can be minimized to reduce the LOS. The waiting time for surgery, time for admission, time for discharge, lack of motivation from doctors, etc. are identified as root causes for the process. It is concluded that Lean and Six Sigma methodologies have great potential to produce clinically significant improvement for surgical patients.

Keywords
Lean, Length of stay, Six Sigma, Surgery.

Introduction

Yeo et al. (2012) stated that intestinal obstruction is a kind of disease, which has been reported throughout history with cases detailed in the Ebers Papyrus of 1550 BC and by Hippocrates. According to Wang et al. (2015), there are 3.2 million cases of Intestinal obstruction in 2015 throughout the globe and unfortunately, 2,64,000 of them died. Specifically, in India, there are more than 1 million cases per year. Ferri (2014) analyzed that this disease, which can occur at any age and affects both sexes equally. Intestinal obstruction is a condition in which digested material is prevented from passing though bowl. Pujahari (2016) found that symptoms include severe bloating, abdominal pain, vomiting, nausea, diarrhea, etc. Gore et al. (2015) concluded that the X-ray is usually required for the diagnosis; however, it is more accurate to perform CT scan and patient may be treated conservatively or with surgery depends upon the condition.

Several studies have shown important concern for the surgery like reducing waiting time, decreasing length of stay (LOS) after surgery, etc. Taner et al. (2007) reduced the waiting time of patients before surgery using Six Sigma. Parks et al. (2008) applied the Lean and Six Sigma approach in trauma centre of the hospital and they were able to reduce reactivation units' dwell time by one hour. Allen et al. (2010) focused on the hospital discharge process using Six Sigma DMAIC approach. They lowered down the average discharge time to 2.8 hours from 3.3 hours. Sedlack (2010) used Six Sigma's DMAIC (Define- Measure- Analyse- Improve- Control) procedure to reduce waiting time of surgeon between the cases. Taner (2013) lowered down the complications of cataract surgery using Six Sigma. Alkinaidri and Alsulami (2018) improved the delays in referral system of hospital using Lean Six Sigma. Molla et al. (2018) improved the timeliness of the discharge process of the hospital using Lean Six Sigma. Suman and Prajapati (2018) reported that the use of Lean and Six Sigma in Indian healthcare sector is very limited. Therefore, the present paper is an attempt to apply these quality initiatives in a northern Indian government hospital. In this paper, Lean and Six Sigma tools are integrated to streamline processes and decrease the LOS period for Intestinal obstruction patients in surgery department. Al-Qatawneh et al. (2019) provided a proposed framework to apply Six Sigma in the area of healthcare logistics. Al-Zain et al. (2019) reduced the patient waiting time using Lean Six Sigma in obstetrics and gynaecology clinic. Davies et al. (2019) optimized

nursing time in a day care unit using Lean and Six Sigma. Brown et al. (2019) improved the rates of day of surgery admission in a national thoracic surgery. Kuiper et al. (2022) reflected upon the ramifications of two decades of Lean Six Sigma implementations in Dutch healthcare institutions in the light of the current COVID-19
pandemic.

1. METHODOLOGY

The following subsection illustrates how the DMAIC cycle and Lean tools are used to determine bottlenecks and minimise patient's LOS period. The present study is approved by the Institutional Review Board of the selected hospital.

Define Phase

In this phase, project scope, problem formulation, objectives and goals of the project are defined clearly. Intestinal obstruction is most frequently performed surgery according to hospital's data. Therefore, determination of bottlenecks in LOS for Intestinal obstruction is taken as a project. The level of satisfaction with current LOS is assessed through survey and is computed to be approximately 50%, which again emphasising the need of this project. Table 1 shows the project charter which is the essential component of define phase. It gives quick idea of project objectives, aims, planned schedule, etc.

Table 1. Project Charter

Project title: Reducing LOS period of Intestinal obstruction patient in Surgery department using Lean and Six Sigma methodology.
Reason for selecting the project: The mean LOS period of Intestinal obstruction patients is exceeding the desired limit of 8 days. This increase the extra work-in-process inventory and overcrowding in Surgery department. This causes various problem to the patients as waiting time for X-ray, waiting time for blood sample collection, waiting time for reports etc. are also increasing.
Aim of the project: To reduce length of stay period from 11.55 days to 8 days.
Project Champion: Director
Project Owner: Medical Superintendent
Project Leader: Doctor in Surgery department
Team Members: 1 attendant, 2 Nurse
Critical to Quality (CTQ) Characteristic: Length of stay
Measures: Days
Expected benefits: The project will results in decrease in LOS period of patient by minimising bottlenecks within the process, which will eventually increase patient satisfaction and decrease cost of the hospital as number of patients discharge per day will also increase.
Schedule: Define 1 week Measure 32 weeks Analyse 2 weeks Improve 2 weeks

2.1 Measure Phase

The measure phase allows the development of process performance metrics and determines process requirements. The complete procedure to treat the surgery patients staring from their entry into the Emergency department to the discharge from surgery ward is shown in Figure 1.

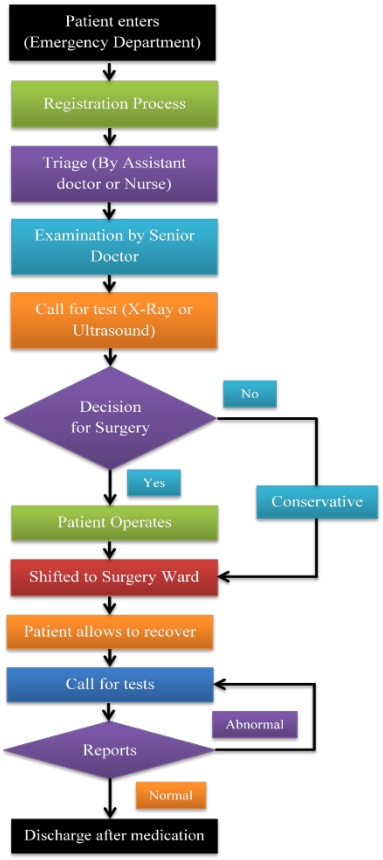

Figure 1. Procedure to Treat The Surgery Patients

It is clear from the Figure 1 that patient with their relatives enters into the Emergency department. First of all, patient's relative has to make card from registration counter and is followed by triage in order to decide degree of urgency. Assistant doctor or nurses perform the triage and senior doctor performs final examination. After that, patient is gone through X-ray or ultrasound depends upon the condition. Based upon the reports, the decision for the surgery is made by doctors. Then patient is transferred to operation theatre where skilled and experienced doctors perform surgery. Patient is allowed to heal for few days in surgery department; from where patient is discharged after medication.

The data for the LOS period of patients for Intestinal obstruction surgery is carefully observed for the period of eight months (given in Appendix A). LOS period includes the time from the patient's entry into the emergency department to their discharge from the surgery ward. It is calculated that mean LOS is 11.55 days with standard deviation of 3.34 days. It is clear from the states that there is a lot of variation in the data as the standard deviation is nearly equal to four days. One thing should be noted that the present study excludes the patients that either treated conservatively or died on the spot.

Analyse Phase

Analyse phase is the key phase of the Six Sigma DMAIC procedure. Lean tool i.e. value stream mapping is applied in order to find the value added and non-value added time between the process as shown in Figure 2. One thing should be noted that value stream mapping does not include the healing time as well as pre-operative conservative time as this varies from patient to patient. The included steps are triage, registration, call for tests, payment for tests, preparation for operation, signing of paper, etc. The total of 335 minutes of non-value added time has been observed from the value stream mapping, as shown in Figure 2. Non-value added time means that this does not pay any value to the patient. Out of total time, only 32.83% of time is valuable for the patient.

Cause and effect analysis is also performed to find the possible reasons for longer LOS period as shown in Figure 3. The thirteen possible reasons have been brainstormed after discussion with doctors and staff members i.e. waiting time for imaging, pathology, reports and surgery, time for admission and discharge. The other reasons are lack of motivation from doctors, staff not well trained, lack of knowledge

in different languages, wrong equipment sent to operation theatre (OT), lack of material handling devices, doctor's preferred setting, post-operative complications and poor hygiene.

Two methods are used to validate the selected possible causes for the problem. Firstly, survey questionnaire is generated in order to know the level of satisfaction of patients about the particular process. The included causes and response of patients are given in Table 2. Patients were asked the question on Likert scale of 1 to 5; where one shows highly disagree and five represents highly agree. It is decided by the team that satisfaction level less than 3 for specific cause will be identified as root cause for the problem. So, it is clear from the Table 2 that waiting time for surgery, time for admission, time for discharge, lack of motivation from doctors are root causes for the LOS period.

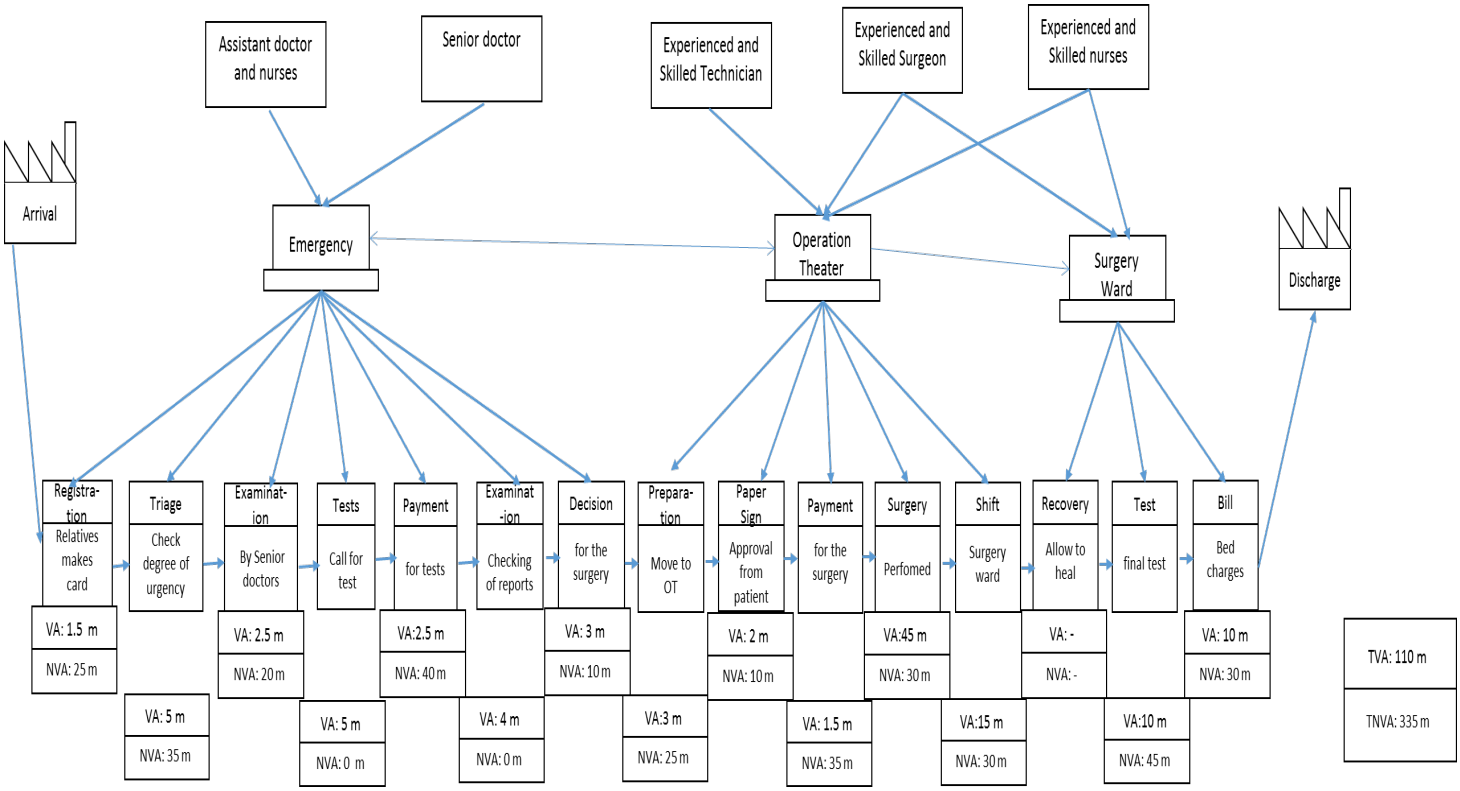

Figure 2. Value Stream Mapping for Surgery Patient
(Note: VA: Value added time, NVA: Non-value added time, TVA: Total value added time and TNVA: Total non-value added time)

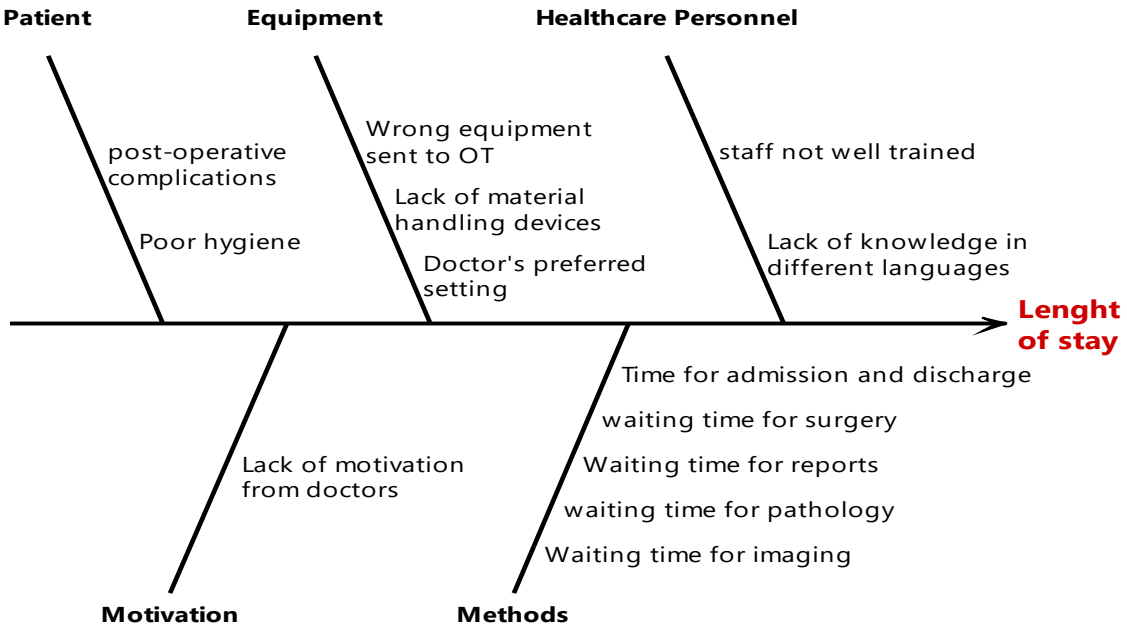

Figure 3. Cause and Effect Diagram for Surgery Patient

Table 2. Patient Satisfaction Score for Possible Causes for LOS Period

Sr. No.	Possible Causes	Question to Patients	Satisfaction level
1	Waiting time for imaging	You have an acceptable waiting time for Imaging to done.	3.23
2	Waiting time for pathology	You have an acceptable waiting time in Pathology department.	3.04
3	Waiting time for reports	You have an acceptable waiting time to get reports.	3.11
4	Waiting time for surgery	You have an acceptable waiting time for surgery.	2.57
5	Time for admission	You feel no delay in your admission.	2.85
6	Time for discharge	You feel no delay in your discharge.	2.84
7	Lack of motivation from doctors	The doctors and staffs also provide motivational support along with medical support.	2.67
8	Lack of knowledge in different languages	The things told by doctors and staffs are well understood by you in the very first time.	4.15

GEMBA technique is used to validate the other possible causes of the problem. In the GEMBA method, the process is observed for specific period, to find out the availability of specific causes. The process is monitored for specific period and results of GEMBA are summarized in the Table 3. So after analysis phase, seven factor out of thirteen comes out as root causes for the problem.

Table 3. GEMBA Observations and Results

Sr. No.	Causes	Observations	Conclusions
1	Staff not well trained	Most of the time junior doctor or medical students are involved in the process.	Root Cause
2	Wrong equipment sent to OT	The technician provide the correct equipment in OT	No Root Cause
3	Doctor's preferred setting	Technician provides machine to doctors with their preferred setting	No Root Cause
4	Post-operative complications	Post-operative complications after surgery increase the LOS.	Root Cause
5	Lack of material handling devices	There is proper material handling system in operation theatre as well as in the ward.	No Root Cause
6	Poor hygiene	Poor hygiene from the patient's part increases the chances of infection.	Root Cause

2.4 Improve Phase

In this phase, possible feasible solutions are suggested for the identified root causes of the problem. The various improvements are as follow:

I. Waiting time for surgery

The satisfaction level of patient with waiting time for surgery is 2.57 out of 5. The value stream mapping also shows various non-value added times before surgery like in preparation of consent form for surgery, time for transfer to operation theatre, payment of surgery, etc. So there should be fast documentation system in the process to reduce the waiting time before surgery.

II. Time for admission and discharge

Patients felt delay during the time of admission and discharge as it is clear from satisfaction level. Actually, both the time of admission and discharge are interrelated. There should be ready-made template documents for patient discharge, which will increase the speed of discharge of patients that automatically reduce the time for admission of new patient.

III. Lack of motivation from doctors

Although, the doctors and nurses in the hospital are very well experienced and skilled, but they do not provide motivational support to the patient. This is a psychological fact, which helps the patients emotionally to recover at faster rate.

IV. Staff not well trained

It is observed that most of the time junior doctor or medical students are involved in the process. This will eventually increase the process time. The management should look upon this thing and proper training system should be arranged.

V. Post-operative complications

Mainly four types of complications occurs after surgery i.e. wound infections, pulmonary complications, re-explore and nutrition deficiency. It is observed that maximum cases of wound infections after surgery. So, the doctors and staff should take necessary steps towards this.

VI. Poor hygiene

Patients from rural region are not able to maintain level of hygiene required after surgery. So they get infected and that will eventually increase the time for their recovery. So proper instructions should be given to the patients/relatives to maintain the level of hygiene and reduce the infection rate.

3. RESULTS AND DISCUSSION

This section presents the discussions related to the various results of the present study. After discussions with doctors and hospital administration, reduction in bottlenecks in LOS period of Intestinal obstruction patients is selected as project. Project charter as shown in

Table 1 gives the various aspects of project i.e. project title, reason for selecting project, team description, etc. The mean and standard deviation for LOS is computed as 11.55 days and 3.34 days respectively.

Lean tool i.e. value stream mapping is used to find the various value added and non-value added time during the entire process as shown in Figure 2. The mapping does not include the healing time as well as pre-operative conservative time as this varies from patient to patient. This includes steps like triage, registration, preparation of patient, etc., whose time is standard and can help in finding non-value added time based on the observation. It is observed that nearly 70% of the total time is non-value added and can be minimised to reduce the time spent by the patient in surgery department. The cause and effect analysis is performed with LOS as effect and possible causes are brainstormed. The thirteen causes are shortlisted after discussions with doctors and staff members. Patient's feedback survey and GEMBA observations are used to validate the possible causes. The survey questionnaire is constructed on 5-point likert scale where one represents minimum satisfied and five shows maximum satisfied. The project leader decides that average satisfaction level less than 3 is considered as root causes of the problem. After survey, waiting time for surgery, time for admission, lack of motivation from doctors are identified as root causes for problem.

GEMBA method is used to validate the causes and these causes are: untrained staff, wrong equipment sent to OT, lack of material handling devices, doctor's preferred setting, post-operative complications and poor hygiene. So total of seven factors are shortlisted after validation by both the methods. Based on the root causes, possible feasible solutions are suggested to the hospital administration to reduce barriers within the process. The recommended solutions include fast documentation system, readymade discharge template, proper motivation from doctors for the patient, proper training of staff, etc.

The present research is limited to determine bottlenecks and provide recommendations to the hospital administration to reduce LOS period. The cost analysis of the suggested recommendations can also be done in future, which will help hospital administration and staff to correlate between investment and quality improvement in their services.

4. CONCLUSIONS

The present paper is basically an initiative to apply Lean and Six Sigma methodologies in Indian healthcare sector. Although, Lean and Six Sigma are being widely applied in healthcare throughout globe but its application in India is very limited. The detailed study of procedure staring from the patient's entry into the department to their discharge has been done to find the bottlenecks within the process. After discussions with doctors, possible solutions are suggested to increase quality of the process. Finally, it can be concluded that these methodologies have the potential to produce clinically significant improvement for surgical patients.

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Appendix A. Data for LOS Period of Intestinal Obstruction Patient

S N	AD	DOS	DD	LOS	S N	AD	DOS	DD	LOS
1	19-07-2018	20-07-2018	27-07-2018	**9**	54	17-11-2018	19-11-2018	24-11-2018	**8**
2	04-07-2018	17-07-2018	25-07-2018	**22**	55	02-11-2018	02-11-2018	09-11-2018	**8**
3	29-07-2018	30-07-2018	08-08-2018	**11**	56	20-11-2018	22-11-2018	30-11-2018	**11**
4	30-07-2018	08-08-2018	15-08-2018	**17**	57	20-11-2018	21-11-2018	01-12-2018	**12**
5	10-08-2018	13-08-2018	26-08-2018	**17**	58	23-11-2018	25-11-2018	04-12-2018	**12**
6	25-08-2018	26-08-2018	11-09-2018	**18**	59	24-11-2018	24-11-2018	06-12-2018	**12**
7	28-08-2018	30-08-2018	11-09-2018	**15**	60	27-11-2018	29-11-2018	08-12-2018	**12**
8	04-09-2018	05-09-2018	11-09-2018	**8**	61	01-12-2018	02-12-2018	10-12-2018	**10**
9	04-09-2018	04-09-2018	10-09-2018	**7**	62	02-12-2018	04-12-2018	13-12-2018	**12**
10	01-09-2018	01-09-2018	09-09-2018	**9**	63	02-12-2018	02-12-2018	11-12-2018	**10**
11	30-08-2018	30-08-2018	07-09-2018	**9**	64	04-12-2018	04-12-2018	14-12-2018	**11**
12	30-08-2018	30-08-2018	09-09-2018	**11**	65	05-12-2018	08-12-2018	20-12-2018	**16**
13	07-09-2018	08-09-2018	30-09-2018	**24**	66	08-12-2018	10-12-2018	18-12-2018	**11**
14	07-09-2018	08-09-2018	16-09-2018	**10**	67	09-12-2018	10-12-2018	21-12-2018	**13**
15	07-09-2018	12-09-2018	24-09-2018	**18**	68	09-12-2018	11-12-2018	20-12-2018	**12**
16	23-08-2018	30-08-2018	15-09-2018	**25**	69	12-12-2018	13-12-2018	20-12-2018	**9**
17	03-09-2018	04-09-2018	14-09-2018	**12**	70	14-12-2018	17-12-2018	30-12-2018	**17**
18	06-09-2018	07-09-2018	12-09-2018	**7**	71	15-12-2018	15-12-2018	24-12-2018	**10**
19	30-08-2018	31-08-2018	07-09-2018	**10**	72	18-12-2018	19-12-2018	29-12-2018	**12**
20	08-09-2018	10-09-2018	14-09-2018	**7**	73	18-12-2018	21-12-2018	29-12-2018	**12**
21	10-09-2018	10-09-2018	23-09-2018	**14**	74	19-12-2018	20-12-2018	29-12-2018	**11**
22	18-09-2018	19-09-2018	22-09-2018	**6**	75	23-12-2018	25-12-2018	02-01-2019	**11**
23	10-09-2018	12-09-2018	02-10-2018	**22**	76	25-12-2018	27-12-2018	06-01-2019	**13**
24	17-09-2018	18-09-2018	24-09-2018	**8**	77	25-12-2018	26-12-2018	02-01-2019	**9**
25	14-09-2018	15-09-2018	24-09-2018	**11**	78	28-12-2018	30-12-2018	08-01-2019	**12**
26	15-09-2018	17-09-2018	24-09-2018	**10**	79	30-12-2018	31-12-2018	11-01-2018	**13**
27	12-09-2018	15-09-2018	22-09-2018	**11**	80	04-01-2019	05-01-2019	12-01-2019	**9**
28	26-09-2018	28-09-2018	22-10-2018	**27**	81	05-01-2019	07-01-2019	15-01-2019	**11**
29	01-10-2018	02-10-2018	05-10-2018	**5**	82	08-01-2019	09-01-2019	19-01-2019	**12**
30	17-09-2018	17-09-2018	30-09-2018	**14**	83	08-01-2019	10-01-2019	16-01-2019	**9**
31	29-09-2018	29-09-2018	18-10-2018	**20**	84	08-01-2019	11-01-2019	22-01-2019	**15**
32	26-09-2018	27-09-2018	10-10-2018	**15**	85	12-01-2019	15-01-2019	23-01-2019	**11**
33	27-09-2018	28-09-2018	05-10-2018	**9**	86	13-01-2019	13-01-2019	21-01-2019	**9**
34	29-09-2018	30-09-2018	08-10-2018	**10**	87	13-01-2019	15-01-2019	22-01-2019	**9**
35	30-09-2018	02-10-2018	12-10-2018	**13**	88	14-01-2019	17-01-2019	28-01-2019	**15**
36	01-10-2018	03-10-2018	15-10-2018	**15**	89	18-01-2019	18-01-2019	26-01-2019	**9**
37	02-10-2018	03-10-2018	12-10-2018	**11**	90	18-01-2019	20-01-2019	28-01-2019	**11**
38	05-10-2018	07-10-2018	15-10-2018	**11**	91	20-01-2019	21-01-2019	01-02-2019	**13**
39	06-10-2018	07-10-2018	16-10-2018	**11**	92	21-01-2019	23-01-2019	31-01-2019	**11**
40	19-07-2018	20-07-2018	27-07-2018	**9**	93	24-01-2019	24-01-2019	02-02-2019	**10**
41	04-07-2018	17-07-2018	25-07-2018	**22**	94	25-01-2019	26-01-2019	03-02-2019	**10**
42	29-07-2018	30-07-2018	08-08-2018	**11**	95	25-01-2019	26-01-2019	04-02-2019	**11**
43	30-07-2018	08-08-2018	15-08-2018	**17**	96	28-01-2019	30-01-2019	08-02-2019	**12**
44	10-08-2018	13-08-2018	26-08-2018	**17**	97	28-01-2019	29-01-2019	07-02-2019	**11**

45	25-08-2018	26-08-2018	11-09-2018	**18**	98	29-01-2019	29-01-2019	10-02-2019	**13**
46	28-08-2018	30-08-2018	11-09-2018	**15**	99	29-01-2019	31-01-2019	09-02-2019	**12**
47	02-11-2018	02-11-2018	09-11-2018	**8**	100	01-02-2019	02-02-2019	11-02-2019	**11**
48	05-11-2018	08-11-2018	19-11-2018	**15**	101	01-01-2019	03-01-2019	11-02-2019	**11**
49	05-11-2018	06-11-2018	13-11-2018	**9**	102	05-02-2019	08-02-2019	18-02-2019	**14**
50	10-11-2018	10-11-2018	22-11-2018	**13**	103	09-02-2019	12-02-2019	21-02-2019	**13**
51	09-11-2018	10-11-2018	18-11-2018	**10**	104	12-02-2019	12-02-2019	21-02-2019	**10**
52	14-11-2018	15-11-2018	22-11-2018	**9**	105	14-02-2019	15-02-2019	23-02-2019	**10**
53	16-11-2018	17-11-2018	26-11-2018	**11**	106	17-02-2019	18-02-2019	26-02-2019	**10**

Note: AD: Admission date, DOS: Date of surgery, DD: Discharge date and LOS: Length of stay

Biography:

Dr. Deoraj Prajapati is working as a professor in the department of Mechanical Engineering, Punjab Engineering College (Deemed to be University) Chandigarh, India. He has teaching and research experience of more than 25 years and published more than 140 research papers in international and national journals of repute and in the proceedings of the conferences. He is also reviewer of 8 international journals. He also guided 6 Ph.D. and more than 32 post graduate theses and guiding one research scholars at present. He has also chaired many international and national conference in India and abroad.

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