Six Sigma Project-Story-Book

for the project: *Quality Improvement in Rural Healthcare*

**Green-Belt Candidate:**
Tony V Raju

Dr Neeta Paul Alice
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<td>Summary</td>
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<td>Graphical Analysis</td>
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<td>Process-Capability</td>
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<td>Control-Charts</td>
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<td>Statistical Test of Improvement</td>
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<td></td>
<td>Project-Management-Plan</td>
</tr>
<tr>
<td></td>
<td>Summary &amp; Benefits</td>
</tr>
</tbody>
</table>
Introduction
**My introduction as a Green-Belt candidate and my Project Sponsor**

**Green Belt:**

**Tony V Raju**

Education: B-TECH Mechanical Engineering (June 2019)

Projects:
1. Ultra-sonic based Imaging of fractured bones
2. Chalk Recycling Device
3. Optimised Transportation model for Kelchandra Pipe Industry

**Sponsor:**

**Dr. Neetha Alice Paul**

Education: MBBS, MS

Position: Medical Officer, CHC Sachivothamapuram

**Company:**

- CHC sachivathomapuram is a rural hospital in Kerala state, India.
- The hospital provides medical service mostly in Non Communicable Disease (NCD) category.
- The hospital has 4 doctors and around 370-430 patients visit daily in this hospital.
CONFIRMATION MAIL

My name is Dr Neetha Alice Paul from the Hospital CHC SACHIVOTHAMPURAM. I am responsible for the medical services offered in this hospital and treatment of patients. I confirm, that Tony V Raju (tonyoct97@gmail.com) will implement the Six Sigma project in my area of responsibility and will support Tony V Raju in the DMAIC phases (DEFINE, MEASURE, ANALYSE, IMPROVE, CONTROL), in the role of a Sponsor.

For the Lean Six Sigma Green Belt certificate he/she will measurable solve:
- a Quality-Problem of the output,
- an Availability-Problem (reduce cycle time or increase volume) and
- a Consumption-Problem (better utilization of inputs and/or resources and/or elimination of waste in the process).

I allow Tony V Raju to conduct interviews with internal customer of (intermediate) outputs, to involve experts of the topic and to conduct at least one workshop a) in the MEASURE phase to analyze the inputs and the process and b) in the transition of the ANALYSIS to the IMPROVE phase to determine the root causes of the problems and to develop solution ideas to eliminate the root causes.

At the end of each DMAIC phase, Tony V Raju will present the most important results of this phase in his/her Project-Story-Book. Based on these results, I will decide on the success of the project so far, either to require adjustments in the current phase or to recommend the transition to the next DMAIC phase.

The decision about the implementation of solutions in the IMPROVE-Phase is up to me. I note, however, that a project in which no solutions are implemented and which does not lead to measurable improvements cannot be certified. Therefore, I will check the financial and other benefits for plausibility after the approved solutions are implemented.

I accept that the application and registration at the TUM School of Management begins with the sending of this e-mail, and that the course fee has to be transferred if the Project-Topic and Project-Definition have passed the suitability check.
Scan of my TUM Lean Six Sigma Yellow Belt Certificate
**Key Figures to our Hospital**

- 4 DOCTORS (NO specialization)
- 6 NURSE & 4 NON MEDICAL STAFF
- 70-75% of total patient are in NCD CATAGORY
- Around 2000 patient visit in a week
- Around 20,000 diabetes medicine are delivered in a week
- 370-430 patient visit in Friday itself
Key Figures to our Hospital

1. Based on a survey (figure left) about type of disease patient have we found that there are two type. One communicable diseases and second non communicable diseases.

2. Communicable disease are disease which spread by air, water, human contact etc. In case of our hospital they include viral fever (14.9%), active diarrhea (2%) and active gastric (4.9%). They form around 20% of total patients.

3. Non communicable disease are life-style disease means they won’t spread by contact. Diabetes, cholesterol, hypertension are some of its type. They form roughly 80% of total patient.

4. In case of communicable disease patient will go directly to pharmacy after consultation but in case of non communicable disease patient will go to lab and based on lab result they will go to pharmacy.

5. Since non communicable disease (NCD) form 80% of patients we can focus on that group and it will be beneficial in long run.
Medical Service in our Hospital

Queue at consultation Room

Queue at Pharmacy

The average Length of stay of patient in hospital is around 1.75-2.5 hours a particular day as doctors have to handle a large population and it cause poor medical service. The workload on lab is very high and also frequent unavailability of medicine occurs.
**Survey among patients**

![Pie chart showing customer voice with categories and percentages]

**Results**
1. Based on the survey conducted among patients, it is found that
2. Waiting time is the major problem they suffer the most.
3. Lab capacity, which in turn affects the waiting time, also contributes a major part.
4. Medicine quality, a problem which we cannot address as it is out of control, becomes the third most raised problem.

**Interpretation and implication**
From the survey, we can conclude that solving waiting time and lab capacity can improve the quality of medical service offered to a higher level.
DEFINE

Identification and Definition of a Six Sigma Project
Project-Topic

Project Definition

The hospital has to handle large patient size and thus the length of stay of patient in government hospital is very high as 2.5 hrs compared to 30 minute length of stay in private hospital. The longer length of stay not only affect the patient health condition but it also create medical error and affect the quality of medical service. The poor capability of diagnosis laboratory also affect the length of stay. The frequent unavailability of some medicine also make situation worse.

MEDICAL SERVICE - i.e. products/services, that we create - take a long time/ are available too late. The loss of time/delay occurs very often and has a strong impact on the internal/external customer. The problem can be solved with a very big contribution by the own department.

Relevance of the topic: 35%
Suitability for method: Six Sigma
Solvable by own department up to: 80%

Section 1: Process and Output

Summary:
The Service MEDICAL SERVICE is an intangible final Output for external Customers and is in the Creation Process TREATING PATIENT within a year 53 - 365 times generated. Important Input of the Process to generate the Product MEDICAL SERVICE is: TICKET, MEDICINE, LAB FACILITIES, DIAGNOSIS DEVICES.
Project-Definition (1/2)

Section 2: Problem

Summary:
1. Problem: MEDICAL SERVICE THE PATIENTS DOES NOT GET ENOUGH TIME FOR TREATMENT. MEDICAL SERVICE fulfills the requirement on Quality (is error-free) in 30%.

2. Problem: MEDICAL SERVICE NCD LABORATORY TAKE TOO MUCH TIME. MEDICAL SERVICE fulfills the requirement on efficient utilisation of means (no waste of Input, Resources) in 30%.

3. Problem: MEDICAL SERVICE FREQUENT UNAVAILABILITY OF MEDICINE IN PHARMACY. MEDICAL SERVICE fulfills the requirement on Availability (right quantity) in 40%.

Section 3: Effect

Summary: Voice of Business
The satisfaction of the process-owners with the Consumption in the Creation Process of the MEDICAL SERVICE is: 50%.
The total costs of the specified 3 problems are estimated by 2500€ / year.
They are primarily the result of quality costs due to scrap and additional expenditure.
The solution of the problems is rated as:
- medium URGENT (70%-Level)
- major IMPORTANT (80%-Level)
Project-Definition (2/2)

Summary: Voice of Customer
The satisfaction of the external customers with the:
- Quality of MEDICAL SERVICE is: 40%.
- Availability of MEDICAL SERVICE is: 30%.

Section 4: Solution

Solution Idea to 1. Problem
An effective study on which area cause bottle neck in the patient flow from ticket counter to pharmacy is need to be identified and improving that stage for example pharmacy or labortary can reduce the problem.

Solution Idea to 2. Problem
The efficiency of the device and operator are need to be analysed and the inabilities are need to be rectified.

Solution Idea to 3. Problem
The critical medicines are need to be identified and provide provision for stocking them

additional Information
Your additional comments, advices, feedback ... are very appreciated.
DEFINE

SIPOC, Voice to Criticals, Project-Charter, Stakeholder Communication
**SIPOC with the core process steps included in the project**

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Input (x)</th>
<th>Process (xMR)</th>
<th>Output (Y)</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ticket Counter</td>
<td>Patient (Information)</td>
<td>Record Patient Details</td>
<td>Patient (General Ticket)</td>
<td>Ticket Counter</td>
</tr>
<tr>
<td>2. Patient</td>
<td>Patient (General Ticket)</td>
<td>Consult Patient</td>
<td>Patient (OP Report)</td>
<td></td>
</tr>
<tr>
<td>3. Lab Technician</td>
<td>Patient (Lab Sample)</td>
<td>Test sample</td>
<td>Patient (Lab Report)</td>
<td>Doctor</td>
</tr>
<tr>
<td>5. Hospital (Pharmacy Dept)</td>
<td>Medicine (order)</td>
<td>Produce medicine</td>
<td>Medicine (Delivery)</td>
<td>Hospital</td>
</tr>
</tbody>
</table>

**Results**

1. First process steps represent ticket counter operation
2. The process steps 2-4 represent consultation, testing & pharmacy activity respectively
3. The process step 5 represents procurement of equipment and medicine respectively.

**Interpretation and implication**

Since the process is a service system, actual process may not work in systematic fashion. The laboratory testing are only for NCD category patients and others have to go to pharmacy directly.
Voice of Customer & Business, Customer & Management Requirements and Problems

<table>
<thead>
<tr>
<th>Y</th>
<th>Voice</th>
<th>Critical Business Requirement (CBR) or Critical Customer Requirement (CCR)</th>
<th>Problem</th>
<th>Kano-Category</th>
<th>Severity</th>
<th>Critical to Quality (CIQ) Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y_01</td>
<td>Patient (medical treatment)</td>
<td>CCR: Patient (medical treatment) Length of stay short</td>
<td>Patient (medical treatment) Length of stay too short</td>
<td>Must-Be</td>
<td>90%</td>
<td>1</td>
</tr>
<tr>
<td>Y_02</td>
<td>Patient (Lab Report)</td>
<td>CCR: Patient (Lab Report) Facility usage efficient</td>
<td>Patient (Lab Report) Facility usage inefficient</td>
<td>Must-Be</td>
<td>83%</td>
<td>2</td>
</tr>
<tr>
<td>Y_03</td>
<td>Medicine (Delivery)</td>
<td>CBR: Medicine (Delivery) Availability stock level &gt;= demand</td>
<td>Medicine (Delivery) Availability stock level &lt; demand</td>
<td>More/Less-to-Better</td>
<td>45%</td>
<td>3</td>
</tr>
<tr>
<td>Y_04</td>
<td>Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results
1. Three critical problems are identified under three domain.
2. Two problem are based on customer and one based on management.

Interpretation and implication
The quality and consumption problem are critical and are need to be effectively addressed and the availability problem can improve patient situation a lot.

The most important problems are: Patients length of stay & Facility usage inefficient
CTQ Bar Chart for the Problems and their evaluation by the KANO Model

Interpretation and implication
The focus of my project is on the Must-Be problems (CtQ’s): Length of stay and Facility usage
**PROJECT CHARTER**

**Business Case**
The Service 'MEDICAL SERVICE' is an intangible final Output for external Customers and is in the Creation Process 'TREATING PATIENT' within a year 53 - 365 times generated. Important Input of the Process to generate the Product 'MEDICAL SERVICE' is: 'TICKET', 'MEDICINE', 'LAB FACILITIES', 'DIAGNOSIS DEVICES'.

**Process & Output**

<table>
<thead>
<tr>
<th>Process/Service: Medical Service</th>
<th>Process: Treating Patient</th>
</tr>
</thead>
</table>

**Voice of Customer (VoC)**
The satisfaction of the external customers with the:
- Quality of 'MEDICAL SERVICE' is: 40%.
- Availability of 'MEDICAL SERVICE' is: 30%.

**Problems**
- Y_01 | Patient (medical treatment) | Length of stay too long
- Y_02 | Patient (Lab Report) | Facility usage inefficient
- Y_03 | Medicine (Delivery) | Availability stock level < demand

**Solution-Ideas**

- Y_01 | Medicine (Delivery) | Availability stock level < demand
- Y_02 | Patient (medical treatment) | Length of stay too long
- Y_03 | Patient (Lab Report) | Facility usage inefficient

**Comment**
- Medicine Labortary equipments
- Labortary sample.

**Timeline**

- Target-Date: 1 August 2019
- Define: 1.11.2019
- Measure: 25 September 2019
- Analyse: 28 October 2019
- Improve: 05 November 2019
- Control: 17 November 2019
- End: 01 December 2019

**Interpretation and implication**
The length of stay and laboratory efficiency are related while availability of medicine is related to an external supplier.
Stakeholder-Analysis and communication plan

Interpretation and implication

1. The principal stakeholders are Doctors, Lab technician, Pharmacist and Nurse
2. The Doctors forms the promoter group as they have power and interest
3. The lab technician has power but not so aware about the project
4. Nurse show the least power and less influence

Results

1. The effective ranking of each person are assigned
2. The strategy which is needed to be adopted for each category are identified
3. The unawareness among nurse and lab technician is need to be addressed
**Results of the **Define**-Steering**

<table>
<thead>
<tr>
<th>Define-Steering</th>
<th>Proceed to next-Phase</th>
<th>Remarks</th>
<th>Date</th>
<th>Contact/ Verification-ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Reiner Hutwelker</td>
<td>yes</td>
<td>Dear Tony, You give a transparent representation of the process weaknesses, already enriched by your own analyses and have successfully applied the tools to hospital operations. That is not self-evident - beautiful performance. Therefore a clear GO to MEASURE from me. Please let your Sponsor now also decide on this phase. - Reiner</td>
<td>30.7.2019</td>
<td><a href="mailto:reiner.hutwelker@softlogik.de">reiner.hutwelker@softlogik.de</a></td>
</tr>
<tr>
<td>Sponsor</td>
<td>Proceed to next-Phase</td>
<td>Remarks</td>
<td>Date</td>
<td>Contact</td>
</tr>
<tr>
<td>Dr Neetha Alice Paul</td>
<td>yes</td>
<td>Statistical analysis are verified and found to be valid but the unawareness about this program may create confusion among different people working in this hospital so I recommend necessary communication. I am okay to go with further processing.</td>
<td>03.08.2019</td>
<td><a href="mailto:neethapaul95@gmail.com">neethapaul95@gmail.com</a></td>
</tr>
</tbody>
</table>

*Only proceed to the next phase after a positive decision of MBB and Sponsor*
MEASURE

Input-Analysis, Process-Mapping/-Analysis, C&E-Matrix, Data-Collection-Plan, Hypothesis
Input Analysis

**Results**

1. Overall 4 different negative influences of the inputs on our defined problems were identified.

2. The estimated frequencies of these negative influences range between 55-80%.

**Interpretation and implication**

1. The input patient illness show deviation in two operation that is in laboratory as well as in ticket counter.

2. Sampling indirectly affect the length of stay of patients.

3. The ordering of medicine play a key role in the out of stock problem of medicine like metformin.

Four negative influences of the inputs on our defined problems were identified, with a frequency between 55-80%.
Workshop flipchart with the process-mapping analysis

**Process mapping analysis was executed with our subject matter experts**
Process-Mapping and Process-Analysis for the focussed process in the hospital

Interpretation & implication

1. The reduction in number of doctors at consultation room due to clinical rotation will affect the length of stay of patients at consultation.

2. The patients who came late in an hour will take more time for getting lab result because of processing of initial lab sample they received.

3. The long waiting time of patient at pharmacy also affect the availability of critical medicine availability.

4. The variable patient volume is considered under availability category.

Clinical rotation of doctors, queue rules in the laboratory and the variable patient volume are the most important influences
Bar Chart: Influences of methods and resources on the activities

Interpretation and implication

1. The negative influences on the activities in the occur with a similarly high frequency

2. The Length of stay is the area where it is affected by both the clinical rotation as well as the long processing of lab sample

Results

1. The influences of methods and resources on the activities of the process show an estimated frequency between 65-75%

Process mapping analysis was executed and the negative influences are identified
### Cause & Effect Matrix (1/2)

#### C&E Matrix

<table>
<thead>
<tr>
<th>Problems (= Effects)</th>
<th>Severity 90% 83% 45%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cause &amp; Effect Matrix</td>
</tr>
<tr>
<td>Y_01</td>
<td>Problem: PATIENT (MEDICAL TREATMENT) LENGTH OF STAY TOO LONG</td>
</tr>
<tr>
<td>Y_02</td>
<td>Problem: PATIENT (LAB REPORT) FACILITY USAGE INEFFICIENT</td>
</tr>
<tr>
<td>Y_03</td>
<td>Problem: MEDICINE (DELIVERY) AVAILABILITY STOCK LEVEL &lt; DEMAND</td>
</tr>
</tbody>
</table>

#### Influences from Input (xI (= Causes))

- **xI_01: Input: Patient (Information)** | Requirement: Quick processing of general ticket | Requirement-Category: Quality (Faultlessness/ Fulfilment of Purpose) | negative Influence: Delayed processing of general ticket |
- **xI_02: Input: Patient (General Ticket)** | Requirement: Availability of medical service | Requirement-Category: Quality (Faultlessness/ Fulfilment of Purpose) | negative Influence: Different Disease takes different time for medical service. |
- **xI_03: Input: Patient (Sample)** | Requirement: Clean and on time sample | Requirement-Category: Consumption (Material/Machine/Personnel/Time/Energy) | negative Influence: Delayed processing of Laboratory sample. |
- **xI_04: Input: Medicine (order)** | Requirement: Optimum stock with regular filling | Requirement-Category: Availability (right quantity just in Time) | negative Influence: Out of stock condition of medicine and higher inventory |

#### Influences from Process-Step (xMR (= Causes))

- **xMR_06: Activity: Generate Laboratory Result** | Input: Patient (Lab Sample) | Methods: Arrival Time of patients | Resources: ./. | Output: Patient (Lab Report) | Influence on Quality: The patients who came after first serum separation take longer time for result | Influence on Availability: ./. | Influence on Consumption: ./. |

#### Results for: Determination of Outputs (Y) by Influences (x & xP)

| Product Sum of the Determination of each Output (Y) by the Influences (x & xP) | 2.3839 | 0.8771 | 0.5244 |
| Percentual Determination of each Output (Y) by the Influences (x & xP) | 87% | 25% | 14% |
| Ranking of the Determination of each Output (Y) by the Influences (x & xP) | 1 | 2 | 3 |
Interpretation and implication
1. The cause & effect are analyzed and classified into suitable category.
2. The length of stay of patient is affected by ticket processing, different type of disease, arrival of patients as well as the clinical rotation of doctors.
3. The lab test result is affected mostly by the time spent by lab technician for processing result.
4. The availability of medicine is affected by both the number of patient as well as time spend at pharmacy.
### Cause & Effect Heat Map (1/2)

#### CHC SACHIVOTHAMPURAM

<table>
<thead>
<tr>
<th>Influence from Input (xI) (= Causes)</th>
<th>Probability D</th>
<th>E</th>
<th>F</th>
<th>Results for: Impact of Influences (xI &amp; xP) on the Outputs (Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>xI_01: Input: Patient (Information)</td>
<td>0.3099</td>
<td>12%</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>xI_02: Input: Patient (General Ticket)</td>
<td>0.5938</td>
<td>22%</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>xI_03: Input: Patient (Sample)</td>
<td>0.6054</td>
<td>10%</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>xI_04: Input: Medicine (order)</td>
<td>0.0858</td>
<td>3%</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

#### Influences from Process-Step (xMR) (= Causes)

<table>
<thead>
<tr>
<th>Influence from Process-Step (xMR) (= Causes)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>xMR_01: Activity: Describe illness</td>
<td>0.0000</td>
</tr>
<tr>
<td>xMR_02: Activity: Create general ticket</td>
<td>0.0000</td>
</tr>
<tr>
<td>xMR_03: Activity: Consult the patient</td>
<td>0.4014</td>
</tr>
<tr>
<td>xMR_04: Activity: Send Patient to the required Laboratory</td>
<td>0.0600</td>
</tr>
<tr>
<td>xMR_05: Activity: Collect Blood</td>
<td>0.3723</td>
</tr>
<tr>
<td>xMR_06: Activity: Generate Laboratory Result</td>
<td>0.2800</td>
</tr>
<tr>
<td>xMR_07: Activity: Prescribe Medicine based on lab result</td>
<td>0.0708</td>
</tr>
</tbody>
</table>

#### Results for: Determination of Outputs (Y) by Influences (x)

<table>
<thead>
<tr>
<th>Results for: Determination of Outputs (Y) by Influences (x)</th>
<th>xI</th>
<th>xP</th>
<th>Y_01</th>
<th>Y_02</th>
<th>Y_03</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-weighted Product Sum of the Determination of each Output (Y) by the Influences (xI &amp; xP)</td>
<td>1.7443</td>
<td>0.7816</td>
<td>0.1058</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-weighted Percentage Determination of each Output (Y) by the Influences (xI &amp; xP)</td>
<td>63%</td>
<td>20%</td>
<td>9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranking of the non-weighted Determination of each Output (Y) by the Influences (xI &amp; xP)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cause & Effect Heat Map (2/2)

Results

1. According to the C&E Matrix and Heatmap the two Must-Be problems (CtQ’s) are triggered by negative influences of the input and activities, resulting in comparable high risks for the corresponding x-Y-pairs

3. The risk is highest for the influence of different type of disease on length of stay of patient at hospital

4. The length of stay of patient at pharmacy has the lowest x-Y-risks

Interpretation and implication

1. The most important risks in influence-problem pairs (x-Y-pairs) will serve as a basis for the hypotheses
Summary of important influence (x) problem (Y) relationships and ...

Interpretation and implication:
Y01: Different medical service times is a strong risk while clinical rotation, arrival nature & ticket processing are moderate risks
Y02: Delayed processing of lab sample is moderate risk while variable patient sample is small risk
Y03: Medicine demand & Pharmacy waiting time are of low risk on the medicine order

... the risks, that the influences trigger or increase the problems

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**Data Collection Plan**

### Results

1. Data collection plan is formulated effectively
2. The circumstances are also evaluated
3. The USL and LSL are also specified, as well as the time period of collection plan mentioned.
4. The sample sizes are specified

### Interpretation and implication

1. The parameter, charts and one-sample tests are suggested for the collected data
2. The output are all cardinal scale and has required specific limits.
3. The input and its method are of nominal as well as cardinal scale.
Hypotheses (1/2)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Hypothesis</th>
<th>Interpretation and implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>39.99%</td>
<td>There is no difference in the degree of ( Y_{-01} ) Output: Patient (medical treatment) [Degree of: Time (Minutes)] between the Levels of: ( x_{L01} ) Input: Patient Information [Levels of: Ticket nature (New ticket/Old Ticket)].</td>
<td>1. The categorical nature of input need ANOVA and T test to determine the results and for further analysis</td>
</tr>
<tr>
<td>58.30%</td>
<td>There is no difference in the degree of ( Y_{-01} ) Output: Patient (medical treatment) [Degree of: Time (Minutes)] between the Levels of: ( x_{L02} ) Input: [Patient (General Ticket)] [Levels of: Disease Type (Diabetes, Cholesterol, Hypertension etc.)].</td>
<td>2. The Length of stay of patient under different disease category has the most risk factor</td>
</tr>
<tr>
<td>28.00%</td>
<td>There is no difference in the degree of ( Y_{-01} ) Output: Patient (medical treatment) [Degree of: Time (Minutes)] between the Levels of: ( x_{MFL05} ) Activity: Generate Laboratory Result [Levels of: Type of patient (Initial patient / Final patient)].</td>
<td>3. The Initial and final patient meant to determine the impact on early sample arrival and can be determined by T-test</td>
</tr>
<tr>
<td>48.14%</td>
<td>There is no difference in the degree of ( Y_{-01} ) Output: Patient (medical treatment) [Degree of: Time (Minutes)] between the Levels of: ( x_{MFL03} ) Activity: Consult the patient [Levels of: Doctor number (Doctor present / Doctor absent)].</td>
<td></td>
</tr>
</tbody>
</table>

Results

1. The variation in time among New ticket/Old ticket are need to be analysed using the t-test.
2. The different disease take different time which is also need to be analysed using ANOVA.
3. The Initial and final patient meant to determine the impact on early sample arrival and can be determined by T-test.
### Interpretation and implication

1. The regression will help to determine relation between medicine demand and patient number.

2. The time at pharmacy can also be a decisional factor.
### Example data-sheet of collected data

<table>
<thead>
<tr>
<th>Serial no</th>
<th>Y_01 Patient length of stay</th>
<th>Y_02 Patient Lab Report</th>
<th>Y_03 Medicine Order</th>
<th>X_01 Delayed Processing of ticket</th>
<th>X_02 Different medical service time</th>
<th>X_03 Delayed processing of lab sample</th>
<th>X_04 Medicine demand</th>
<th>Xmr_01_Clinical Rotation of doctors</th>
<th>Xmr_02_Arrival Nature of patient at lab</th>
<th>Xmr_03 Pharmacy waiting time</th>
<th>Xmr_04 variable patient volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>12</td>
<td>19160</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Present</td>
<td>Initial Patient</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>9</td>
<td>24410</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Final patient</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>82</td>
<td>11</td>
<td>26500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Initial Patient</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>43</td>
<td>8</td>
<td>22610</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Final patient</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>119</td>
<td>12</td>
<td>18510</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Initial Patient</td>
<td>52</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>140</td>
<td>11</td>
<td>20280</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Final patient</td>
<td>62</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>110</td>
<td>13</td>
<td>22780</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Initial Patient</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>36</td>
<td>9</td>
<td>20550</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Final patient</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>9</td>
<td>57</td>
<td>10</td>
<td>20450</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Absent</td>
<td>Final patient</td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>10</td>
<td>76</td>
<td>11</td>
<td>19880</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Doctor Present</td>
<td>Initial Patient</td>
<td>41</td>
<td>12</td>
</tr>
</tbody>
</table>

### Results

1. The time spent by patients of different token are recorded.
2. The similar data records across different days and weeks are also collected

### Interpretation and implication
### Results of the MEASURE-Steering

<table>
<thead>
<tr>
<th>Measure-Steering</th>
<th>Proceed to next-Phase</th>
<th>Remarks</th>
<th>Date</th>
<th>Contact/ Verification-ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master-Black-Belt</td>
<td>yes</td>
<td>Hello Tony, A clear GO to ANALYSE. Please collect as much as data as possible, suggested in the Data-Collection-Plan. This can be laborious, but it is necessary for a successful continuation of your project.</td>
<td>27.9.2019</td>
<td><a href="mailto:reiner.hutwelker@softlogik.de">reiner.hutwelker@softlogik.de</a></td>
</tr>
<tr>
<td>Sponsor</td>
<td>yes</td>
<td>The data collection plan are found to be feasible and satisfied with the current plan for data collection. The concept of initial patient and final patient needs some amount of clarity. So suggesting for more data collection in that area.</td>
<td>2.10.2019</td>
<td></td>
</tr>
</tbody>
</table>

**Only proceed to the next phase after a positive decision of MBB and Sponsor**
Analyse

Data Evaluation, Process Performance, Test of Hypotheses, Root Cause Analysis
The graphical summary of Y_01 patient length of stay

The graphical summary of the patient’s length of stay in the hospital shows that it does not follow a normal distribution and the general trend in data is evident from the time series plot.

Interpretation and implication

1. The A square value equals 1.43 and p value less than 0.05. Thus, by rejecting the null hypothesis and concluded that data does not follow normal distribution.
2. The non zero skewness value indicate the non symmetric nature of distribution.
3. The skewness is increased by the bi-modal distribution, probably due to a special cause
4. The 75% of the data is less than or equal to 171.25 and hence larger value above 200 occurs less frequently.

Results

The graphical summary indicates that

1. The histogram shows the distribution of data and it follows a bimodal pattern – one reason that the normality test indicate a significant deviation.
2. The test gives 95% confidence interval range for mean, median and mode.
3. The time series plot shows the variation of length of stay across the mean and shows a high deviation.
4. The box plot displays the distribution of data based on minimum,median and maximum value of patient’s length of stay.
Mean and standard deviation Multivariate Chart of patient’s length of stay based on disease & clinical rotation

Interpretation and implication
1. The Multivariate chart shows how the clinical rotation of the doctor and the type of the disease affect the length of stay of patients in the hospital.
2. The condition of absence of doctors at consultation increases the length of stay of patients in the hospital and is higher in diabetic patients.
3. The length of stay is highest for diabetic patient and lower for hypertension patients.

Results
1. The Multi-Vari Chart shows the variation of the:
   - Y Patient length of Stay related to the different levels of the variables:
     - x1-The type of patient’s disease.
     - x2-The clinical rotation of doctor.
2. The length of stay for diabetic patients is under both doctor rotation conditions (x2) higher than for all other conditions.
3. The cholesterol patients show an appreciable variation in standard deviation in length of stay when considering the effect of clinical rotation.
Normal Distribution process capability & I-MR chart analysis

Interpretation and implication
1. The Ppk value shows how well the process is centred about the upper specification limit of 150 minutes.
2. The process performance here shows that hospital current operations are not satisfactory.
3. Because the data is not normally distributed, also the Binomial Capability Analysis is calculated. For this, the cardinal scaled data need to recoded to nominal scaled data.

Results
1. The Ppk, % Out of spec and DPMO indicate the process performance.
2. Ppk= 0.16, corresponding to a Z.Bench= 0.47 (Sigma-Level).
3. These indicators are equivalent to 32.01% of the data falling outside the specific limits.
4. However, the normality test failed (data on length of stay of patient in the hospital is not normally distributed) and thus the interpretation of the results are under reservation.

The process capability shows that almost 32% of patient’s length of stay in hospital exceeds the upper specific limit of 150 minutes and since it is not normally distributed, the binomial capability analysis is needed to be done.
Binomial process capability analysis of patient’s length of stay in hospital

Interpretation and implication
1. The binomial capability analysis is carried out because the data does not follow a normal distribution. Thus we recode the length of stay data with: 0 data lies within the limit of 150 minutes and 1 when data lies outside the specific limit of 150.
2. The current performance level is that 69% of patient’s length of stay is below or equal to 150 minutes and that means a poor performance compared to our target of 99% population to be within that limit.

Results
1. The binomial capability analysis of the given data set is carried out with a sub group size of 1 and the P chart shows the proportion of non conforming units for each sub group.
2. The process capability measures 30.95% defects with a confidence interval from 17.62 to 47.09%
3. This corresponds to 309524 parts per million defects.
4. The process z is found to be 0.5 indicating a low Sigma Level.

Binomial capability analysis shows, that 31% of the patient’s length of stay in the hospital falls above the specification limit of 150 minutes
Mood’s median test on type of patient ticket’s impact on length of stay patients in hospital

<table>
<thead>
<tr>
<th>Risk</th>
<th>Y_01: Output: Patient (medical treatment) [ Degree of: Time (Minutes) ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>39.99%</td>
<td>There is no difference in the degree of: Y_01: Output: Patient (medical treatment) [ Degree of: Time (Minutes) ] between the Levels of: x_01: Input: Patient (Information) [ Levels of: Ticket nature (New ticket/Old Ticket) ].</td>
</tr>
</tbody>
</table>

Interpretation and implication
1. The difference in length of stay of new ticket patients and old ticket patients are neither statistically significant nor practically relevant (2-3 minutes difference).
2. It can be concluded that the type of ticket plays a negligible role in the overall length of stay of patients in the hospital.

Results
1. The Mood’s median test is a nonparametric test that is used to test the equality of medians from two or more populations.
2. The p = 0.758 and it is greater than the specified alpha criterion of 0.05, which confirms the null hypothesis.
3. The 95% confidence intervals (CI) of the Median indicate the same range for both patient types.
4. The Medians for the length of stay differ by 2 minutes between new and old patients.
5. The boxplot diagram shows this small difference and the similar variation of the length of stay based on median.
Mood's median test on clinical rotation’s impact on length of stay of patient in hospital

<table>
<thead>
<tr>
<th>Risk</th>
<th>Y_01: Output: Patient (medical treatment)</th>
<th>Degree of: Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.14%</td>
<td>There is no difference in the degree of Y_01: Output: Patient (medical treatment) (degree of Time (Minutes)) between the Levels of: SPL_03: Activity: Consult the patient</td>
<td>Levels of: Doctor number: Doctor present/Doctor absent</td>
</tr>
</tbody>
</table>

Results

1. The Medians for length of stay differ by 17 minutes when one doctor go for clinical rotation or attending the emergency case.
2. This difference is statistically not significant (p= 0.757), thus confirming the Null Hypothesis.

Interpretation and implication

1. The difference in length of stay of patient based on clinical rotation of doctor is not statistically significant. Although the median under the condition: Doctor absent is 17 minutes longer, the high variability in the length of stay and the small sample size probably camouflages this difference.
2. Especially for the condition: Doctor absent, we should investigate its causes, to reduce the variability.

Although the result is not significant, we should investigate the root causes for the increased and variable length of stay, if the Doctor is absent
**Mood’s median test on type of patient’s disease**

### Results

1. The Medians for length of stay differ by 78 minutes between creatin patient (lowest LOS) and diabetic patient (highest LOS).

2. This result is statistically significant (p = 0.011).

3. The 95% confidence intervals (CI) of the Median indicate different ranges for the four types of disease, with the highest variability for Diabetes and the lowest variability for Hypertension.

4. The boxplot diagram indicates these contrasts in length of stay between Diabetes and the three other diseases, concerning the length of stay in the hospital.

### Interpretation and implication

1. The difference in length of stay based on type of disease is statistically significant as well as practically relevant. A diabetic patient spends one hour or more to get a treatment comparing to a creatin patient.

2. The type of disease thus seriously influences the length of stay of patients in hospital.

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©reiner.hutwelker@sigmaLogic.de Six Sigma Project-Story-Book for: Tony V Raju (E-tonyoct97@gmail.com)
Hypothesis: There is a difference in: the variability of the length of stay (Y) between the states of clinical rotation (x)

Interpretation and implication
1. The p value equals 0.008 and is less than the alpha criterion of 0.05 and hence we can reject the hypothesis that variance are equal and can be concluded that clinical rotation of doctor results in a higher variance on length of stay of patients in hospital.
2. When 4 doctors are present in the consultation room the standard deviation is found to be 28.46 but when one doctor goes for clinical rotation it increases the standard deviation of patient’s length of stay to 47.372.
3. This variation in the length of stay, depending on clinical rotation, will be included in the root-cause-analysis, to adjust this effect on our patients.

The variance of the length of stay of patients in hospital is affected by the clinical rotation of doctors in hospital.
## Analysis strategy: Combined Disease type and Clinical rotation

### Root Cause Analysis by Hierarchy Tree

<table>
<thead>
<tr>
<th>Problem</th>
<th>Length of stay of patient high (LOS) (Y1a)</th>
<th>Difference Hypothesis Y1a ≠ Y1b (Test: mood median test) Effect of clinical rotation of doctor</th>
<th>Length of stay of patient high (LOS) (Y1b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem-Focus</strong></td>
<td>LOS during clinical rotation high (Y1a)</td>
<td>Difference Hypothesis Y1a ≠ Y1b (Test: mood median test)</td>
<td>LOS during normal consultation high (Y1b)</td>
</tr>
<tr>
<td><strong>1. Cause-Level</strong> <em>(Causation by trigger)</em></td>
<td>Different disease have different LOS (x1)</td>
<td>Pharmacists take time to deliver medicine (x1.2.3.2)</td>
<td>Variation in the arrival rate of different type of medicines (x1.2.3.3)</td>
</tr>
<tr>
<td><strong>2. Cause-Level</strong> <em>(intermediate causation)</em></td>
<td>Non-Diabetic patients have lower LOS compared to Diabetic (x1.1)</td>
<td>Diabetic patients have higher LOS (x1.2)</td>
<td>Variation in consultation time (x1.2.1)</td>
</tr>
<tr>
<td><strong>3. Cause-Level</strong> <em>(intermediate causation)</em></td>
<td>Delayed laboratory results (x1.2.2)</td>
<td>Delayed medicine delivery (x1.2.3.1)</td>
<td>Delayed laboratory sampling (x1.2.2.1)</td>
</tr>
<tr>
<td><strong>4. Cause-Level</strong> <em>(intermediate causation)</em></td>
<td>Variation in the arrival rate of patient (x1.2.2.2)</td>
<td>Quick change over of different type of medicines (x1.2.3.3)</td>
<td>Variation in consultation time (x1.2.1)</td>
</tr>
<tr>
<td><strong>5. Cause-Level</strong> <em>(Causation by root cause)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Results

1. The root cause analysis is carried out to find the cause behind the higher length of stay of patients in the hospital through statistical results and expert reasoning.

2. Due to the practical relevance of clinical rotation, it is better to focus on patients who were consulted when one doctor out of four went for clinical rotation.

3. The type of disease patient has also played an important role in the patient’s length of stay. The higher length of stay for diabetic patients is evident from the mood median test and is practically relevant.

4. The reason for the higher length of stay for diabetic patients was found through analysing each process like consultation, laboratory test, and the pharmacy operations.

The main causes, that will serve as interfaces for solutions are: delayed laboratory operation and variation in arrival rate of patients.
Analysis strategy: Combined Disease type and Clinical rotation

Interpretation and implication

1. From the root cause analysis, it is evident that it is better to focus on the diabetic patients and the impact of clinical rotation on length of stay of patients in the hospital in the improvement phase.

2. In diabetic patient’s process flow, it can be observed that consultation, laboratory test, and pharmacy play the most critical role and improvement is need to be done on this process.

3. In consultation, the time taken by the doctor depends on his treatment method, type of disease, situation, etc. which can’t be controlled.

4. In laboratory operation, delayed results are a result of delayed processing of patient samples. The delayed processing of patient samples is because of variation in the arrival rate of patient to laboratory and thus it becomes difficult for lab technicians to handle multiple different operations at the same time. However, the schedule and timing of the laboratory could be adapted to reduce the effect of the variation in arrival rate.

5. In Pharmacy, medicine delivery took a long time and is because pharmacists can’t handle the changeover in medicine requirements. To deliver a medicine pharmacist has to check the inventory level, take the medicine from the store and then update the inventory level in software. The pharmacy offers two queues for males and female and it is found that pharmacists take less time to process the medicine requirement of similar disease patient than different patients.

The main causes, that will serve as interfaces for solutions are: delayed medicine delivery and change over in type of medicine.
Root cause analysis of low number of patient’s lab report was done based on statistical results & expert reasoning
Root Cause Analysis by Hierarchy Tree

<table>
<thead>
<tr>
<th>Problem</th>
<th>Root Cause Analysis by Hierarchy Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem</strong></td>
<td>Low number of patient lab report (Y2)</td>
</tr>
<tr>
<td><strong>Problem-Focus</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1. Cause-Level</strong></td>
<td>Critical process like serum separation and reagent addition require more time (x1)</td>
</tr>
<tr>
<td><strong>2. Cause-Level</strong></td>
<td>Lab technician has to handle upcoming patient sampling requirements in parallel (x2)</td>
</tr>
<tr>
<td><strong>3. Cause-Level</strong></td>
<td>Variation in arrival rate of patient to the laboratory (x3)</td>
</tr>
<tr>
<td><strong>4. Cause-Level</strong></td>
<td>Consultation time of different diabetic patient are different (x4)</td>
</tr>
</tbody>
</table>

**Analysis strategy: Low number of patient laboratory report**

1. The root cause analysis is carried out to find the cause behind lower number of patient lab report in the hospital through statistical results and expert reasoning.
2. From the mood median test, the laboratory sampling time is highest for diabetic patient and it is better to focus on diabetic laboratory operations.
3. In the sample processing, serum separation and reagent addition require more time and found that these critical process can explain 51% (R-square value of regression analysis) of the no of lab report produced.
4. These critical process are delayed because of variation in arrival time of patient and statistically speaking their R-square value equals 19% but still, they play a critical role in delaying the process (based on opinion from the technician).

**Results**

The main causes, that will serve as interfaces for solutions is: delay in critical process of diabetes test.
Analysis strategy: Combined Disease type and Clinical rotation

Interpretation and implication

1. From the root cause analysis, it is evident that it is better to focus on the diabetic patient’s lab sample processing, but the same improvement can be applied for cholesterol patients too as they follow a common methodology but vary in type of reagent and time for processing.

2. In diabetic patient’s sample processing the most critical areas are serum separation and reagent addition and focus is need to be on reducing error and improving its cycle time.

3. When a lab technician handles one sample, he needs to focus on it but because of the different arrival times of the patient, she/he has to handle other patient requests also and thus delay the process.

4. The different arrival time of the patient is because of diabetic patients are consulted by the doctor in different time as he has to handle other patient along with it.

The main causes, that will serve as interfaces for solutions is: delay in laboratory sampling.
## Results of the ANALYSE-Steering

<table>
<thead>
<tr>
<th>Analyse-Steering</th>
<th>Proceed to next-Phase</th>
<th>Remarks</th>
<th>Date</th>
<th>Contact/ Verification-ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Reiner Hutwelker</td>
<td>yes</td>
<td>Hello Tony, Also your results on the ANALYSE phase fulfill all our requirements. Here is my clear GO to IMPROVE. Please again present these results to your Sponsor to get the GO from your hospital.</td>
<td>26.11.2019</td>
<td><a href="mailto:reiner.hutwelker@softlogik.de">reiner.hutwelker@softlogik.de</a></td>
</tr>
<tr>
<td>Sponsor</td>
<td>yes</td>
<td>The progress are satisfactory and root cause analysis found reasonable. The improvement areas are effectively found.</td>
<td>27.11.2019</td>
<td></td>
</tr>
</tbody>
</table>

*Only proceed to the next phase after a positive decision of MBB and Sponsor*
IMPROVE

Development and selection of Solutions, Measures and risk prevention, Implementation
The improvement solutions based on root causes & effort-benefit analysis

Results

1. The main root cause behind the higher length of stay in laboratory and pharmacy are the variation in arrival rate of patients and higher processing time for pharmacist to deliver medicines respectively.

2. The disease-specific priority can reduce the time interval between diabetic patients.

3. The NCD department within pharmacy can reduce the length of stay in pharmacy.

Interpretation and implication

1. The Effort X Benefit diagram is plotted based on financial and feasibility analysis.

2. The disease specific priority requires less effort and more benefit than implementing NCD department in the pharmacy, but both are equally possible and feasible.
Results

1. The disease specific priority can be implemented by introducing a specialised doctor in consultation and using NCD specific ticket.
2. The implementation of NCD can be achieved by an effective 5S implementation in pharmacy and by employing a particular pharmacist for NCD.
3. Based on FMEA analysis, the practical modification for the solutions are effectively identified.
4. The proposed result is a continuous smooth operation of laboratory and quick processing of pharmacy.

The action plan for specialised doctor and NCD ticket counter were developed by considering all the constrain.
The interpretation of the proposed improve action plan

Interpretation and implication

1. The concept of specialised doctor will help in reducing the time interval between the diabetic patients and thus it will reduce the variation in arrival time of patient to laboratory.

2. NCD specific ticket can improve communication and also reduce the consultation time without compromising quality.

3. Specific department for NCD in pharmacy will reduce the processing time for pharmacist and long waiting time for NCD patient after laboratory.

4. 5S practice can improve the visual management of pharmacy as a whole.
FMEA analysis of the proposed solutions

<table>
<thead>
<tr>
<th>Measure</th>
<th>Measure (What has to be done?)</th>
<th>actual controls to detect the failures/problems</th>
<th>potential effects of the failures/problems</th>
<th>potential causes of the failure/problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Laboratory operation should start only when the number of diabetic patients in the laboratory reach a particular number say 10</td>
<td>By which existing controls can the failure/problem be detected, before it occurs?</td>
<td>Which effect results from the failure/problem?</td>
<td>Which influence triggers the failure/problem?</td>
</tr>
<tr>
<td>2.</td>
<td>The Consultation department can reduce the time interval between diabetic patients by employing a good number of doctors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>1 out of 4 doctors should be exclusively for diabetic patients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Employ new HCD specific ticket for better communication and quick services</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. The resistance of patients for giving a preference to diabetic patients should be taken care of seriously. The specialised doctor should be implemented in a fair manner. The difficulty in implementing 5S & shortage of pharmacist also should be taken care.

Results

1. The RPN refers to risk priority number and is estimated based on detection of the problem, severity of the effect and probability of the cause. The RPN value is high for both improvement solutions in laboratory and pharmacy. The risk factor can be reduced by considering the following.

2. The resistance of patient for giving a preference to diabetic patient should be considered seriously. The specialised doctor should be implemented in a fair manner. The difficulty in implementing 5S & shortage of pharmacist also should be taken care.

Based on FMEA the “Risk Priority Number” of the current solutions are computed and then modified the solutions
The interpretation of the proposed improve action plan

**Interpretation and implication**

1. The project trial and implementation on only some particular days can convince the people.
2. The specialised doctor can be implemented on a rotational basis. Thus the NCD specialised doctor should change day by day.
3. The disease specific queue in pharmacy can be implemented on peak time if pharmacist shortage exists.

The proposed solution modified based on constrains and stakeholder’s opinion
### The financial and other benefits of the proposed solutions

#### Interpretation and implication

1. Most of the benefits can’t be quantified into financial terms but still in long term it helps to improve the overall service offered by the hospital.

2. The key performance index should be mostly evaluated based on the reduction in waiting time, processing time as well as adaptation of people to improved ecosystem.

#### Results

1. The cost is estimated based on average money spend by hospital to improve the physical infrastructure and service cost of different stakeholders involved in it.

2. The lower length of stay is the main benefit but at the same time it can reduce the work stress of the pharmacist, technician as well as doctors.

### The project benefits hospital around 800€ yearly savings and helps laboratory technician and pharmacist to reduce work stress
NCD-specific ticket design

Results

1. The present ticket does not differentiate between communicable diseases and non-communicable diseases so it can reduce the quality of information.

2. The NCD specific ticket can provide better communication as well as it can reduce missing data.

3. NCD specific ticket has information regarding history of consultation, separate table for medicine consumption time and next date of consultation.

Old ticket layout

New ticket layout

New NCD specific ticket layout designed
In consultation one doctor should be made exclusively for diabetic patients and it should be on a rotational basis.

**Diabetic specific doctor**

Results

1. Specialised doctor is the concept in which 1 out of 4 doctors should consult only diabetic patients in a particular day and it should be implemented on a rotational basis.

2. It can reduce the variation in arrival time of diabetic patient to laboratory.

3. It can reduce the higher waiting time during clinical rotation and in emergency case.

A graphical illustration on the idea that 1 out of 4 should be assigned for diabetic patients.
**NCD specific ticket counter in pharmacy**

**Results**

1. The male vs female queue in pharmacy counter experience almost same waiting time and pharmacist experience no difference in time for delivering medicine.

2. The concept of special queue for diabetic patient can reduce the changeover time for different diseases.

3. It also helps to reduce the waiting time for the patient who came after long queue in laboratory.

*The proposed ticket counter helps to reduce the pharmacist processing time*
5S model in hospital pharmacy

Results

1. Separate medicine boxes for different diseases.
2. Effective storage of outdated and cancelled medicine.
3. Special NCD counter within pharmacy.
4. Special label for critical medicine.
5. Visual inventory check for medicine.
7. Ergonomic consideration for pharmacist

5S based medicine arrangement can improve the processing speed of pharmacist
Diabetic card for long term patients

Results

1. The diabetic patients maintain minimum 3 month to more than 1 year relationship with hospital so employing a permanent diabetic card can help to control the next date and time for consultation.

2. The diabetic card contain information regarding last and next date of consultation and about the quantity of medicine they purchased last time.

3. The card also give a quick overview about the history and type of diabetic patient has.
### Results of the IMPROVE-Steering

<table>
<thead>
<tr>
<th>Improve-Steering</th>
<th>Master-Black-Belt</th>
<th>Proceed to next-Phase</th>
<th>Remarks</th>
<th>Date</th>
<th>Contact/ Verification-ID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dr. Reiner Hutwelker</td>
<td>yes</td>
<td>Hello Tony, your results, interpretations and implications look plausible. The impulse to start an additional 5S initiative is convincing. I hope, that you will be able and allowed to implement the solutions.</td>
<td>6.1.2020</td>
<td><a href="mailto:reiner.hutwelker@softlogik.de">reiner.hutwelker@softlogik.de</a></td>
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</thead>
<tbody>
<tr>
<td>Dr Neetha Paul</td>
<td>yes</td>
<td>The improvement results are impressive and most of them are implemented on a trial basis. 5S implementation require time but separate diabetic counter implemented</td>
<td>10.01.2020</td>
<td></td>
</tr>
</tbody>
</table>

**Only proceed to the next phase after a positive decision of MBB and Sponsor**
CONTROL

Results

1. Pareto chart shows the disease-wise average length of stay and boxplot shows the overall reduction in length of stay of patients in the hospital.

2. The overall length of stay decreased from 139.31 minutes to 93.95 minutes.

3. The overall deviation in length of stay also decreased from 39.5 minutes to 22 minutes.

4. The highest length of stay also reduced from 232 minutes to 151 minutes, showing an improvement in diabetic patient’s length of stay, to be tested statistically.

Interpretation and Implication

1. Diabetic patient’s length of stay reduced by almost 36%, which is primarily due to improvement in pharmacy and laboratory.

2. After improvement second-highest length of stay changed from cholesterol to creatin patients.

After improvement the overall length of stay of patient in hospital decreased by 32%
The I-MR chart analysis of patient’s length of stay in hospital

Results

1. Individual value chart shows the course of all recorded length of stay values with horizontal lines representing the average and the upper (UCL) and the lower (LCL) control limits.

2. The highest recorded length of stay after improvement is 151 minutes which is less than the upper limit of 161.6 minutes. There are no signals in this chart, e.g. outliers.

3. In the moving range chart, the difference of adjacent values is mapped. The data point here refers to difference between successive length of stay values.

4. The MR chart can’t be interpreted in this case as it compares length of stay between different disease which is not practically logical.

Interpretation and implication

1. The I chart clearly shows the higher length of stay in diabetic patients and corresponding lower length of stay for other diseases.

2. The higher values in MR chart is because of the assumption that all length of stay are the same.

3. In MR chart difference of adjacent values is considered, meaning in our data to compare the length of stay of diabetic patient with hypertension patient. This information is useless to us.
Results

1. The length of stay data (Before/After improvement) fails the Anderson-darling test so the data deviate from the normal distribution.

2. The cardinal data is converted into binomial form based on the concept that patients whose length of stay is more than 150 minutes will be treated as a deviation.

3. The percentage defect reduced from 30.95 to 4.76%.

4. The process Z (= Z.bench) increased from 0.5 to 1.67.

5. The deviation after improvement is only reported for diabetic patients and for other disease the length of stay is within the specification. This was expected, because lab processing time of diabetics take time to get reduced and 5S practice is not completely intiated in pharmacy.

Interpretation and implication

1. The improvement causes a total reduction in length of stay from 139.31 to 93.95 minutes.

2. Out of 42 sample only 2 patient’s length of stay reached above 150 minutes.

3. The standard deviation also reduced from 39.56 to 22 minutes. This difference will be tested statistically with the F-Test (see below).
2-sample t test for the patient’s length of stay before and after improvement

**Results**

1. Statistical parameters for analysing patient’s length of stay before and after improvement are
   
   I. Before improvement: mean=139.31, SD=39.5
   
   II. After improvement: mean=93.93, SD=22

2. Difference between the average length of stay before and after improvement is 45.38 minutes which is statistically significant and practically relevant.

3. The interval diagram plots the difference between the mean and its confidence interval as well as the difference =0 for the H0

4. The two histograms show the distribution of the length of stay before and after improvement with their mean and the related confidence interval of the mean.

**Interpretation and implication**

1. After improvement 95% of the patient’s length of stay lies between 87 minutes to 101.5 minutes.

2. The distribution of length of stay also reduced considerably leading to a uniform length of stay for non-diabetic patients.

3. The reduction in standard deviation is primarily because of disease specific priority in pharmacy.

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The improvement resulted in reducing the length of stay of patient in hospital by almost 45 minutes
2-sample standard deviation test for the patient’s length of stay before and after improvement

Interpretation and implication

1. The reduction in length of stay for diabetic patient from 176 minutes to 112 minutes resulted in making their length of stay comparable to others. The disease specific priority in consultation and pharmacy resulted in reducing variation by 19 minutes.

2. If we can improve the uniformity of lab processing time, it can produce more reduction in variation of results. This can be achieved by training, implementing poke yoka and designing lab ecosystem based on ergonomics etc.

Results

1. The 2 sample standard deviation test clearly shows that standard deviation of patient’s length of stay before and after improvement differ significantly.

2. From the confidence interval the maximum expected deviation reduced from 50 minute to 29 minutes. The average deviation also reduced by 44%.

3. The reduction in length of stay above 200 minute for diabetic patient is the primary reason behind low deviation.

2 sample standard deviation test shows that standard deviation differ significantly after improvement
Process-Management-Plan

Interpretation and implication
1. Process management plan ensure the sustainability of the implemented measure by
   I. Monitor future performance with control chart
   II. Response to performance drop determined in reaction plan.

2. Control charts and maintenance of the plan are effectively implemented.

Results
1. The process management plan is a document for the process owner to monitor the process in future, identify new problem find their cause and solve them.
Reaction plan for the treatment of deviation

Results
1. Reaction plan was developed by considering feedback from stakeholders, feasibility and by analysing hospital operations.

Interpretation and implication
1. The deviations in the proposed plan are need to be identified correctly. Hospital stakeholders as well as patients have same role in it.
2. Deviation in laboratory and pharmacy should be given priority and feedback from pharmacist and lab technician should be taken seriously.
3. 5S checklist should be implemented in both laboratory and pharmacy.
4. Patient feedback form should be implemented and need to follow up.

Reaction plan developed based on feasibility and feedback from stakeholders
Interpretation and Implication

1. The financial benefit is calculated based on increase in number of patients after improvement. Pareto chart shows the disease wise increase in number of patients after improvement.

2. If the patients start utilising public healthcare instead of private hospital they can save ₹500 per visit. On an average it could deliver service worth ₹80000 monthly.
**Lessons learned in the course of the project**

<table>
<thead>
<tr>
<th>What I learned in the course of the project, concerning:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Subject matter/ Product:</strong> Hospital operations with principal focus on optimisation of cycle time in consultation, pharmacy and laboratory.</td>
</tr>
<tr>
<td><strong>2. Process:</strong> Process sequence of laboratory test for diabetics, cholesterol and then about inventory management of medicines in pharmacy.</td>
</tr>
<tr>
<td><strong>3. Methods/ Tools:</strong> Statistic methods like ANOVA, t-test, regression, pareto analysis, FMEA and softwares like minitab, anylogic etc</td>
</tr>
<tr>
<td><strong>4. People/ Teams:</strong> Doctors, pharmacist, lab technician, nurse and patients</td>
</tr>
<tr>
<td><strong>5. Management:</strong> KMCH (kerala medical community health) and its organisation and medicine distribution cycle etc.</td>
</tr>
<tr>
<td><strong>7. Company:</strong> CHC Sachivothampuram</td>
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</table>

**Potentials/ topics for further improvements:**

1. The current upper limit of length of stay of patient in hospital (150 minutes) can be reduced to 100 minutes in future with effective planning.
2. 6S can be implemented in laboratory for increasing the processing speed of laboratory technician.
3. Diabetic card can be computer generated which will produce more precise planning for arrival rate of NCD patients.
4. MRP can be implemented in pharmacy to autogenerate order when medicine level go below safety stock.

**Interpretation and implication**

1. The project gave a good insight about the opportunities and challenges in implementing six sigma in a service-oriented industry.
2. The Project is expected to deliver **additional medical service worth 1000 € per month** and thus it could indirectly benefit **more than 160 patients a month**.
3. The effective training of medical staff can reduce cycle time but adopting to that culture take time. MRP for medicine inventory and auto generate diabetic card can further improve the result significantly.
### Results of the CONTROL-Steering

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<tr>
<td>Dr. Reiner Hutwelker</td>
<td>yes</td>
<td>Dear Tony, you have completed your project with excellent results. You have shown mastery of all tools, can interpret the results and draw conclusions. You have also shown relationships to other management techniques that were not part of the course and thus integrated the new knowledge very well. Thus the requirements for your certification from our side are fulfilled. Congratulations, Reiner Hutwelker</td>
<td>4.3.2020</td>
<td><a href="mailto:reiner.hutwelker@softlogik.de">reiner.hutwelker@softlogik.de</a></td>
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<td>yes</td>
<td>to be filled in by the Sponsor (if you like then use the Sponsor-Checklist in sigmaGuide)</td>
<td>X.X.XXXX</td>
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<tr>
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**Only proceed to the next phase after a positive decision of MBB and Sponsor**
End of this Project-Story-Book

Six Sigma process improvement methods and tools