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Study of Lean Six Sigma Methodology on the OPD Services in a Tertiary Care Hospital Setting

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Abstract

Background: Outpatient departments (OPDs) serve as the first point of contact for patients in tertiary care hospitals. However, rising patient demand and complex workflows often result in inefficiencies, prolonged waiting times, and reduced satisfaction. Lean Six Sigma (LSS) has emerged as a systematic methodology to identify inefficiencies and optimize processes, but its application in Indian healthcare OPDs remains limited. **Objective:** This study aimed to evaluate the application of Lean Six Sigma methodology in identifying inefficiencies and optimizing OPD workflows within a tertiary care hospital. **Methods:** An observational cross-sectional study was conducted at the Central Referral Hospital, Gangtok, using the DMAIC framework of LSS. The Define, Measure, and Analyze phases were applied. Process mapping, value stream mapping, and time-motion analysis were conducted on OPD workflows. Pareto analysis and Fishbone (Ishikawa) analysis were employed to identify bottlenecks and root causes of delays. **Results:** A total of 59 process steps were identified across OPD services. Laboratory (50.33 min) and Radiology (52.01 min) contributed the longest average delays. Day-wise analysis revealed turnaround times ranging from 125 to 198 minutes per patient. Pareto analysis showed that Radiology (30%) and Laboratory (29%) accounted for nearly 59% of total defects. Fishbone analysis highlighted causes including inadequate staff training, redundant process steps, limited diagnostic equipment, and high patient volumes. **Conclusion:** The study demonstrated that Lean

Six Sigma is an effective framework for diagnosing inefficiencies in OPD services. While the Improve and Control phases were not implemented, the findings provide actionable insights for administrators to reduce delays and enhance patient flow. Future studies should integrate full DMAIC implementation across multiple sites to validate and sustain improvements.

Keywords: Lean Six Sigma; Healthcare quality improvement; Outpatient department; Process mapping; Value stream analysis; Patient waiting time; Hospital management; Operational efficiency

Introduction

In today's rapidly evolving healthcare landscape, ensuring efficient and high-quality services has become a priority for healthcare organizations worldwide. Tertiary care hospitals, in particular, face the challenge of managing large volumes of patients seeking outpatient department (OPD) services. The OPD functions as a critical gateway, providing initial consultations, diagnostic tests, and follow-up appointments. However, increasing patient demand and complex care processes often lead to operational inefficiencies, prolonged waiting times, reduced patient satisfaction, and potential compromises in quality of care (Gijo & Antony, 2014; Ruparel, 2018).

To address these challenges, many healthcare organizations have adopted Lean Six Sigma (LSS), a methodology rooted in continuous improvement, waste reduction, and variation control. Lean focuses on eliminating non–value-added activities and streamlining processes, while Six Sigma emphasizes reducing variability and defects in service delivery (Munro et al., 2008). The integration of these approaches has shown promise in improving healthcare quality, efficiency, and patient outcomes (Van den Heuvel, Does, & de Koning, 2006).

While the application of Lean Six Sigma has been extensively explored in manufacturing and service industries, its utilization in healthcare—especially in OPD settings of Indian tertiary hospitals—remains relatively limited (Suman & Prajapati, 2021). Previous studies have demonstrated its effectiveness in reducing waiting times, improving registration processes, and enhancing diagnostic workflows (Bhat, Gijo, & Jnanesh, 2014; Kam et al., 2021). However, contextual challenges such as resource constraints, workforce limitations, and inadequate process standardization hinder widespread adoption in Indian hospitals (Yaduvanshi & Sharma, 2017).

The present study seeks to bridge this gap by evaluating the application of Lean Six Sigma in optimizing OPD services within a tertiary care teaching hospital in Gangtok. Specifically, it aims to:

1. Identify value-added and non–value-added steps in OPD workflows.
2. Measure average time spent across different service areas.
3. Analyze bottlenecks and root causes using Lean Six Sigma tools.

By systematically mapping OPD processes and applying the DMAIC framework (Define, Measure, Analyze, Improve, Control), this study contributes to the evidence base on healthcare

process improvement. The findings are expected to offer actionable insights for hospital administrators and policymakers, with implications for enhancing efficiency, reducing patient waiting times, and improving overall patient satisfaction in tertiary care OPD settings.

In summary, this study investigates the application of Lean Six Sigma in optimizing OPD services within a tertiary care hospital. Through a comprehensive analysis of processes, performance indicators, and associated challenges, it aims to generate practical recommendations for enhancing efficiency, quality, and patient satisfaction. Ultimately, the research contributes to the broader goal of continuous improvement and innovation in healthcare delivery.

Methods

Study Design:

This was an observational, cross-sectional study conducted using the Lean Six Sigma (LSS) methodology, specifically the DMAIC framework (Define, Measure, Analyze, Improve, Control). For the scope of this study, the Define, Measure, and Analyze phases were applied to assess process inefficiencies within OPD services.

Setting:

The study was conducted at the Central Referral Hospital (CRH), Gangtok, a 550-bedded tertiary care teaching hospital affiliated with Sikkim Manipal University. The hospital offers multiple general and super-specialty services, including a structured OPD that serves as the primary access point for patient consultations and diagnostic services. The study duration was four months.

Study Population and Criteria:

The study population included patients availing services from the OPD.

- **Inclusion criteria:** New registration patients and re-registration patients attending the OPD.
- **Exclusion criteria:** Inpatients and patients attending the emergency department.

Data Collection:

Data were collected through direct observation of patient workflows from the point of arrival at the hospital to completion of services at the pharmacy. A structured checklist was used to record each step of the OPD process. The average time taken by six patients across different OPD service points was documented to establish baseline process performance.

The observed process steps were classified into three categories:

1. **Value-added activities** – activities directly contributing to patient care.
2. **Operational activities** – supportive functions essential for process flow.

3. **Non–value-added activities** – redundant steps that do not contribute to patient outcomes.

Data Analysis:

The **Define phase** involved process mapping and development of a value stream map to capture the flow of activities.
The **Measure phase** included time-motion analysis, with average time per activity calculated.
The **Analyze phase** applied two quality tools:

- **Pareto analysis** to prioritize defect-prone areas contributing to delays.
- **Fishbone (Ishikawa) analysis** to identify root causes of inefficiencies, categorized under People, Process, Equipment, Materials, and Environment.

Statistical summaries (means, percentages) were used to interpret process delays across different service areas (registration, OPD, laboratory, radiology, and pharmacy).

Ethical Considerations:

Ethical approval was obtained from the Institutional Ethics Committee of Sikkim Manipal University. Informed consent was taken from patients prior to observation. Anonymity and confidentiality of patient information were strictly maintained throughout the study.

Results

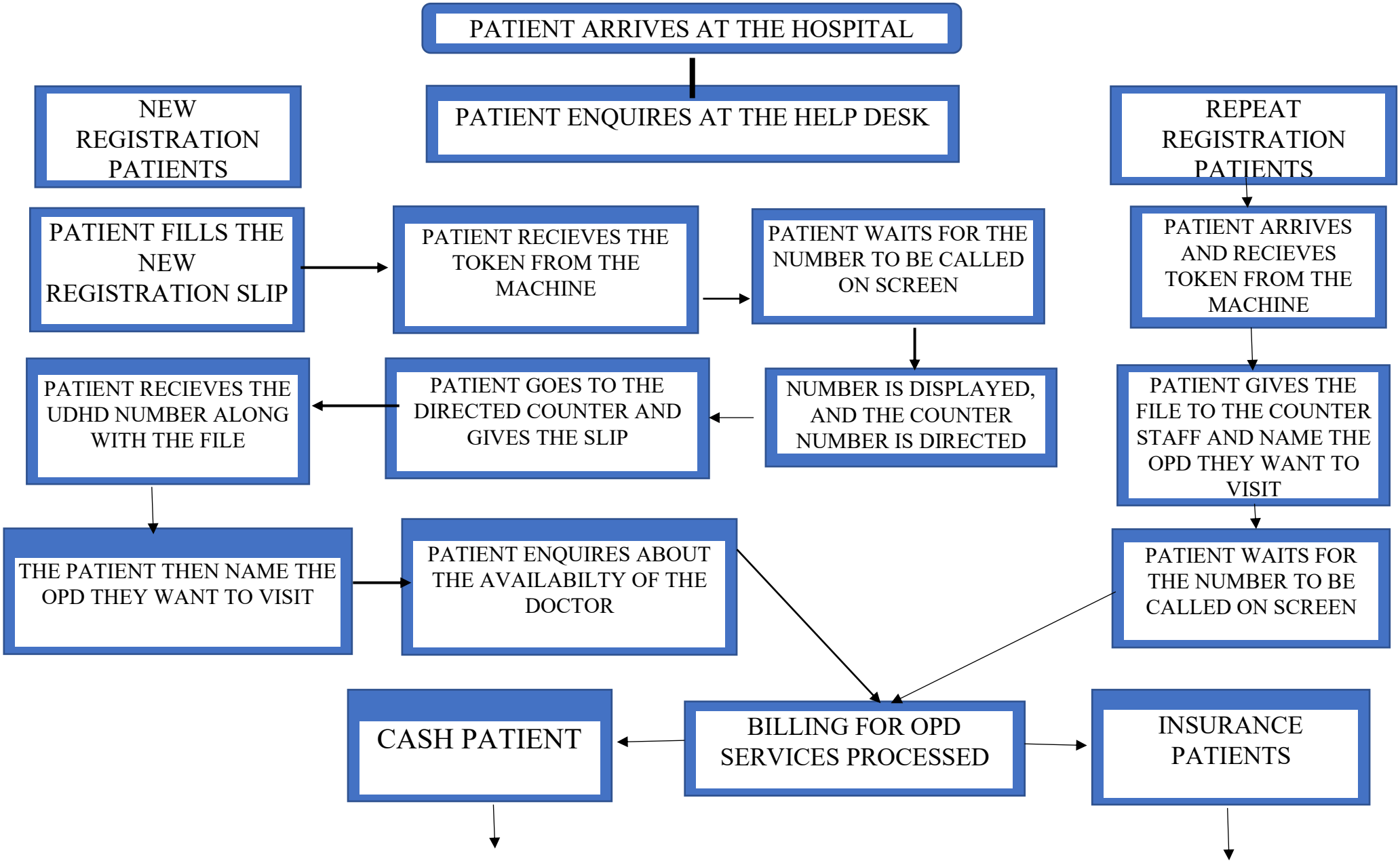
Overview:

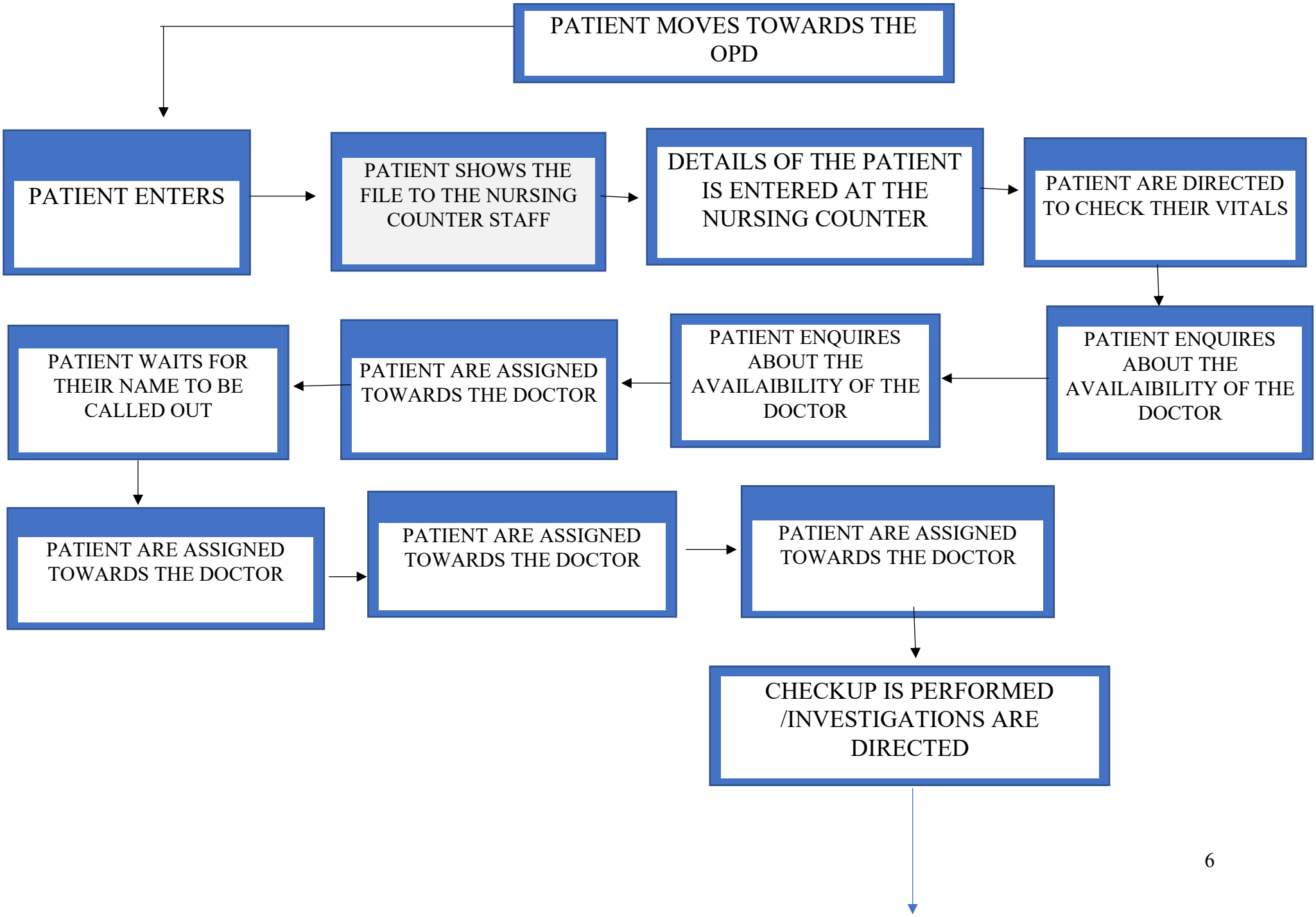
The study analyzed outpatient department (OPD) workflows using the Lean Six Sigma DMAIC framework (Define, Measure, Analyze). A total of **59** process steps were identified, which were further classified into value-added, operational, and non–value-added activities. Time-motion data were collected from six patients across different service areas, and performance bottlenecks were analyzed using value stream mapping, Pareto analysis, and fishbone analysis.

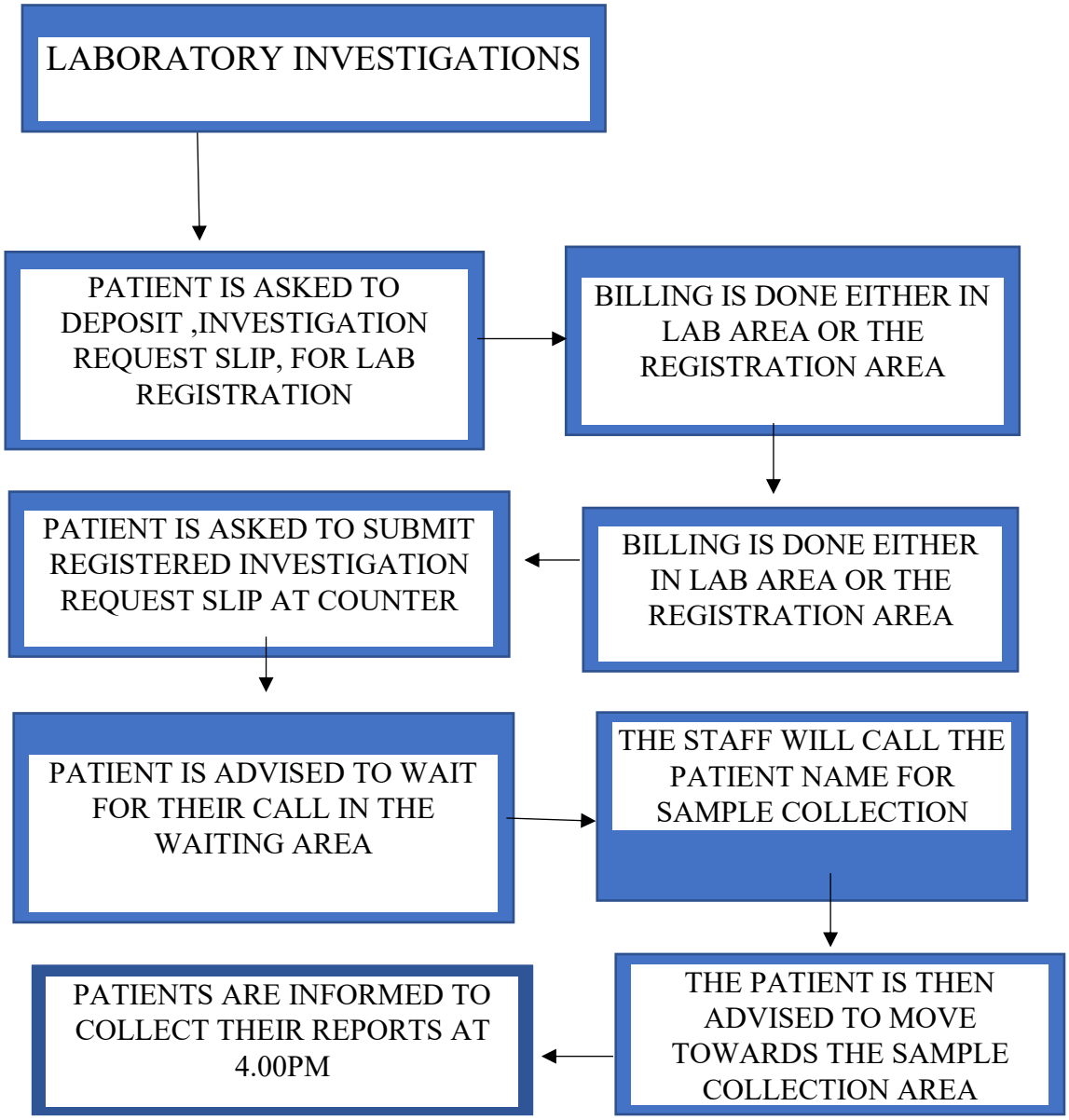
Define Phase

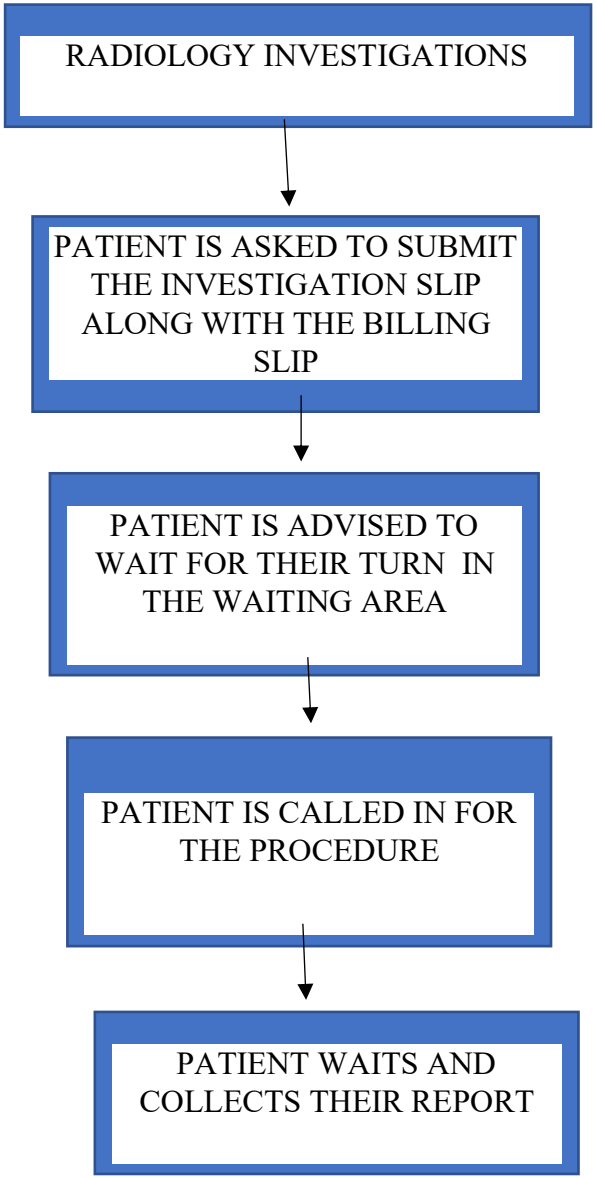
The overall OPD process was mapped from registration to pharmacy services.

- Five key service points were identified: Registration, OPD consultation, Laboratory, Radiology, and Pharmacy.
- Both new and repeat registrations were included.


PATIENT ARRIVES AT THE HOSPITAL
PATIENT ENQUIRES AT THE HELP DESK
NEW REGISTRATION PATIENTS
REPEAT REGISTRATION PATIENTS
PATIENT FILLS THE NEW REGISTRATION SLIP
PATIENT RECIEVES THE TOKEN FROM THE MACHINE
PATIENT WAITS FOR THE NUMBER TO BE CALLED ON SCREEN
PATIENT ARRIVES AND RECIEVES TOKEN FROM THE MACHINE
PATIENT RECIEVES THE UDHD NUMBER ALONG WITH THE FILE
PATIENT GOES TO THE DIRECTED COUNTER AND GIVES THE SLIP
NUMBER IS DISPLAYED, AND THE COUNTER NUMBER IS DIRECTED
PATIENT GIVES THE FILE TO THE COUNTER STAFF AND NAME THE OPD THEY WANT TO VISIT
THE PATIENT THEN NAME THE OPD THEY WANT TO VISIT
PATIENT ENQUIRES ABOUT THE AVAILABILTY OF THE DOCTOR
PATIENT WAITS FOR THE NUMBER TO BE CALLED ON SCREEN
CASH PATIENT
BILLING FOR OPD SERVICES PROCESSED
INSURANCE PATIENTS


PATIENT MOVES TOWARDS THE OPD
PATIENT ENTERS
PATIENT SHOWS THE FILE TO THE NURSING COUNTER STAFF
DETAILS OF THE PATIENT IS ENTERED AT THE NURSING COUNTER
PATIENT ARE DIRECTED TO CHECK THEIR VITALS
PATIENT ENQUIRES ABOUT THE AVAILAIBILITY OF THE DOCTOR
PATIENT ENQUIRES ABOUT THE AVAILAIBILITY OF THE DOCTOR
PATIENT ARE ASSIGNED TOWARDS THE DOCTOR
PATIENT WAITS FOR THEIR NAME TO BE CALLED OUT
PATIENT ARE ASSIGNED TOWARDS THE DOCTOR
PATIENT ARE ASSIGNED TOWARDS THE DOCTOR
PATIENT ARE ASSIGNED TOWARDS THE DOCTOR
CHECKUP IS PERFORMED /INVESTIGATIONS ARE DIRECTED


LABORATORY INVESTIGATIONS
PATIENT IS ASKED TO DEPOSIT ,INVESTIGATION REQUEST SLIP, FOR LAB REGISTRATION
BILLING IS DONE EITHER IN LAB AREA OR THE REGISTRATION AREA
PATIENT IS ASKED TO SUBMIT REGISTERED INVESTIGATION REQUEST SLIP AT COUNTER
BILLING IS DONE EITHER IN LAB AREA OR THE REGISTRATION AREA
PATIENT IS ADVISED TO WAIT FOR THEIR CALL IN THE WAITING AREA
THE STAFF WILL CALL THE PATIENT NAME FOR SAMPLE COLLECTION
PATIENTS ARE INFORMED TO COLLECT THEIR REPORTS AT 4.00PM
THE PATIENT IS THEN ADVISED TO MOVE TOWARDS THE SAMPLE COLLECTION AREA


RADIOLOGY INVESTIGATIONS
PATIENT IS ASKED TO SUBMIT THE INVESTIGATION SLIP ALONG WITH THE BILLING SLIP
PATIENT IS ADVISED TO WAIT FOR THEIR TURN IN THE WAITING AREA
PATIENT IS CALLED IN FOR THE PROCEDURE
PATIENT WAITS AND COLLECTS THEIR REPORT

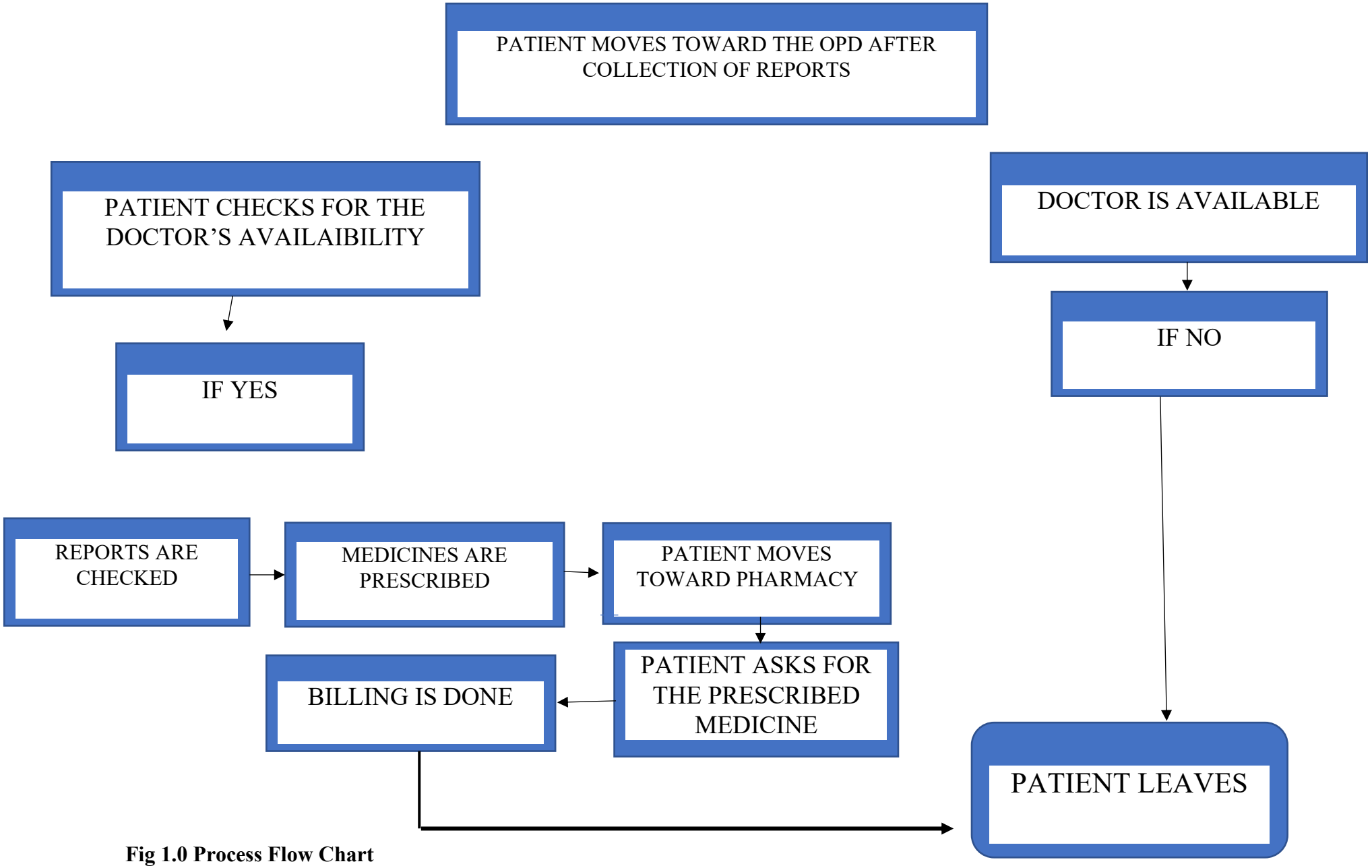


Fig 1.0 Process Flow Chart

Measure Phase

The process was broken down into value-added, operational, and non–value-added steps.

- A total of **59 steps** were required for availing OPD services.
- Non–value-added steps were most prominent in radiology and laboratory services.

	AREA	REGISTRATION TYPE	VALUE ADDED ACTIVITY	OPERATIONAL ACTIVITY	NON-VALUE ADDED ACTIVITY
1	REGISTATION COUNTER				
		NEW REGISTRATION	5	9	1
		REPEAT REGISTRATION	3	6	1
2	OPD AREA		3	5	1
3	LAB AREA		4	4	2
4	RADIOLOGY AREA		1	3	2
5	OPD& PHARMA		3	4	1
	Tot Steps Required for availing OPD services= 59 steps				

Table 1.1 Current State Value Stream Mapping

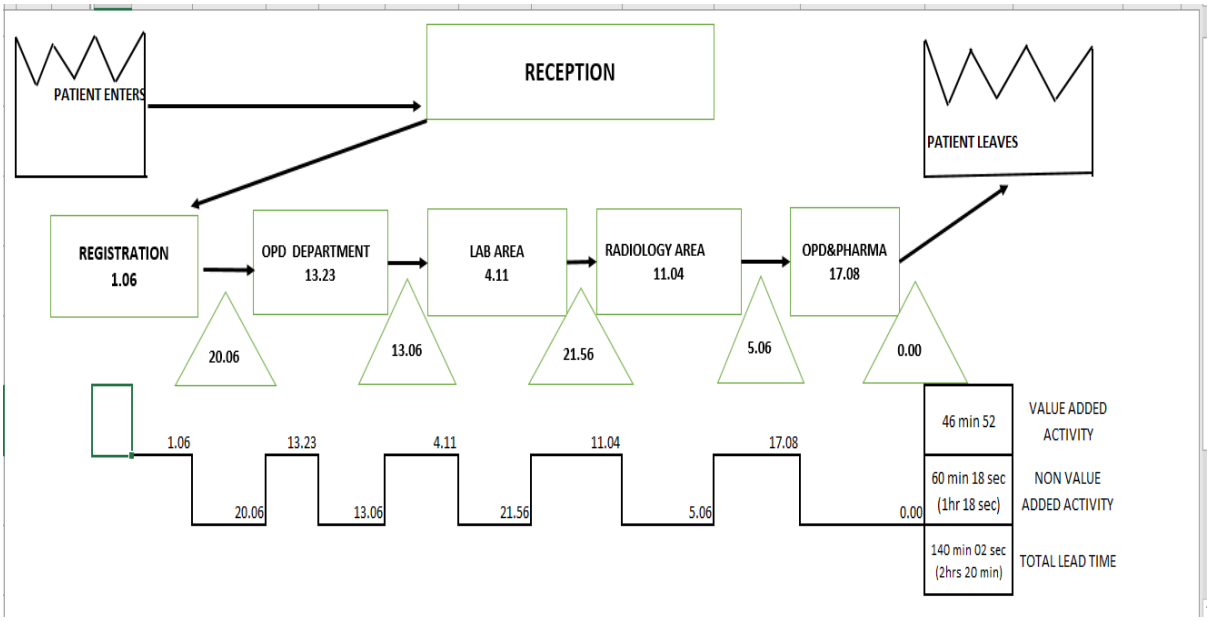


Fig 1.2 Value stream mapping of the entire OPD services

Time-Motion Analysis

The average time taken across service areas was:

- Registration: **22.31 min**
- OPD Consultation: **25.82 min**
- Laboratory: **50.33 min**
- Radiology: **52.01 min**
- Pharmacy: **22.27 min**

AREA	AVERAGE TIME TAKEN
REGISTRATION AREA	22.31
OPD AREA	25.82
LABORATORY AREA	50.33
RADIOLOGY AREA	52.01
OPD&PHARMA	22.27

Table 1.2: Average Time Taken by Service Area

Day-wise variation showed the highest total turnaround time on Tuesday (197.53 min) and the lowest on Saturday (125.59 min).

DAYS	REGISTRATION AREA	OPD AREA	LABORATORY AREA	RADIOLOGY AREA	OPD&PHARMA	TOT TIME TAKEN
MONDAY	26.54	17.10	42.92	34.98	28.72	150.26
TUESDAY	13.96	27.13	99.42	34.98	22.04	197.53
WEDNESDAY	25.31	25.08	47.44	30.16	23.52	151.51
THURSDAY	13.37	31.03	41.95	53.80	24.6	164.75
FRIDAY	16.71	20.52	62.70	50.50	18.19	168.62
SATURDAY	9.45	25.54	41.38	41.01	8.21	125.59

Table 1.3: Day-wise Average Time Taken for OPD Services

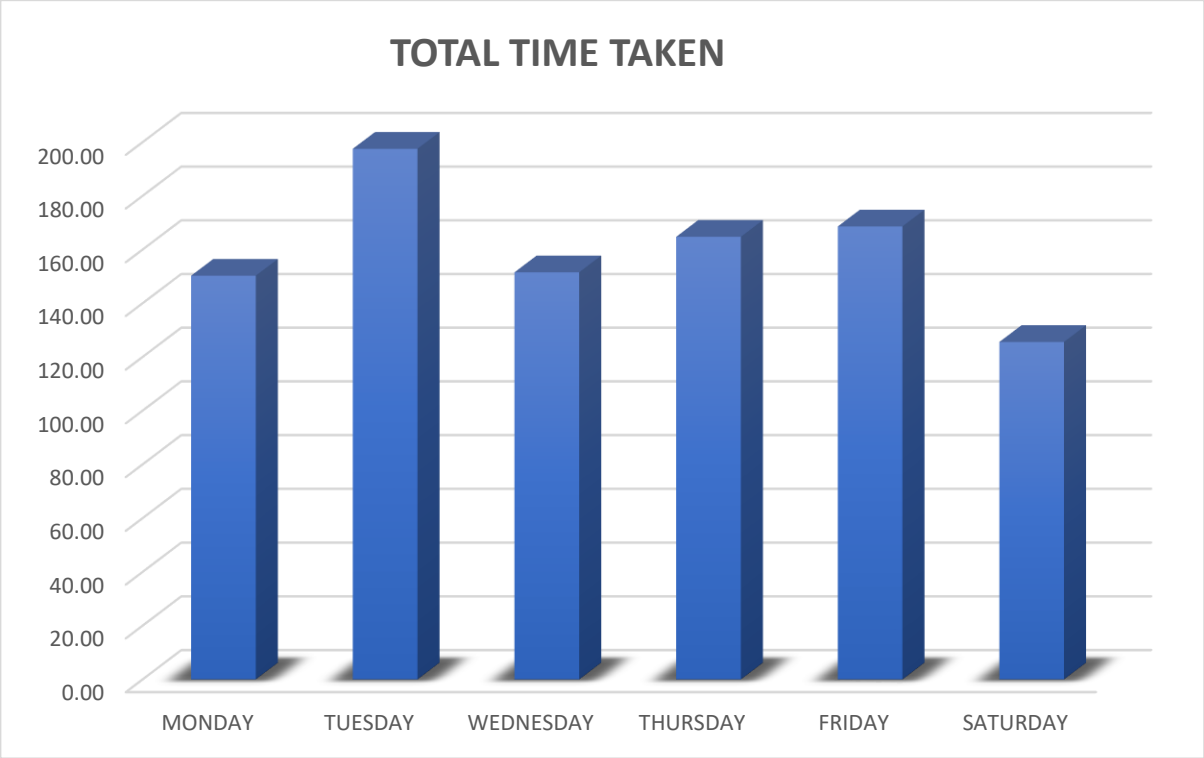


Figure 1.3: Bar Graph of Average Time Taken per Day

Analyze Phase

Pareto Analysis

- The Radiology (30%) and Laboratory (29%) areas accounted for nearly 59% of total defects.
- Registration and pharmacy contributed less significantly (13% each).

DEFECT AREA	DEFECT QUANTITY	DEFECT QUANTITY IN %	CUMULATIVE %
RADIOLOGY	52	30%	30%
LABORATORY	50	29%	59%
OPD AREA	25	15%	74%
REGISTRATION AREA	22	13%	87%
OPD&PHARMACY	22	13%	100%
	TOTAL= 171	TOTAL= 100%	

Table 1.4: Pareto Analysis of Defects

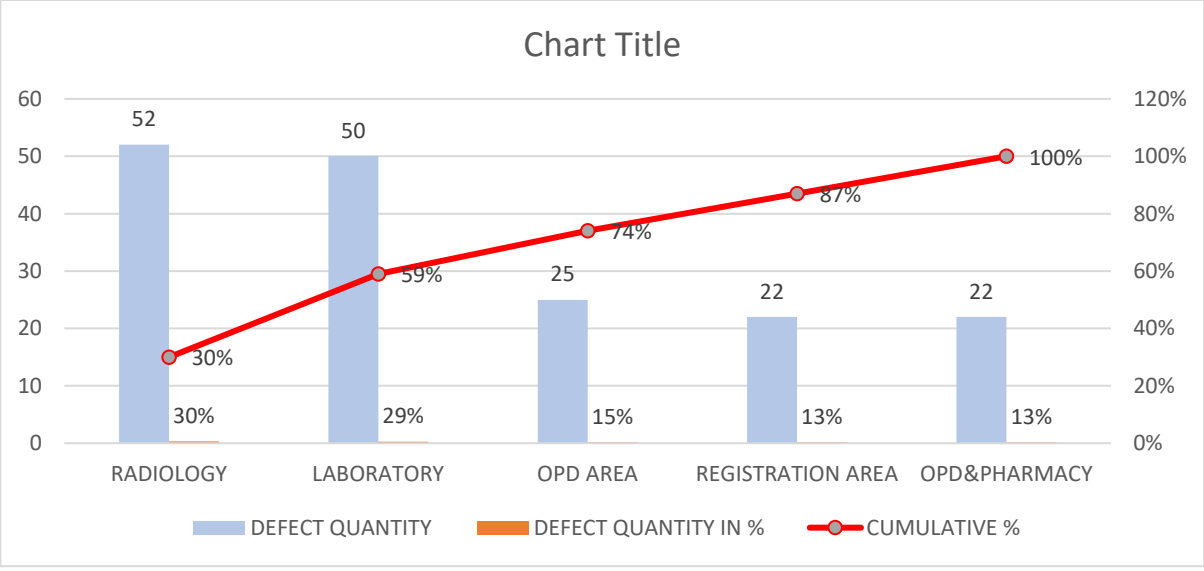


Figure 1.5: Pareto Chart of OPD Defects

Fishbone Analysis

A cause-and-effect (Ishikawa) diagram was used to identify root causes contributing to inefficiencies.

- **People**: Lack of adequate staff training, poor communication.
- **Process**: Redundant steps, unclear patient flow.

- **Equipment**: Limited diagnostic equipment availability.
- **Materials**: Delay in laboratory consumables.
- **Environment**: High patient volume and space constraints.

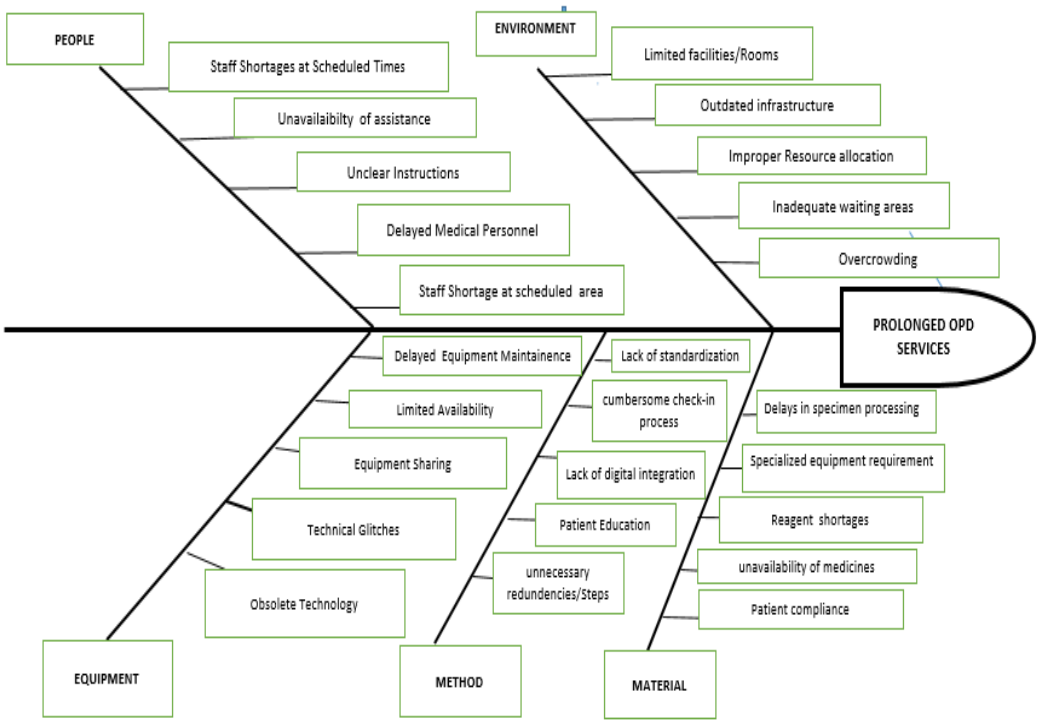


Figure 1.6: Fishbone Diagram of Root Causes

Key Findings:

1. OPD services involved 59 process steps, several of which were non–value-added.
2. Radiology and laboratory delays were the primary contributors to prolonged patient turnaround times.
3. Average total time per patient ranged from 125 to 198 minutes, with significant variability across days.
4. Lean Six Sigma tools (value stream mapping, Pareto, fishbone) revealed actionable opportunities to reduce non–value-added steps and optimize workflow.

Conclusion

This study examined the application of Lean Six Sigma (LSS) methodology to outpatient department (OPD) services in a tertiary care hospital. By employing the Define, Measure, and Analyze phases of the DMAIC framework, the study successfully mapped the existing OPD workflows, identified value-added, operational, and non–value-added steps, and quantified baseline process performance. The results revealed that certain areas, particularly the laboratory and radiology units, contributed disproportionately to delays and defects in service delivery. Pareto analysis highlighted these as priority targets for improvement, while the Fishbone diagram provided a systematic exploration of root causes, spanning people, process inefficiencies, equipment gaps, material shortages, and environmental factors.

The findings underscore the potential of Lean Six Sigma in identifying inefficiencies, reducing non–value-added activities, and improving patient flow within OPD settings. By creating a structured baseline and highlighting problem areas, this study provides actionable insights that can inform hospital administrators and quality managers in developing targeted interventions. Ultimately, the adoption of Lean Six Sigma principles holds promise for enhancing patient satisfaction, optimizing resource utilization, and fostering a culture of continuous improvement in healthcare organizations.

However, several limitations must be acknowledged. First, the study relied on average time data collected over a limited duration, which may not fully capture day-to-day variations in patient volume, staff availability, or seasonal fluctuations. Second, while the Define, Measure, and Analyze phases were rigorously applied, the Improve and Control phases of the DMAIC cycle were deliberately excluded. As such, the study does not provide validated solutions or assess the sustainability of improvements over time. Third, data collection was confined to a single hospital setting, which may limit the generalizability of findings across diverse healthcare contexts. Finally, potential human errors in observation and recording of time data may have introduced minor measurement biases.

Despite these constraints, the study contributes significantly to the growing body of literature on Lean Six Sigma in healthcare. It emphasizes that even partial application of the methodology can uncover bottlenecks and inefficiencies with clear implications for process improvement. Future studies should extend this work by implementing the Improve and Control phases, piloting and validating interventions in real-time, and monitoring the long-term impact of these changes. Moreover, conducting multi-site or comparative studies across different hospitals would enhance the generalizability of findings and offer broader insights into Lean Six Sigma's role in healthcare transformation.

In conclusion, Lean Six Sigma offers a robust framework for diagnosing and addressing inefficiencies in OPD services. Although this study stopped short of implementing changes, it provides a strong foundation for future work aimed at operational excellence, cost reduction, and improved patient-centered care in tertiary healthcare systems.

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