

Original Research

Leadership Style and Lean Management Capabilities in Improving Pharmacy Practice and Service Quality: Insights from Mediclinic Parkview Hospital, United Arab Emirates

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Abstract

Background: Hospital pharmacies encounter significant operational challenges that can affect service quality and client's satisfaction. **Objective:** This study focuses on the fundamental role of hospital pharmacy leadership and Lean management practices in transforming pharmacy operations at Mediclinic Parkview Hospital in Dubai, United Arab Emirates (UAE). **Methods:** Lean Leadership was vital in executing Lean Six Sigma (LSS) in the hospital pharmacy, promoting a patient-focused approach emphasizing quality, improvement, and staff engagement. The study employed the LSS DMAIC (Define, Measure, Analyze, Improve, Control) method to identify inefficiencies and improve overall performance, statistical analyses, and Sigma-level calculations. **Results:** Implementing Lean Six Sigma methodologies led to substantial enhancements in three Critical-to-Quality (CTQ) Key Performance Indicators (KPIs). Waiting times were reduced by 76%, patient satisfaction, as measured by Net Promoter Score (NPS), increased by 136%, and employee engagement scores improved by 28%. These advancements increased operational efficiency, improved patient retention, and decreased staff turnover. Additionally, the research utilized a validated questionnaire to examine the influence of DMAIC constructs on service quality using the SERVQUAL instrument across five dimensions: Tangibility, Empathy, Assurance Reliability, and Responsiveness. The results showed significant improvements across all models, with P-values below 0.001 confirming the robustness of the findings. Adjusted R-squared values ranging from 0.386 to 0.638 demonstrate that the Lean and Six Sigma methodologies applied in the study played a substantial role in enhancing service quality. **Conclusion:** This research emphasized the efficiency of the Lean Six Sigma DMAIC framework in enhancing hospital pharmacy operations, leading to substantial advancements in service quality across essential dimensions. The study focused on specialized training, Lean Leadership principles, and customized DMAIC components, supporting its practical implementation in healthcare settings.

Keywords: hospital pharmacy; Lean Six Sigma; DMAIC; key performance indicators; process improvement; critical to quality; service quality; SERVQUAL

INTRODUCTION

The complexity of managing a hospital pharmacy involves navigating numerous challenges, from ensuring the safe and timely distribution of medications to effectively managing inventory, staff, and information systems and achieving and maintaining quality accreditations.^{1, 2} In areas such as the Arabian Gulf and Middle East, these challenges are exacerbated by the swift expansion of populations, the prevalence of chronic illnesses, and the distinct cultural and

regulatory environments.³ Adopting innovative and strategic management practices in hospital pharmacies can significantly improve operational efficiency, reduce wait times, lower costs, and ultimately improve patient outcomes.⁴

Moreover, with the global rise of international healthcare medication management standards and the increasing interconnectivity of healthcare systems, understanding and implementing effective management strategies in hospital pharmacies have implications that exceed regional boundaries.^{1, 5}

Background of the Study

Historically, hospital pharmacists performed purely technical tasks such as preparing and distributing medications.⁶ However, numerous changes have occurred with the rapid progress of technology, research, education, various communities' evolving cultural and socioeconomic backgrounds, and patient growing needs and demands.⁷ These changes have ultimately led to higher service quality and safety requirements.⁵ Additionally, pharmacists' responsibilities have expanded to include a greater focus on providing patient-centered services.^{6, 8}

This research holds significance as it examines Lean Six Sigma (LSS) methods within pharmacy operations management at a tertiary care hospital in the UAE. This setting presents specific operational requirements and opportunities for resource

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optimization. The study aims to provide empirical evidence on the impact and efficacy of LSS in hospital pharmacies, offering a systematic approach to enhancing process efficiency, service quality, and client satisfaction. Given their complex nature, emphasis is placed on the need to improve the quality of pharmaceutical services.

Literature Review

The Lean concept originated in the Japanese automotive industry, known as the Toyota Production System (TPS).⁹ It was one of many advancements and innovations introduced by Japanese manufacturers during the 1980s. With a balance between continuous breakthrough improvement and a customer-centric approach, the Lean philosophy focuses on eliminating inefficiencies from processes to improve productivity and lower operational expenses.^{10,11} Six Sigma (SS) is a business management strategy and data-driven methodology developed in 1986 by Bill Smith, an engineer at Motorola. Its primary objective is to decrease the process defect rate by implementing statistical tools and techniques. The ultimate goal of Six Sigma is to enhance process performance and capability to minimize variation within a process that can lead to defects or errors.^{12, 13} It is a problem-solving methodology that can enhance the quality of various business procedures, including those within the healthcare industry.¹⁴

Table 1 compares Lean and Six Sigma methodologies based on their definitions, objectives, tools, scope, and application examples.

The hospital pharmacy division is well-known for its crowding and extensive workload compared to other healthcare departments.¹⁵ As the last step in the patient journey, delays or mistakes in pharmacy operations can present client difficulties, leading to patient dissatisfaction and additional complications. Ultimately, this undermines the hospital’s ability to deliver high-quality services overall.

Role of Hospital Pharmacies in Healthcare

Hospital pharmacies play a crucial role in the healthcare system by offering diverse services to support the procuring, storing, and distributing of medications and medical supplies within the hospital.¹⁶ They collaborate with physicians, nurses, and other healthcare providers to ensure medication safety and effective utilization.¹⁷ This role includes reviewing prescriptions, preparing customized drug formulations, and continuously monitoring patients for adverse reactions. Hospital pharmacists counsel patients, educate healthcare staff on proper medication management, and actively participate in

committees that contribute to developing hospital policies and procedures. Additionally, numerous hospital pharmacies are actively involved in research, evaluating new quality and safety initiatives and treatment protocols. With these comprehensive services, hospital pharmacies optimize patient outcomes and elevate the overall quality of healthcare delivery.

The management strategies of hospital pharmacies substantially impact their overall effectiveness, as they directly affect operational efficiency and patient outcomes. Optimizing pharmacy operations is of the utmost significance with increasing demands for healthcare and limited resources, particularly in economically challenged regions or those with healthcare inequalities.² Overseeing a hospital pharmacy involves navigating numerous complexities, from ensuring the secure and prompt dispensation of medications to efficiently supervising the stock, managing personnel, and information systems while also accomplishing and upholding quality accreditations.^{1, 5}

The advantages of utilizing professional pharmacy services to enhance service quality and patient outcomes and decrease healthcare expenses are widely acknowledged and backed by substantial evidence.^{18, 19} Pharmacy leaders can optimize healthcare operations and enhance performance by adopting process improvement methodologies such as Lean and Six Sigma.²⁰ Implementing Lean principles allows pharmacies to eliminate unnecessary tasks, inefficiencies, and waste in medication processes using various tools to support workplace organization.²¹ Simultaneously, Six Sigma empowers leaders to decrease process variations through statistical analysis, identifying underlying causes, and implementing error-proofing methods. Leveraging complementary strategies for continuous improvement enables pharmacy leaders to refine workflows, elevate safety and quality, and diminish costs within medication management processes.²²

Service Quality

Service quality refers to the discrepancy between anticipated levels of service and the actual service customers experience.²³ Academics have long been interested in service quality, and over the last few decades, scholars have developed various models to support its enhancement. These models serve as valuable tools for managers to understand the different aspects of service quality that can be used to enhance their organizations’ offerings. However, the SERVQUAL model is widely recognized as the foremost model for assessing service quality.^{24, 25} Parasuraman, Zeithaml, Berry ²⁶ presented the five-dimension SERVQUAL model in the mid-nineteen eighties.

Table 1: Comparative Overview of Lean and Six Sigma Methodologies		
Comparison Aspect	Lean	Six Sigma
Definition	Efficiency	Variation
Objective	Reduce waste, add value	Reduce variation, improve quality/consistency
Tools	Business principles and concepts	Statistics, charts, data
Scope	Ongoing operational philosophy	Narrow but high-impact project
Application	Reduce average time to assemble products or provide services	Decrease scrap from flawed products or miscalculated inventory



The first dimension, Tangible, is assessed by four items and measures the visual appeal of physical facilities, equipment, and personnel. The second dimension, Empathy, includes five items and evaluates the service provider's level of care and personalized attention toward customers. The third dimension, Assurance, comprises four items and assesses knowledge, politeness, and ability to instill confidence and trust. The fourth dimension, Reliability, consists of five items and reflects the capability to deliver the promised service accurately and consistently. The final dimension, Responsiveness, includes four items and measures the service provider's willingness to assist customers and provide prompt service.

Numerous scholars have employed the SERVQUAL scale to evaluate the dimensions of service quality offered in many sectors, including healthcare establishments.²⁷⁻³² Al-Neyadi, Abdallah, Malik³³ employed an adapted SERVQUAL model to evaluate healthcare services by examining the factors that impact patient contentment within hospitals in the United Arab Emirates. AlOmari³⁴ assessed the standard of healthcare provided by five privately owned hospitals in the Syrian capital, Damascus, from the patient's perspective using the SERVQUAL model. In the investigation conducted by Shafiq, Naeem, Munawar, Fatima³⁵, a modified edition of the SERVQUAL model was utilized to evaluate the standard of service provided at nine hospitals in Lahore, Pakistan. The Pramanik³⁶ study on the quality of healthcare services in India found a pressing need for significant improvements in health services offered by healthcare organizations. These improvements are necessary to ensure satisfactory services and reduce the time and financial resources spent addressing customer and beneficiary complaints.

A review by Endeshaw³⁷ espoused that healthcare service organizations must establish their methodology for assessing the quality of healthcare services. Moreover, it is of the ultimate importance to continually redefine the metrics used to measure quality and conduct detailed investigations into the complex components of service quality in healthcare settings.^{38, 39}

The Association between Lean Six Sigma and Services Quality

The association between Lean Six Sigma and the quality of services is significant and relevant.⁴⁰ Lean Six Sigma, a methodology focusing on process improvement and efficiency, has positively impacted service quality within the healthcare industry. The research conducted by Yun, Chun⁴¹ demonstrated that the combined utilization of both Six Sigma and SERVQUAL (Service Quality Framework) proved to be a systematic and effective method for evaluating the Critical-to-Quality (CTQ) requirements of telemedicine patients to achieve ongoing enhancement in service quality. Therefore, the association between Lean Six Sigma and service quality is vital for achieving excellence and delivering optimal results.⁴²

Incorporating SERVQUAL within the Lean Six Sigma DMAIC Framework

Once the strategy group of an organization has decided on the critical success factors and key performance indicators (KPIs),

SERVQUAL was explored as a supporting instrument in the Lean Six Sigma DMAIC project. The Control phase was ideal so that LSS process improvements could be monitored and maintained.⁴²

Lean Leadership

Effective leadership is an essential element in the successful implementation of LSS.⁴³ A leader is a crucial bridge between top management and the various levels within the healthcare organization. Leaders carry essential duties, including securing corporate support, inspiring and educating employees, and ensuring the availability of necessary resources.

According to the systematic review by Sallam⁴⁴, Lean pharmacy leadership, with its emphasis on quality, strict standards, daily evaluations, error transparency, data-driven decisions, open discussions, collaborative decision-making, staff involvement, cost-effective quality improvement, humility, and patient well-being, is particularly notable for its patient-focused nature. This shift to the lean model highlights its adaptability and inclusivity, promoting patient involvement and direct engagement and enhancing the overall quality of patient care.

METHODS

This research utilized a quality improvement project approach to examine how implementing Lean Six Sigma with lean leadership support using the DMAIC methodology (Define, Measure, Analyze, Improve, Control) impacts pharmacy performance in Mediclinic Parkview Hospital (MPAR) in the United Arab Emirates. Methodology was drawn from the author's doctoral thesis, emphasizing Lean and Six Sigma integration to optimize hospital pharmacy operations and enhance service quality⁴⁵ (Figure 1). The study on MPAR Lean Six Sigma lasted 19 months, from 1 November 2022 to 31 May 2024. The core focus of this investigation involved analyzing quality data and metrics (KPIs/CTQs) collected from the pharmacy management records before and after the implementation of LSS. This approach for data analysis aimed to identify significant issues and provide insights into the effects of LSS on service quality.

Research Site

The study setting is Mediclinic Parkview Hospital (MPAR), which has 185 beds and is a JCI-accredited tertiary healthcare facility located on the southern side of Dubai, UAE, as shown in Figure 2. MPAR was established in 2018 as Mediclinic Middle East's most extensive greenfield initiative with a broad spectrum of medical services, a range of more than 46 medical specialties, and an extensive in-house 24/7 operating pharmacy that illustrates its commitment to delivering diverse and sophisticated healthcare solutions to the community.⁴⁶

Study Duration

A Gantt chart (Figure 3) served as the study's planning tool, facilitating the visualization and tracking of task progress throughout the project duration.⁴⁷

Project Charter



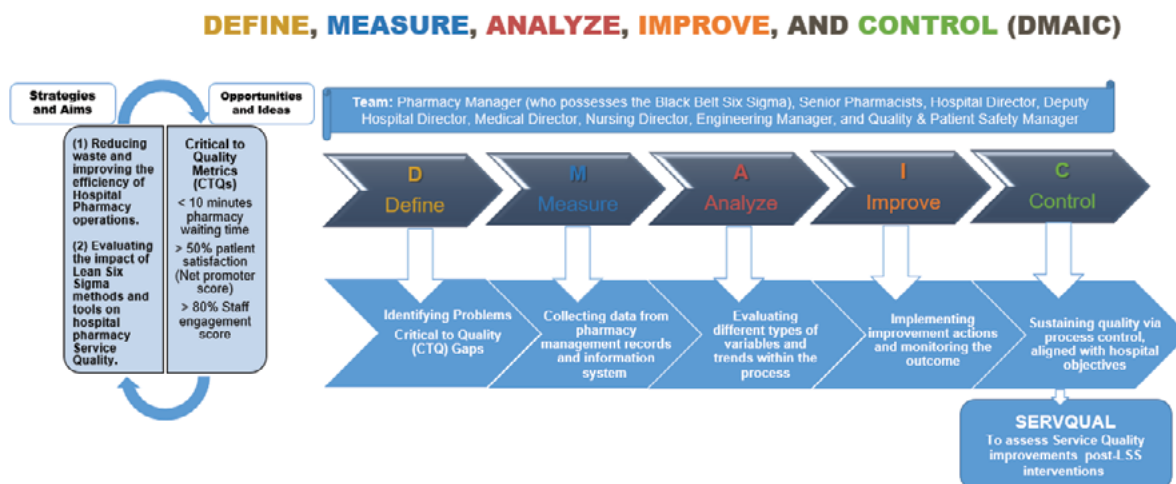


Figure 1. MPAR hospital pharmacy project activity diagram with value driver analysis.

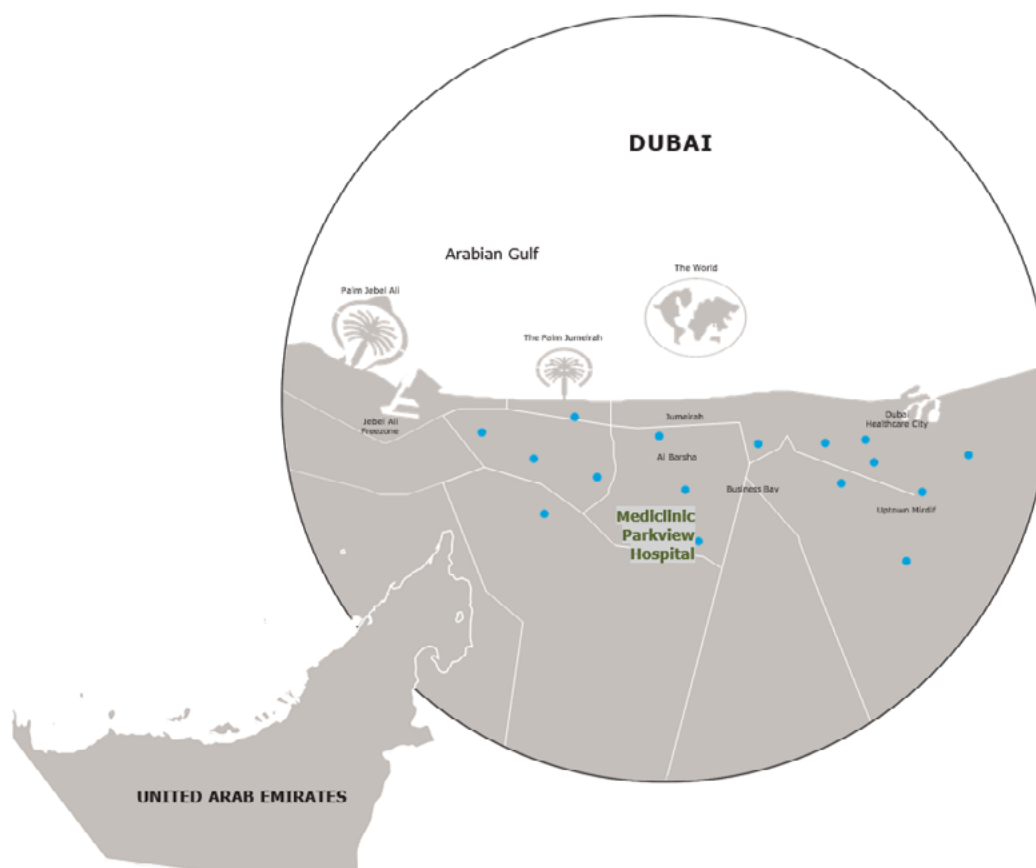


Figure 2. MPAR hospital strategic location in "new Dubai"

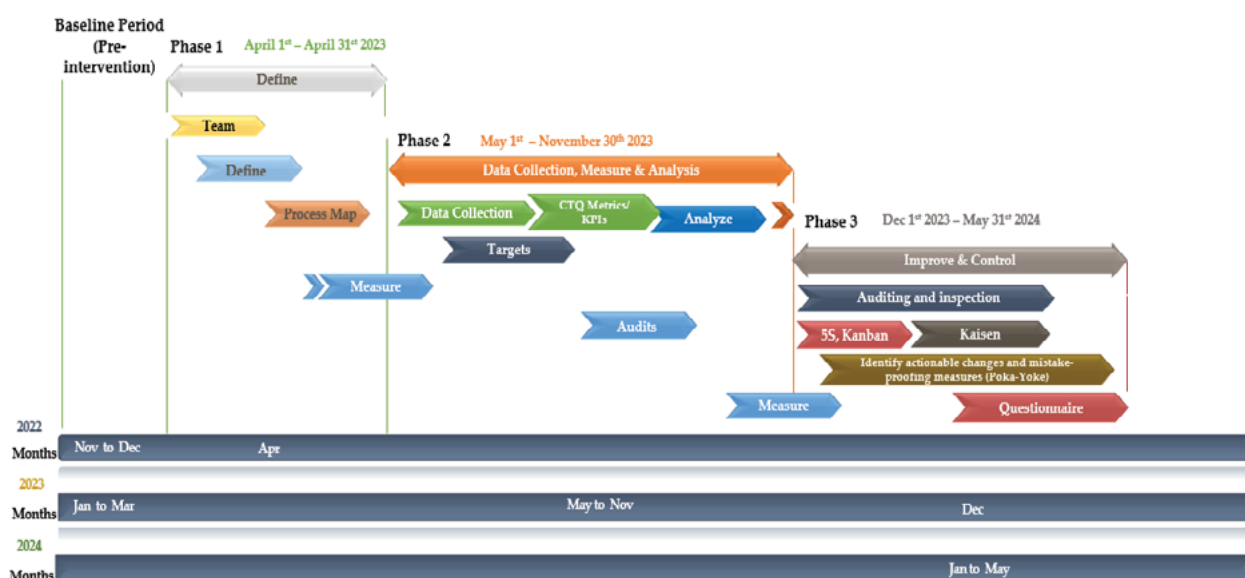


Figure 3. Project Gantt chart.

The study charter document typically contains many essential elements. Table 2 provides a detailed breakdown of these elements. The average pharmacy waiting time (KPI 1) was aimed at improving client experience by reducing patient waiting periods to below 10 minutes. A random sample of monthly waiting time records (n=100) was obtained using the pharmacy EaZy-Q queue management system. Possible causes contributing to waiting are identified and prioritized (Table 3).

The KPI, Net Promoter Score for patient satisfaction (NPS), was employed to evaluate operational excellence by measuring patient satisfaction. The desired NPS was above 50%.⁴⁸ Likely contributing factors to low patient satisfaction are listed in (Table 4). Lastly, the third key performance indicator is the staff engagement score, measured by the reputable Q12 questionnaire created by Gallup Inc.⁴⁹ (KPI 3), which concentrated on operational involvement by aspiring to elevate staff morale and efficiency with a desirable score surpassing 80%. Underlying estimated reasons for low staff engagement scores are highlighted in (Table 5).

KPIs Validity and Reliability

The validity of the KPIs was verified using the Content Validity Index (CVI), ensuring the indicators adequately cover the study's objectives. The (CVI) was applied to each attribute of the indicators to evaluate the content validity of the experts' feedback. The CVI was determined by nine experts, each of whom independently rated the attributes based on a binary rating scale (1 = satisfactory, 2 = unsatisfactory).

Data Collection Sources and Instruments

The hospital's pharmacy management records and information system were used to collect CTQs and KPIs. The Lean Six Sigma team took a random sample of all outputs from each process monthly from November 2022 to March 2024.

Define Phase

Pharmacy Process Flow Mapping

A process map was a helpful tool that visually represented a process. It assisted the employees in comprehending the actual process, including any inefficiencies, redundant elements, or workflow issues. A comprehensive, detailed process mapping of the Mediclinic Parkview Hospital (MPAR) pharmacy operations was conducted to understand where bottlenecks hinder pharmacy efficiencies.

SIPOC (Suppliers, Inputs, Processes, Outputs, Clients)

It was integrated into the study, and the end-to-end processes within pharmacy operations at MPAR were comprehensively mapped. By identifying the key suppliers, inputs, processes, outputs, and customers, SIPOC enabled a detailed workflow analysis, helping to pinpoint areas for improvement in alignment with Lean management principles. This tool facilitated a more effective implementation of strategies to enhance efficiency, reduce waste, and improve patient and staff satisfaction.

Measure Phase

Evaluating Variation and Business Performance $Y = f(X)$

In Table 6, X represents the different factors in the process, while Y represents the result. The outcome Y will also change when there are changes in the inputs, whether common cause or special cause variation. Six Sigma is a methodical way of solving problems that rely on data, where the elements that go into the process (X) are pinpointed and improved to impact the final outcome (Y). The key equation that guides Six Sigma is $Y = f(X)$, which represents the end result crucial to the business; f represents the function that determines how to address and control the connections between variables; and X represents the variables that need to be managed to predict Y accurately.

Table 2: Project charter		
Element	Description	Specifications
Project	Name of the project	MPAR Hospital pharmacy operations and financial improvements
Project Description and Process Scope	Describe the project scope	Implementing Lean Six Sigma with managerial team support. The project used the Define, Measure, Analyze, Improve, Control (DMAIC) methodology.
Business Case	To provide project justification and alignment with organizational strategies and business success	Efficient pharmacy operations are essential for supporting the overall initiatives and goals of the hospital; therefore, implementing Lean Six Sigma (LSS) methodology to improve pharmacy operations was crucial. This initiative targeted the following operational domains: 1) Pharmacy waiting time, 2) Patient satisfaction, 3) Staff engagement
Problem Statements	To highlight issues or pain points within current hospital pharmacy operations, including lack of Lean practices and process variation	1) Extended pharmacy waiting times, 2) Low patient satisfaction scores, 3) Low staff engagement scores
Goals/Objectives	What CTQ metrics will be improved? What is the average baseline performance of those metrics? How much improvement is targeted?	Metric 1: Average Waiting Time - KPI: Average pharmacy waiting time (minutes) - Unit of Measure (UOM): Minutes - Average Baseline: 20 - Average Goal (Target): 10 - % Targeted Improvement: 50% Metric 2: Patient Satisfaction Index - KPI: Patient satisfaction (Net promoter score) - Unit of Measure (UOM): % - Average Baseline: 0.24 - Average Goal (Target): 0.50 - % Targeted Improvement: 108% Metric 3: Staff Engagement Level - KPI: Staff engagement score (Gallup Q12 survey) - Unit of Measure (UOM): % - Average Baseline: 0.43 - Average Goal (Target): 0.80 - % Targeted Improvement: 86%
Project Benefits to Internal and External Clients	Details	Both internal and external stakeholders were engaged in addressing the service deficiencies. Gemba walks were conducted to observe the process thoroughly, while interviews were held with internal clients to understand recurring challenges. Input from staff was gathered through brainstorming to identify effective solutions.
Project Owner	Project leader	Head of Pharmacy Department
Project Team	Lists the members involved. Ensures team members are not overloaded and project demands do not compromise their regular duties.	A diverse Lean Six Sigma team including the Pharmacy Manager (Black Belt Six Sigma), Senior Pharmacists, Hospital Director, Deputy Hospital Director, Medical Director, Nursing Director, Engineering Manager, and Quality and Patient Safety Manager
Project Milestones	Baseline	Define: 1 Nov 2022 – 31 March 2023, Measure/Analyze: 1 April 2023 – 30 April 2023, Improve/Control: 1 May 2023 – 30 November 2023, Completion: 1 December 2023 – 31 May 2024

Table 3: Possible reasons for long pharmacy waiting time
e-Rx (electronic prescription) and hospital information system-related issues
Frequent stockouts and backorders (Drug shortages)
Poor scheduling and shift planning
Distractions
Low staff engagement and motivation
Crowded and disorganized pharmacy layout and shelves
Inefficient use of available space

Table 4: Likely reasons for low patient satisfaction scores
Delays in medication processing and follow-up
Frequent stockouts and backorders (Drug shortages)
Ineffective communication
Lack of focus on patient experience
Low staff engagement and motivation
Crowded and disorganized pharmacy layout and shelves
Lack of privacy in the dispensing counter area

Table 5: Estimated reasons for low staff satisfaction scores
Unpleasant or toxic work culture
Poor leadership and micro-management
Lack of teamwork or collaboration
Poor training
Lack of communication
Disorganized or cluttered workspace
Lack of diversity and inclusion

Table 6: Functional Method $Y = f(X)$ for the three Selected Pharmacy Metrics	
KPI 1: Average Pharmacy Waiting Time [minutes]	
Project Scope Element	Description
Goal (Y)	Reduce the average waiting time for pharmacy services
Key Output Variable (Y)	Average waiting time in minutes for pharmacy service
Key Input Variables (X's)	X1: Number of staff on duty
	X2: Efficiency of prescription processing systems

	X3: Layout and design of the pharmacy area
Potential Causes (for Analysis)	Staff shortages, inefficient workflows, poor physical layout
Mathematical Relationship	$Y1 = f(X1+X2+X3)$
Measurements	- Time tracking from patient arrival to prescription handover
	- Staff levels and efficiency metrics
Improvement Strategies	- Optimize staff schedules to match peak hours
	- Implement or enhance automated dispensing systems
	- Redesign pharmacy space for better flow and efficiency
Control Mechanisms	- Regular audits of waiting times and process adjustments
	- Feedback mechanisms for patient and staff input
KPI 2: Patient Satisfaction (Net Promoter Score) [NPS]	
Project Scope Element	Description
Goal (Y)	Improve patient satisfaction and loyalty
Key Output Variable (Y)	Net Promoter Score (NPS)
Key Input Variables (X's)	X1: Quality of customer service provided by pharmacy staff
	X2: Efficiency and speed of the pharmacy service
	X3: Ease of access and comfort in the pharmacy environment
Potential Causes (for Analysis)	Poor service quality, long waiting times, uncomfortable pharmacy setting
Mathematical Relationship	$Y2 = f(X1+X2+X3)$
Measurements	- Conduct NPS surveys at regular intervals
	- Monitor and analyze feedback for trends and areas of improvement
Improvement Strategies	- Staff training programs focused on customer service skills
	- Process optimizations to reduce waiting times
	- Enhancements to the physical layout and amenities of the pharmacy
Control Mechanisms	- Continuous monitoring of NPS and implementing feedback loops
	- Regular review sessions to discuss improvements and adapt strategies
KPI 3: Staff Engagement Score [Gallup Q12 survey]	
Project Scope Element	Description
Goal (Y)	Enhance staff engagement and job satisfaction
Key Output Variable (Y)	Gallup Q12 survey score
Key Input Variables (X's)	X1: Quality of work environment
	X2: Recognition and feedback provided to staff
	X3: Availability of professional development opportunities
Potential Causes (for Analysis)	Inadequate workplace conditions, lack of recognition, limited growth opportunities
Mathematical Relationship	$Y3 = f(X1+X2+X3)$
Measurements	- Conduct regular Gallup Q12 surveys
	- Assess feedback on work conditions and satisfaction levels
Improvement Strategies	- Improve workplace conditions and facilities
	- Implement a comprehensive recognition and rewards system
	- Develop and promote staff training and development programs
Control Mechanisms	- Regular reviews of engagement scores and feedback
	- Adjustments to strategies based on survey results and feedback

CTQ Tree Diagram

The CTQ (Critical to Quality) Tree Diagram, a structured tool, was utilized to transform overall customer requirements into detailed and measurable criteria via a multi-tiered procedure (Figure 4). At the initial level, the diagram pinpointed the essential demands of the customer; subsequently, Level 2 ascribed quality factors that influenced these demands⁵⁰. Progressing to Level 3, these quality factors were dissected into performance drivers, drawing attention to particular CTQ deficiencies within various domains such as efficiency of service delivery, patient experience, and employee engagement. These performance drivers were then associated with specific metrics, with the end goal of achieving predetermined objectives. This hierarchical method ensured that all clients' requirements were methodically examined and quantified, resulting in tangible enhancements in quality.

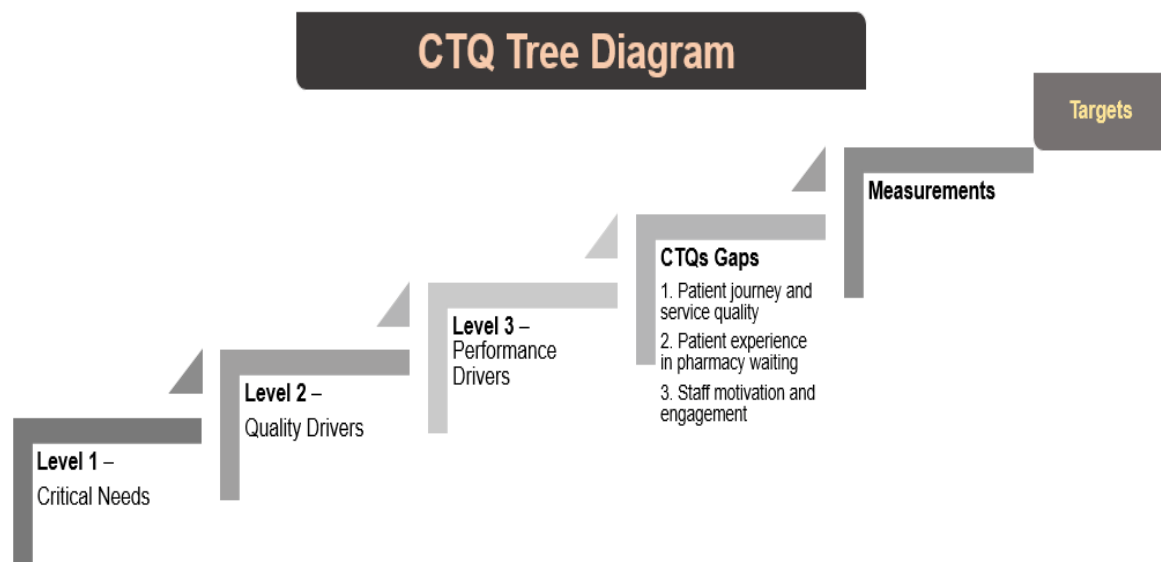


Figure 4. CTQ tree diagram

insight into potential failures that may arise during the process, resulting in additional obstacles. FMEA is a risk management tool that helps locate and address risks effectively⁵². The Risk Priority Number (RPN) was computed to ascertain the failures that posed the highest risk to the efficiency of pharmacy processes.

Pareto Charts

The Pareto principle, also known as the 80/20 rule, posits that a minority, 20% of cases, are responsible for the majority, 80% of effects. This concept is also called the law of the vital few, indicating that a small number of inputs drive most of the outputs. A Pareto chart helped to visually represent the frequency or impact of different factors, events or causes contributing to the particular CTQ problem or outcome. It helped to identify the most significant factors that should be prioritized for improvement efforts. The Pareto rule suggests that 80% of the pharmacy efficiency outcomes can be attributed to 20% of the factors involved by presenting data in a clear,

Analyze Phase

Root Cause Analysis (RCA)

During this stage, a Fishbone diagram, also known as an Ishikawa diagram, was employed for each CTQ to ascertain the potential origins and fundamental reasons for divergences occurring within the process. During a cause-and-effect brainstorming session, the LSS team analyzed potential problem causes, systematically arranged these possibilities, and visually represented the information to determine priorities, patterns, and connections between ideas⁵¹. Root cause verification was completed and documented via the root cause verification matrix.

Failure Modes Effects Analysis (FMEA)

A Failure Modes Effects Analysis (FMEA) was conducted to gain

organized, and prioritized. Pareto charts aid decision-making by allowing the team to concentrate on the most critical factors to yield significant improvements or cost savings.

Improve Phase

In the improve stage of a DMAIC project, the Lean Six Sigma team engaged in a collaborative brainstorming session to identify potential remedies for the underlying issues uncovered during the analysis phase. These solutions were evaluated based on their cost, effectiveness in decreasing waste, ability to amplify efficiencies, and feasibility, with analytical rankings as the basis for prioritizing and selecting solutions for implementation⁵³.

Changes during the improve phase that can boost operational performance include reorganizing the activities and functions of workstations, implementing administrative controls, providing further training for employees to elevate their competencies, relocating workstations to optimize flow, and redesigning the facility layout to create a more efficient work environment⁵⁴.

Each of these interventions played a role in the continuous pursuit of process excellence, and they are frequently revisited and adjusted to meet the evolving demands of the healthcare setting.

Control Phase

In the final phase, after implementing the identified process improvements in the pharmacy process, teams created monitoring systems to ensure that the process continues to perform successfully after implementing all changes to the standard business process⁵⁵. Ongoing staff training and open communication channels became essential to ensure adherence to the new standardized procedures. Pharmacy leadership directed continuous coaching and knowledge-sharing sessions to reinforce the changes and allow frontline staff to provide feedback for necessary adjustments. Following a few months of the optimized processes, it was advisable to re-measure key metrics like medication turnaround times, error rates, and workflow inefficiencies. This measure validated whether the improvements have been sustained as expected or if any new process risks requiring mitigation had emerged. Regular quality control reviews facilitated long-term success by enabling prompt course correction and fostering an environment of continual enhancement aligned with continuous improvement in patient safety and care delivery.

Survey/Questionnaire

Additionally, this research employed a standardized and validated questionnaire to collect healthcare professionals' perspectives concerning changes in operational efficiency, quality, and other vital factors after implementing Lean Six Sigma interventions. The self-administered questionnaire was derived from the study conducted by Sharabati, Duraini, Jabali⁵⁶ and carried out through Google Forms. Also, it was disseminated through authorized work email channels. The questionnaire included (1) Informed consent, (2) demographic information, and (3) close-ended questions to measure perceptions on DMAIC phases and pharmacy service quality post-LSS interventions. The study's variables are assessed using five Likert scales [1 (Never), 2 (Seldom), 3 (Sometimes), 4 (Always), 5 (Frequently)] to measure participants' real perceptions of each item. The rating ranges from 1, indicating a solid absence of implementation, to 5, indicating a strong level of implementation.

Questionnaire Target Population, Sampling Method, and Sample Size

The study utilized a stratified random sampling technique to ensure a representative sample from the target population at Mediclinic Parkview Hospital. This method allows dividing the total population into distinct subgroups or strata (such as pharmacy staff, doctors, nurse managers, and senior leadership teams). Within these strata, individuals were randomly selected. This approach ensured that each subgroup was adequately represented in the sample, enhancing the reliability and generalizability of the findings. The sample size was determined based on the existing count of 12 Senior Leadership Team (SLT), 194 Doctors, 11 Unit Managers, 13

Senior Staff, and 44 Staff.

Aiming for an anticipated 80% response rate among the overall sample size while considering a margin of error of 5.0% at a confidence level of 95%, the required sample size would be a minimum of 161 participants. This calculation was conducted using the CheckMarket sample size calculator.⁵⁷

Questionnaire Validity and Reliability

The validated questionnaire was piloted with five healthcare professional volunteers to identify potential issues and gather feedback to enhance the final questionnaire.

Reliability was assessed through a pilot study and Cronbach's alpha to ensure the consistency of the responses.⁵⁸

Questionnaire Inclusion and Exclusion Criteria

Inclusion Criteria: Healthcare professionals currently employed full-time at Mediclinic Parkview Hospital (MPAR), including pharmacy staff, doctors, nurse managers, and senior leadership team (SLT) members.

Exclusion Criteria: Staff not directly involved in pharmacy operations, such as support personnel. Part-time or temporary employees, external contractors.

Research Analytics

Data processing and analysis were conducted using Microsoft Excel 2021 (Microsoft Corporation, Seattle, WA, USA), Minitab Statistical Software 22, and IBM Statistical Package for the Social Sciences (SPSS) Version 29.0, with a significance level set at $P < 0.05$. Quantitative data was analyzed utilizing both descriptive and inferential methods.

Ethical Considerations

Confidentiality

Privacy was ensured for all information obtained. The gathered data was protected and stored securely in encrypted form, with exclusive access granted to the investigator only.

Informed Consent

Informed consent was sought from each questionnaire participant and involved explaining the study's purpose, procedures, and benefits. The study followed ethical guidelines and provided all participants with consent forms to read before they could participate. The consent process explained these measures to ensure that participants understand that their identities will be kept confidential and that their responses will not be linked to them. This approach guarantees the research's credibility while protecting all participants' privacy and confidentiality.

Institutional Review Board (IRB)

Study approval was obtained from the MCME Research and Ethics Committee (REC) [MCME.CR.335.MPAR.2023] was issued on 31/01/2024 and the Dubai Scientific Research Ethics Committee (DSREC), Dubai Health Authority [IRB DSREC-03/2024_22] was issued on 15/04/2024.



RESULTS

(A) LSS DMAIC Project

Define

DMAIC Project Selection Matrix Using the 15-Point Viability Model

The 15-point Viability Model for the DMAIC project yielded a weighted score of 213, with an average score of approximately 3.61, categorizing it as a viable project under the DMAIC framework. This high score, derived from the collaborative assessment of key criteria such as sponsorship, alignment with strategic goals, customer and company benefits, timeline feasibility, and cost-effectiveness, underscores the project’s potential for delivering impactful improvements.

Key Performance Indicators (KPIs) Selection

Three critical Key Performance Indicators (KPIs) were established for hospital pharmacy services, validated through expert ratings using a binary scale, resulting in strong reliability and an Item Content Validity Index (I-CVI) above 0.78 for each metric, confirming their relevance and alignment with intended quality constructs (Table 7).

The KPIs served as a roadmap for the quality of pharmacy medication management services. The top hospital pharmacy metrics were determined following literature review, benchmarking, and consultations with all stakeholders who expressed robust support for the initiative, focusing on the project objectives of evaluating appropriateness, quality, and safety⁵⁹⁻⁶¹.

Pharmacy Process Mapping

A process mapping was constructed to understand the hospital pharmacy process (Figure 5) that commences with a physician generating a prescription in the Electronic Medical Record (EMR). It is then transmitted to a pharmacy technician

Table 7: Item content validity index (I-CVI) results for KPIs		
KPI 1: Average Pharmacy Waiting Time	(1) Relevance	0.94
	(2) Clarity	0.94
	(3) Accessibility	0.94
	(4) Measurability	1.00
	(5) Practicality	0.83
	(6) Objectivity	0.89
	(7) Generalizable	0.78
	(8) Time-bound	0.94
KPI 2: Patient Satisfaction (Net Promoter Score)	(1) Relevance	0.94
	(2) Clarity	0.94
	(3) Accessibility	0.89
	(4) Measurability	0.89
	(5) Practicality	1.00
	(6) Objectivity	0.83
	(7) Generalizable	0.89
	(8) Time-bound	0.94
KPI 3: Staff Engagement Score (Gallup Q12 Survey)	(1) Relevance	0.94
	(2) Clarity	0.78
	(3) Accessibility	0.94
	(4) Measurability	0.94
	(5) Practicality	0.94
	(6) Objectivity	0.94
	(7) Generalizable	0.83
	(8) Time-bound	0.89

who performs a stock availability check. If the medication is on hand, a pharmacist examines the prescription, validates the dosage, and labels the medication. Subsequently, the pharmacy technician dispenses the medication and includes

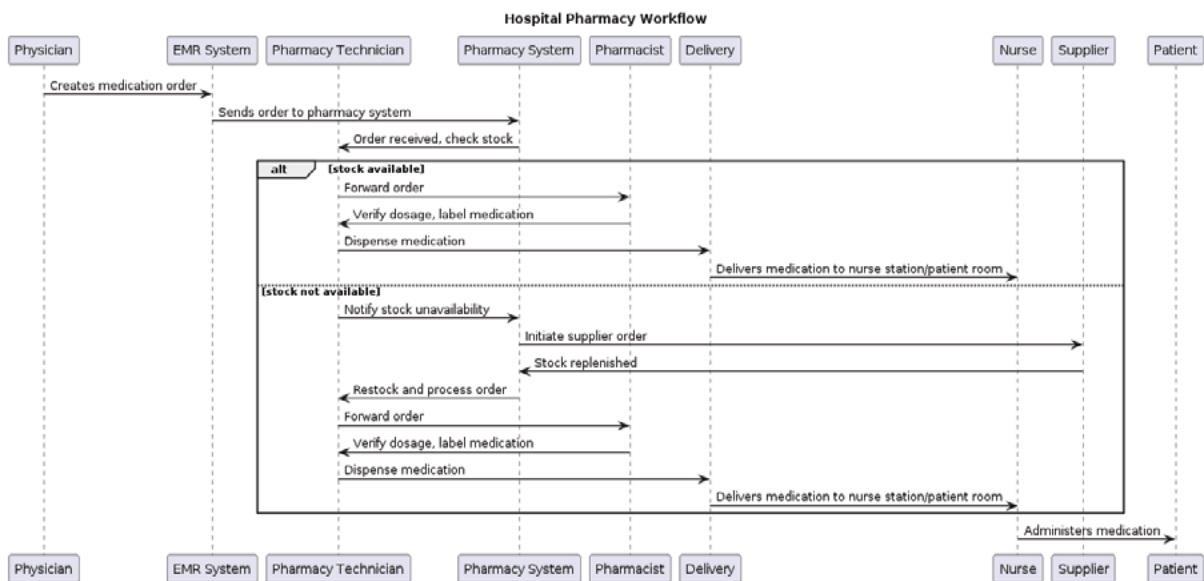


Figure 5. Hospital pharmacy workflow



instructions. The delivery team then transports the medication to the nurse station or patient room, where a nurse administers it to the patient. The flow of information within this procedure involves transferring orders from the EMR to the pharmacy system and dispatching notifications to initiate a supplier order if the medication is unavailable. Critical decision points include confirming the medication’s availability, while possible delays could result from waiting for medication from suppliers or requiring the physician to provide additional clarification if an order is declined. Moreover, this workflow is impacted by local regulations in the UAE related to medication dispensing, potential language barriers, and cultural aspects that may influence communication and medication compliance.

Supplier, Input, Process, Output, and Customer (SIPOC)

In the initial project brainstorming session, the SIPOC diagram was used to gather vital data about the beginning and end of the hospital pharmacy process and represented the events necessary to get a given result (Table 8).

Table 8: SIPOC diagram for hospital pharmacy [†]				
Supplier	Inputs	Process	Outputs	Customers
Local Regulators Pharmaceutical Manufacturers/Distributors Health Information and Communication Technology (ICT) Vendors	Regulatory Requirements Pharmaceutical Supplies Pharmacy Staff Experience and Skills Patient Information Medication Orders	Order Receipt Order Verification Medication prior authorization Medication Picking Medication Dispensing Quality Check Patient Counselling Medication Delivery	Dispensed Medications Medication Safety Patient Instructions Transaction Records Follow up	Internal (Physicians, Nursing Staff) External Patients and their Families
Enablers Dubai Health Authority (DHA) Pharmacy Guidelines Inventory Management System Logistics Support and Delivery Vehicles Electronic Health Records (EHR) Standard Operating Procedures (SOPs) Training Programs and Professional Development Logistics Support and Delivery Vehicles				

Root Cause Analysis (RCA)

A Fishbone diagram also called an Ishikawa diagram, was used for each CTQ to identify the potential sources and underlying causes of variations occurring within process.⁶⁴ The three fishbone diagrams (Figures 6 to 8) proved an effective tool for the pharmacy project team to systematically explore the multiple potential causes contributing to a particular issue of significance. A specific strategy for each critical to quality (CTQ) metric was implemented, with interventions carefully tailored to address the verified root causes outlined in the Ishikawa diagram.

Extended Pharmacy Waiting Times: Frequent e-Rx breakdowns were minimized with regular maintenance and upgraded systems, while technology assessments led to advanced automation investments. Process time studies revealed bottlenecks, streamlining the filling process and workflow analysis established standardized protocols. Staffing analysis added necessary personnel, optimized scheduling, and improved supplier relationships for timely deliveries.

Responsibility, Accountability, and Consulted & Informed (RACI) Matrix

The RACI matrix assigned accountability to the Black Belt LSS Champion, the pharmacy manager, for overseeing project standards. The Project Coordinator managed execution, ensuring 100% task completion, while senior pharmacists handled 70% of operational tasks, including implementing changes and conducting 15 training sessions. The other leadership members ensured compliance through five audits and addressed patient feedback.

Voice of Customer (VOC)/Critical to Quality Parameter

Internal and external customers discussed the service gaps.⁶² Additionally, Gemba was conducted, and the pharmacy process was observed in-depth on the operations floor; interviews were conducted with internal clients to understand the problems workers faced routinely.⁶³ Suggestions were also taken from staff through a brainstorming session where their concerns and the best practical solution were discussed.

The redesigned pharmacy layout reduced distractions. Also, training was provided to enhance competency and focus.

Low Patient Satisfaction Scores: Regular maintenance of e-Rx systems and improved automation technology helped streamline operations, with workflow protocols reducing inconsistencies. Patient feedback informed follow-up care while scheduling and communication channels were optimized to match patient flow. Enhanced inventory management, privacy measures, and reorganized layouts further improved patient experience, alongside customer service training for professionalism.

Low Staff Engagement Scores: System access and usability improved with maintenance and training, while simplified workflows and reduced micromanagement empowered staff. Leadership and employee feedback improved training, recognition, and work-life balance. Additional resources, training updates, and a quieter environment fostered a more positive workplace, while enhanced communication and team-building activities encouraged collaboration and clarity in roles.



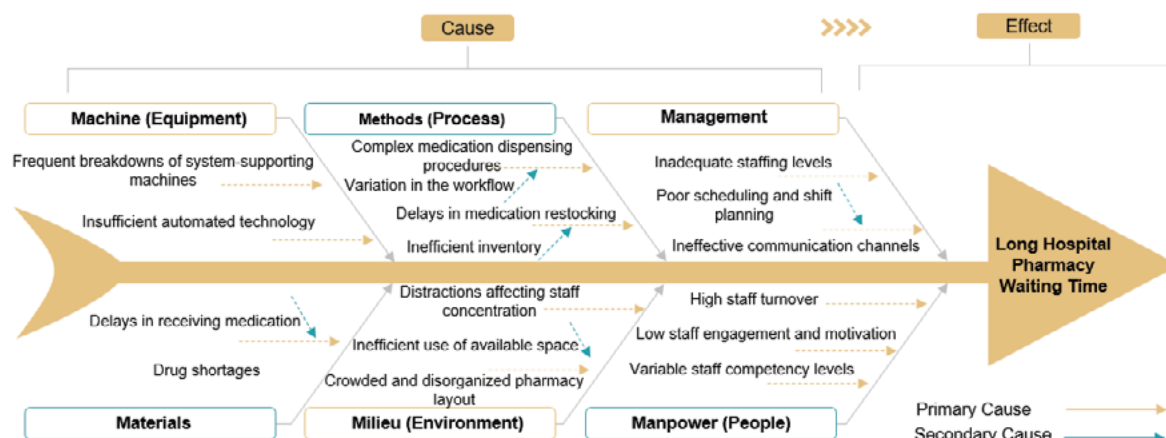
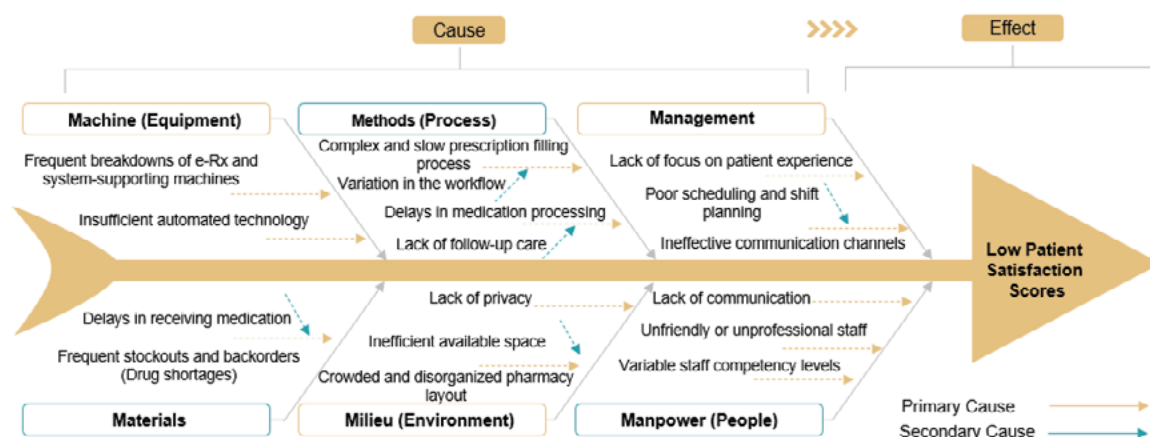
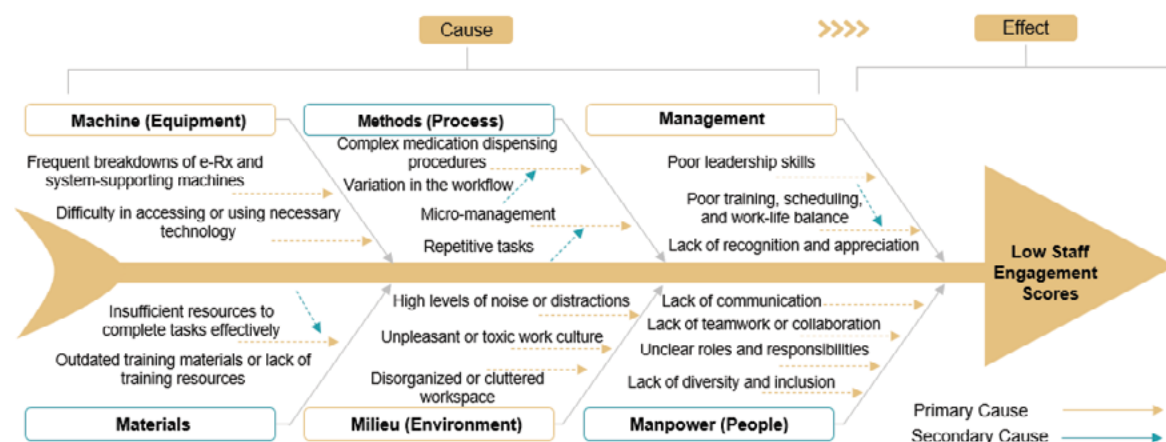


Figure 6. A cause-and-effect diagram (long hospital pharmacy waiting time)



* Notes e-Rx: Electronic prescription

Figure 7. A cause-and-effect diagram (low patient satisfaction scores)



* Notes e-Rx: Electronic prescription

Figure 8. A cause-and-effect diagram (low staff engagement scores)

Measure/Analyze

The Measure phase sought to assess the existing performance of the process or system being improved. The aim was to investigate the data and process to pinpoint the underlying factors contributing to the apparent problems, ensuring that solutions targeted these core causes rather than just the symptoms. The collected data was examined during this stage to understand where and why errors or inefficiencies occurred. Standard tools and techniques used in this phase included the FMEA, Five Whys, and Pareto Analysis.

Failure Mode and Effects Analysis (FMEA)

Due to the complex nature of the challenges, it was essential to perform a proactive, comprehensive examination of the underlying factors via Failure Mode and Effects Analysis (FMEA). The three CTQs were aligned with failure modes in hospital pharmacy and medication management process. The FMEA analysis for April 2023 and December 2023 results (FMEA scores before and after) showed significant reductions in Risk Priority Numbers (RPN) across various failure modes in pharmacy processes, indicating effective interventions. Due to standardized communication and training, the RPN for 1) Extended pharmacy waiting times were reduced by 89.29% from 336 to 36 due to optimized process flows. 2) Low patient satisfaction decreased by 77.78% from 216 to 48 through better service delivery, and 3) Low staff engagement” was cut by 77.78% from 288 to 64, improving staff morale and reducing turnover. These improvements highlight the success of targeted strategies in enhancing pharmacy operations. The diagram (Figure 9) shows a decrease in the Risk Priority Number (RPN) of potential failure modes, suggesting an overall improvement in the process following the failure mode and effects analysis

(FMEA) implementation.

Pareto Analysis

It is established on the Pareto principle, which proposes that the majority of consequences stem from a small number of factors. The Pareto rule advocates prioritizing the primary factor with the most significant impact.

The primary reason for long pharmacy waiting times was e-Rx and system-related issues, contributing to 50% of all cases. Including “Frequent stockouts and backorders” raised the cumulative total to 70% (Figure 10).

Delays in medication processing and follow-up were the dominant reasons for low patient satisfaction scores, making up 60% of all issues identified. Including frequent stockouts and backorders increased this to 75% cumulatively (Figure 11). The most significant factor affecting low staff satisfaction scores was an unpleasant or toxic work culture, accounting for 30% of occurrences. This issue, combined with poor leadership and micromanagement, raised the cumulative total to 55% (Figure 12).

Improve/Control

It was necessary to identify improvements or adjustments, verify them, and implement them to handle potential problems. Guided by the five principles of Lean methodology, widely regarded as a blueprint for enhancing workplace productivity, 1) delineating value, 2) charting the value stream, 3) fostering continuous flow, 4) implementing a pull system, and 5) striving for perfection, the project team has identified, prioritized, and put into effect measures to address the underlying causes of the issues ⁶⁵. An intervention plan was made against all the issues, and improvements were suggested. The association

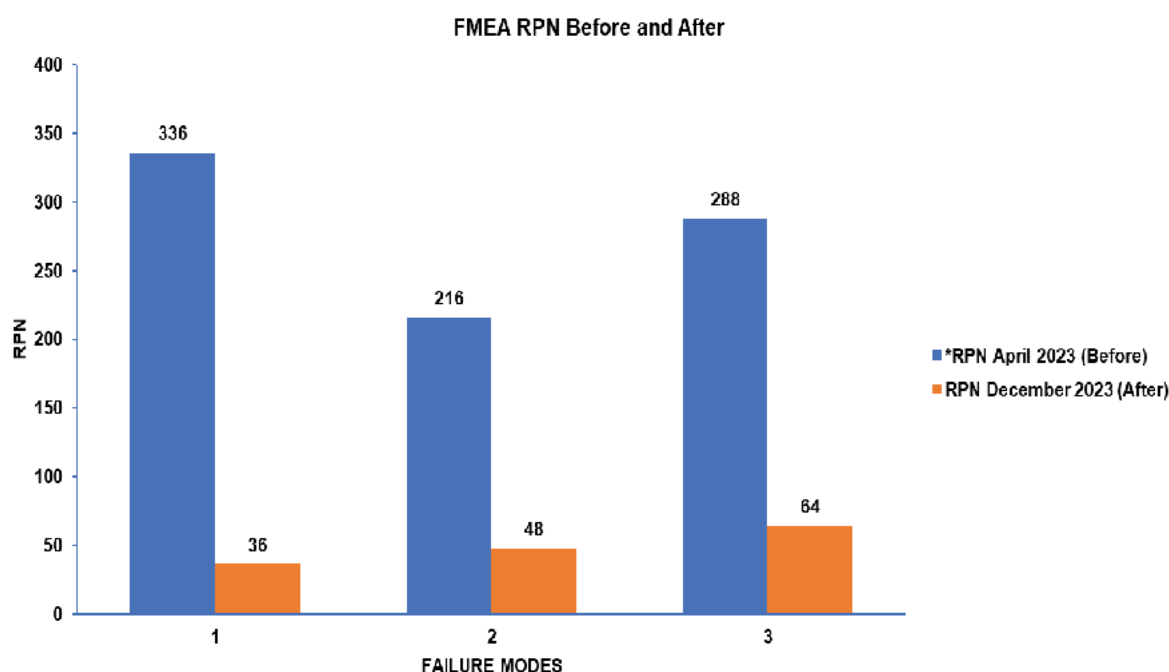


Figure 9. FMEA RPN scores before and after LSS interventions

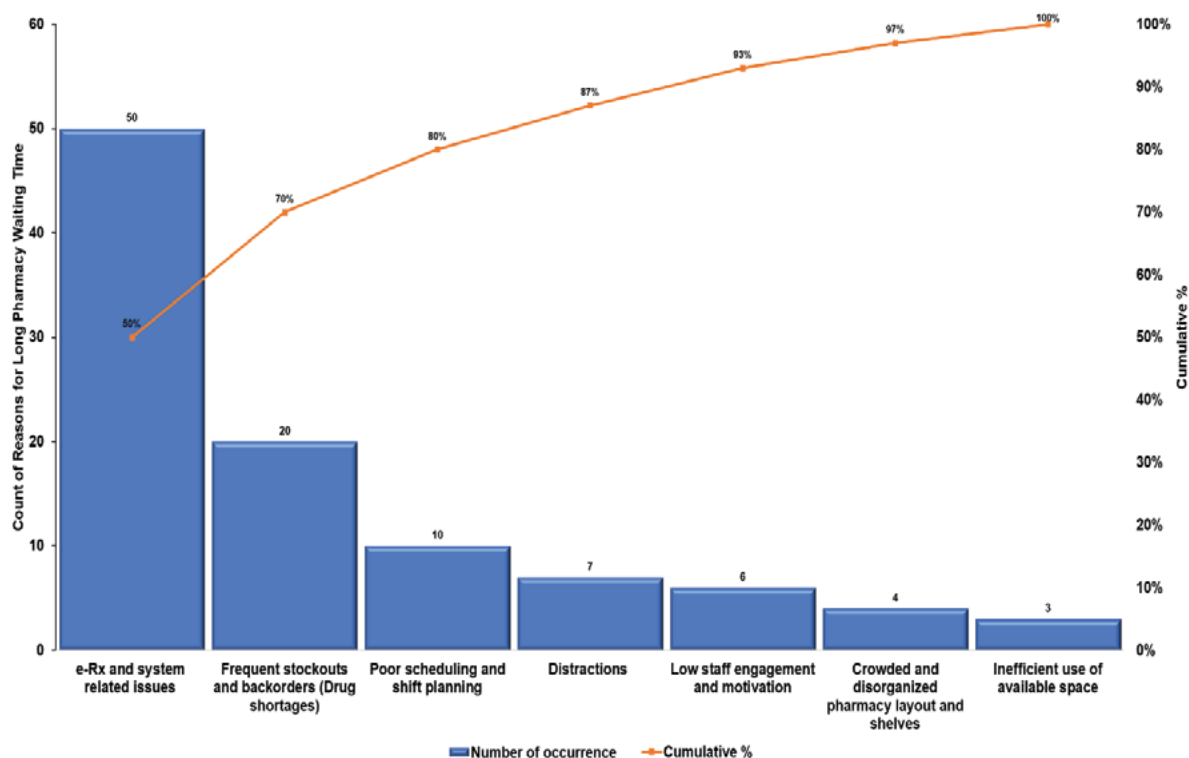


Figure 10. Pareto chart of contributing factors to long pharmacy waiting times

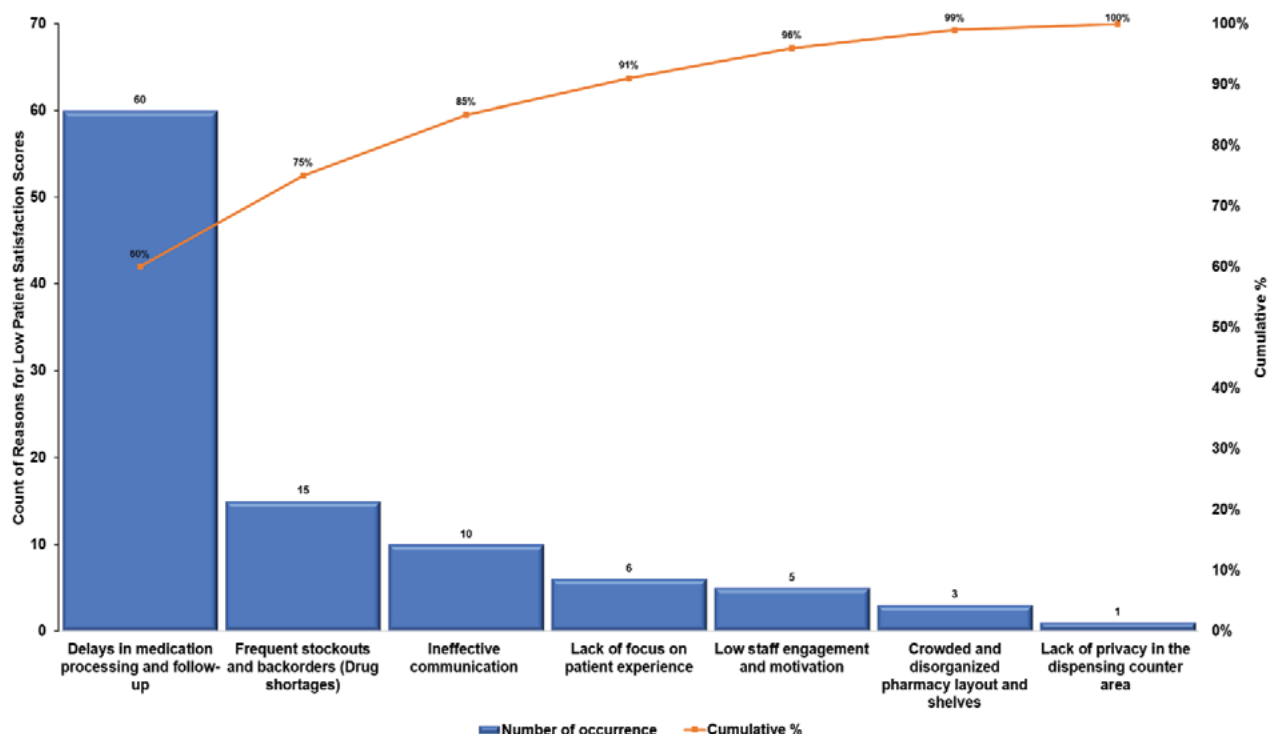


Figure 11. Pareto chart of reasons for low patient satisfaction scores

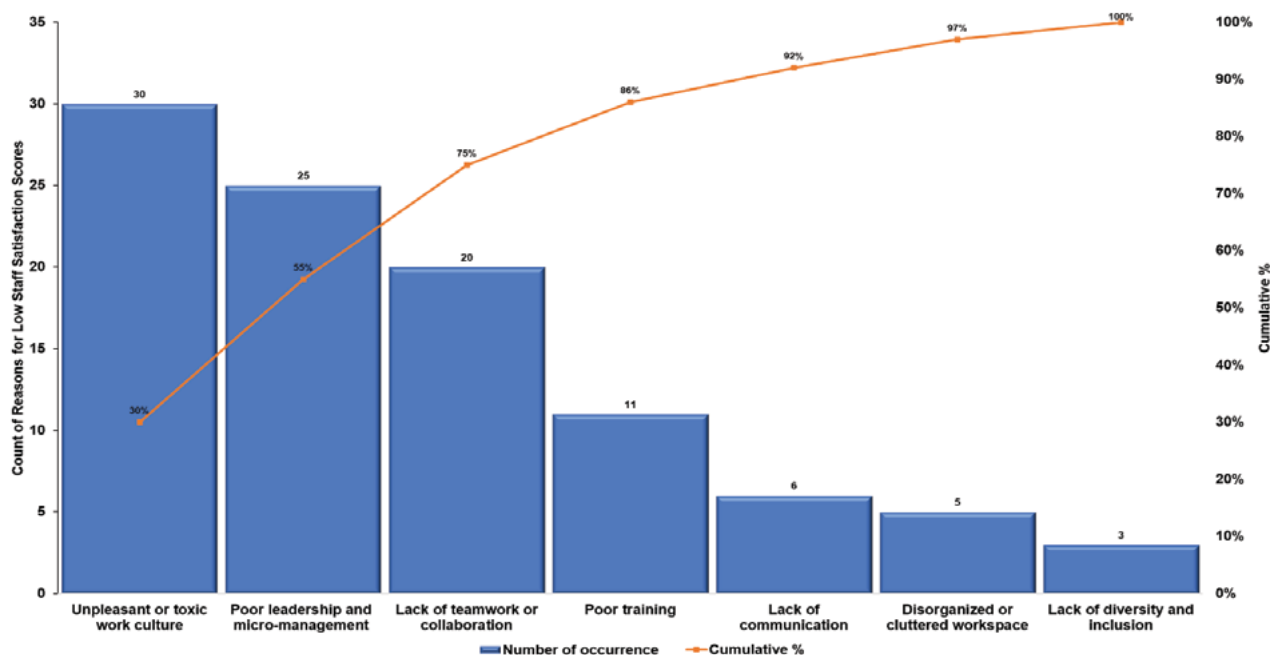


Figure 12. Pareto chart of causes for low staff satisfaction scores

between Lean and Six Sigma methodologies and three selected operational CTQS/KPIS efficiency in the hospital pharmacy. For the first KPI (average pharmacy waiting time), improvement was indicated through the decrease from a median of 18 minutes in the baseline/early Intervention to a median of 5.5 minutes in the Intervention phase ($P=0.003$, Mann-Whitney U test).

The charts and data concerning average pharmacy waiting times illustrated a significant reduction in wait times following LSS interventions. The initial baseline showed an average waiting time of 25 minutes, significantly disappointing the target of 7 minutes. Through successive phases of LSS interventions, these times were reduced considerably, and by the final assessment, average waiting times had stabilized around 6 minutes, exceeding target expectations. The trend chart (Figure 13) illustrates the mean wait time at the pharmacy between November 2022 and March 2024, demonstrating a notable decrease in wait times during this period. A significant turning point was observed seven months into the program. Initially, the average wait time was around 22 minutes in November 2022. By June 2023, this duration had been reduced to approximately 6.5 minutes, coinciding with the summer school break, which typically led to fewer patients due to seasonal variations. July and August also showed the shortest wait times, confirming the impact of seasonal changes on patient attendance. However, September saw a slight increase in wait times as patients returned from summer holidays, underscoring the need to adjust business plans and process improvements to accommodate seasonal fluctuations. November 2023 and March 2024 both experienced slight increases in average waiting times to 7 minutes, aligning with peak patient visits just before the winter and spring school breaks, respectively.

This trend highlighted the importance of factoring in seasonal variables in the planning and enhancing pharmacy operations to ensure sustained service quality throughout the year. The Sigma and DPMO graphs effectively quantify the improvements from Lean Six Sigma interventions. The Sigma level increased from about 2.5 to nearly 5.9, indicating a move towards higher process capability and reduced variability (Figure 14).

Correspondingly, the DPMO graph (Figure 15) shows a substantial decrease, indicating fewer defects per million opportunities in the long waiting times. This trend reflects a precise improvement in pharmacy efficiency, with the process standard deviation decreasing and aligning closely with the target minutes waiting time. These metrics reflect the success of the interventions in enhancing service speed and reducing wait times in the pharmacy.

The improvement strategies to reduce waiting times included early interventions such as ticket-based queue management and staff reallocation for peak coverage, followed by process mapping and automation in the measure/analyze phase to address bottlenecks, and post-intervention efforts focused on continuous process improvements and real-time customer feedback to adjust workflows dynamically (Table 9).

For the second KPI (patient satisfaction, net promoter score; NPS), improvement was observed through an increase from a median of 23 NPS in the baseline/early Intervention to a median of 49 in the Intervention phase ($P=0.003$, Mann-Whitney U test).

The series of data for KPI 2, which tracked the Net Promoter Score (NPS) reflecting patient satisfaction, showed substantial improvement following LSS interventions (Figure 16).

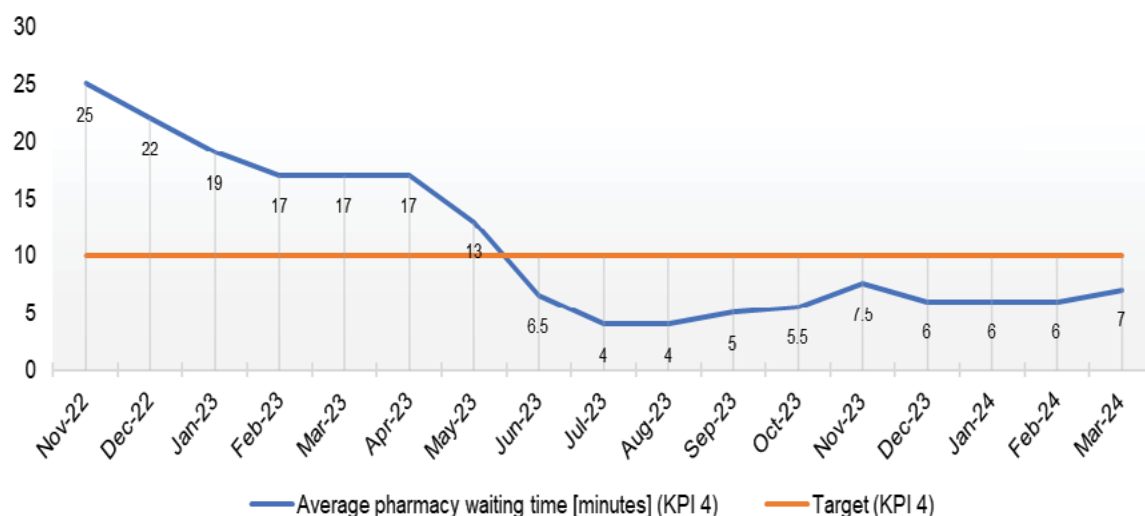


Figure 13. Average pharmacy waiting time (minutes)

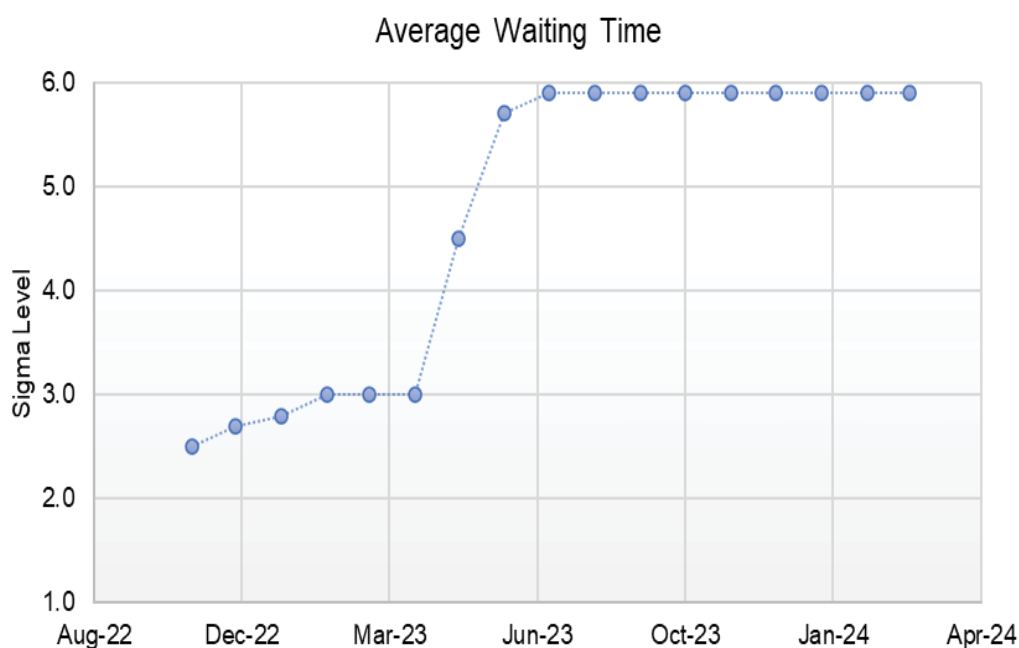


Figure 14. Sigma level for average waiting time

Table 9: Improvement strategies to reduce waiting time	
Phase	Interventions
Early Intervention (17-13 mins)	- Queue Management: Implementing a ticket-based or digital queue management system to streamline patient flow.
	- Staff Reallocation: Optimizing staff shifts and roles to ensure peak time coverage and efficiency.
Measure/Analyze (13-6.5 mins)	- Process Mapping: Detailed pharmacy workflow mapping and analysis to identify bottlenecks.
	- Automation: Introduction of automated dispensing systems to reduce manual handling times.
Post-Intervention (6-7 mins)	- Continuous Improvement Cycles: Regular review and refinement of processes based on ongoing data collection and analysis.
	- Customer Feedback Systems: Implementing real-time feedback tools to identify issues and adjust processes dynamically.

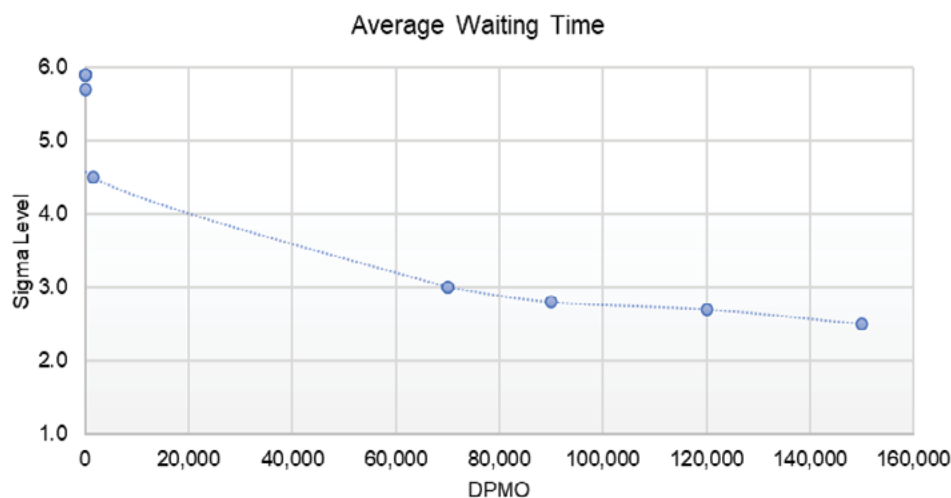


Figure 15. The negative correlation between DPMO and sigma levels for KPI 1

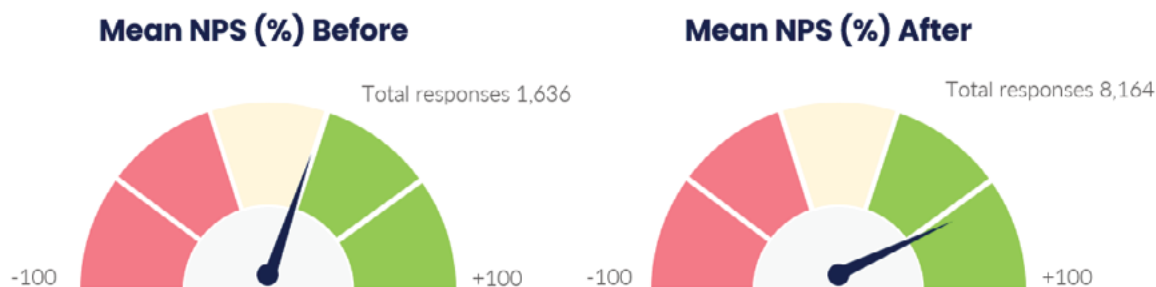


Figure 16. NPS scores before and after LSS implementation

Initial figures of around 20- 24% rose to an average of 52% by the end of the interventions, nearing the target of 53%. The graphical representation of the Net Promoter Score (NPS) for patient satisfaction at a hospital pharmacy between November 2022 and March 2024 (Figure 17) displayed a steady increase,

culminating in a noteworthy breakthrough after thirteen months of implementing improvement strategies. Initially, the patient satisfaction score was 20% in November 2022, influenced by long-standing perceptions of subpar service and negative past experiences. Over time, focused efforts on enhancing service

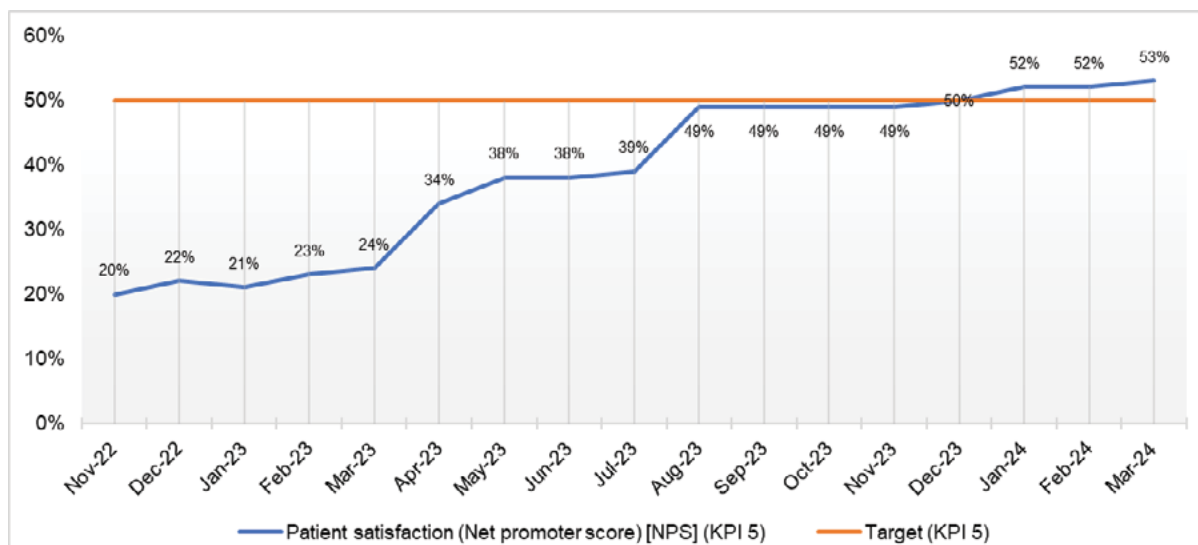


Figure 17. Percentage of patient satisfaction (NPS) scores

quality and patient engagement helped to gradually shift these perceptions. The slow but continuous improvement demonstrated the difficulties of altering established negative impressions and emphasized the necessity for persistent endeavors in improving service and customer interaction. By January 2024, the NPS had surpassed the 50% target, signaling a substantial enhancement in patient satisfaction. This progress resulted from ongoing staff training, refined service protocols, and implementation of systematic feedback mechanisms. The extended period to reach the target underscored the time and consistent dedication needed to improve patient perceptions in healthcare environments.

This positive trend in patient satisfaction was statistically supported by increases in Sigma levels, from about 3.4 to 3.6 (Figure 18), and reductions in DPMO, indicating fewer defects

per million opportunities and a higher process capability and consistency in service delivery (Figure 19).

Strategies to enhance patient satisfaction included early interventions with staff training and standardized service protocols, followed by real-time feedback systems and continuous process improvements during the measure/analyze phase, and post-intervention efforts focused on quality assurance and personalized patient engagement to maintain high service standards (Table 10).

For the third KPI (staff engagement score [Gallup Q12 survey]), improvement was observed through an increase from a median of 0.70 normalized mean Gallup Engagement Score in the baseline/early Intervention to a median of 0.96 in the post-intervention phase ($P=0.003$, Mann-Whitney U test). The data for KPI 3, which tracked staff engagement scores, showed a

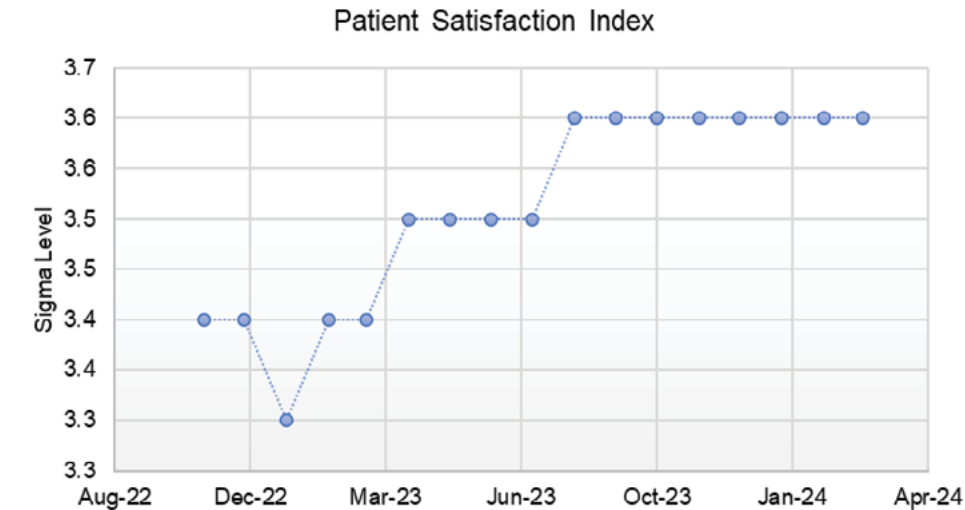


Figure 18. Sigma level for patient satisfaction (NPS) scores



Figure 19. The negative correlation between DPMO and sigma levels for KPI 2



Table 10: Improvement strategies targeting patient satisfaction	
Phase	Interventions
Early Intervention (34-49%)	- Staff Training: Enhanced customer service training for staff.
	- Service Protocols: Standardization of service protocols to ensure consistent patient experiences.
Measure/Analyze (49-52%)	- Feedback System: A real-time feedback system is implemented to capture and address patient concerns immediately.
	- Process Improvements: Continuous improvements based on feedback and data analytics to refine patient interactions and service delivery.
Post-intervention (52-53%)	- Quality Assurance: Regular quality assurance checks to maintain service standards.
	- Patient Engagement: Increased focus on patient engagement and satisfaction through personalized care and communication.

substantial enhancement following LSS interventions. Initially, engagement scores lingered at relatively low levels, between 0.40 and 0.45. With the implementation of LSS strategies, these scores surged dramatically, eventually reaching between 0.90 and 0.96 post-intervention, thereby exceeding the target of 0.8. The progression chart illustrating employee engagement ratings from November 2022 to March 2024 (Figure 20) revealed a substantial improvement, achieving the 90% goal within six months of enacting precise measures to enhance staff participation and satisfaction. Initially, the engagement scores remained between 40% and 45%, indicating a comparatively low level of staff drive and involvement. A significant shift occurred in May 2023, with scores rising to 81%, marking a breakthrough in employee engagement tactics. This notable increase can be attributed to comprehensive staff training, enhanced internal communication, and the implementation feedback mechanisms to address specific staff concerns and suggestions. The ongoing upward trend maintained scores above 90% from September 2023 onward, emphasizing the success of the persistent endeavors to foster a positive work environment and actively engage staff in decision-making processes. This graph showcased the efficacy of targeted strategies in elevating staff morale and engagement within the hospital pharmacy setting.

Statistical improvements supported this significant uplift in engagement; Sigma levels increased from below 3.1

to approximately 4.1 (Figure 21), indicating heightened consistency and efficiency in engagement practices. The defects per million opportunities (DPMO) experienced a substantial decline, evidenced by fewer process failures and increased operational effectiveness (Figure 22).

Approaches to boost pharmacy staff satisfaction included early engagement surveys and communication workshops, followed by recognition programs and prompt feedback implementation in the measure/analyze phase, and post-intervention strategies like continuous improvement meetings and enhanced training programs to support ongoing satisfaction and development (Table 11).

(B) Questionnaire

The information gathered from the survey aimed to enhance the factual results obtained from the LSS DAMIC study, providing a comprehensive understanding of how Lean and Six Sigma affected pharmacy service quality from both factual and personal perspectives.

Sample Characteristics

The final sample comprised a total of 168 participants (Table 12), with the majority of participants aged 44 years or younger (n=89, 53.0%), having 10 years or more work experience (n=104, 61.9%), physicians (n=93, 55.4%), having a postgraduate degree (n=111, 66.1%), and having a clinical job

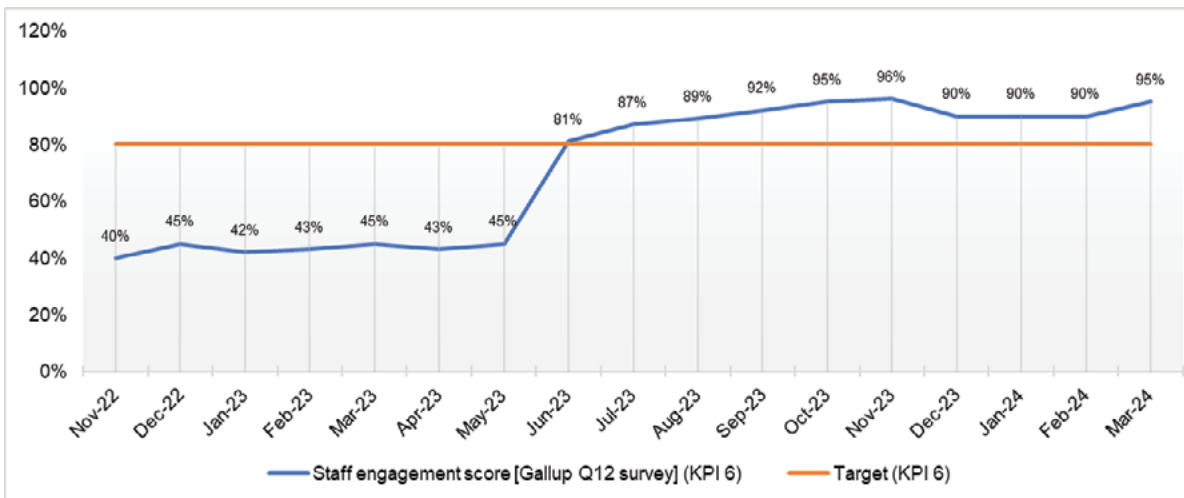


Figure 20. Percentage of staff engagement scores



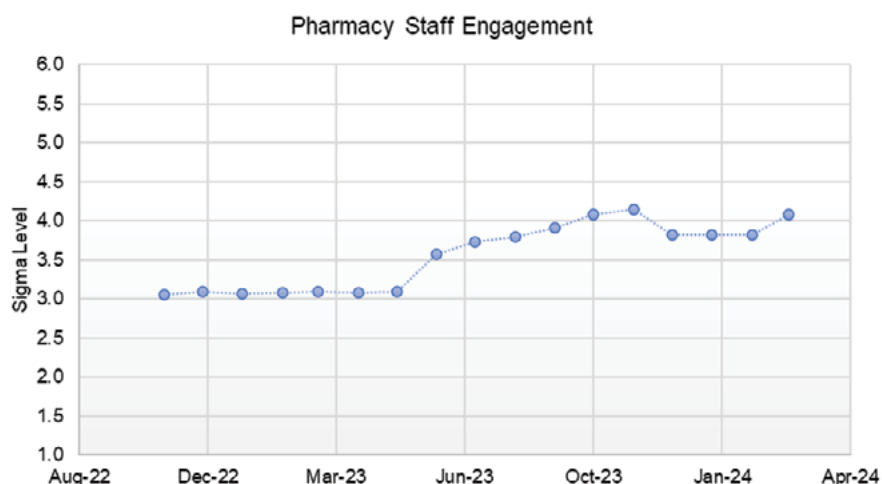


Figure 21. Sigma level for pharmacy staff satisfaction

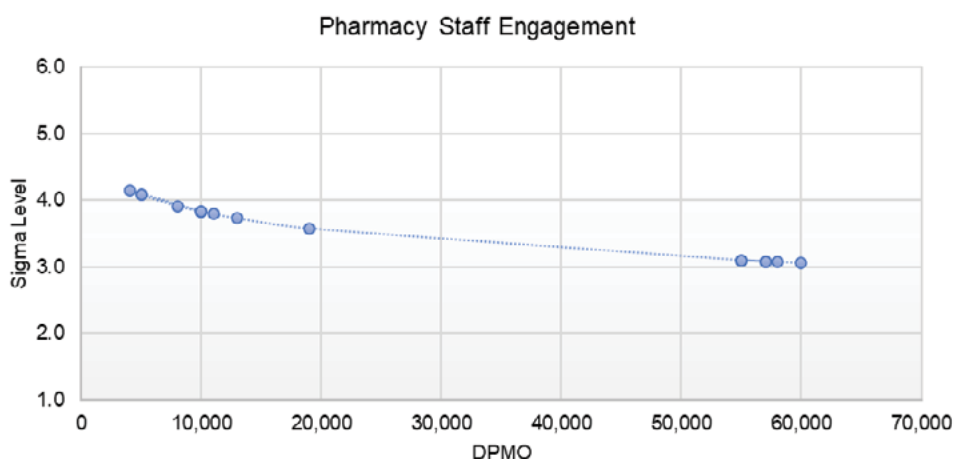


Figure 22. The negative correlation between DPMO and sigma levels for KPI 3

Table 11: Improvement strategies for pharmacy staff satisfaction

Phase	Interventions
Early Intervention (43-45%)	- Engagement Surveys: Regular surveys to gauge staff sentiment and identify areas for improvement.
	- Communication Workshops: Workshops to enhance internal communication and team collaboration.
Measure/Analyze (81-92%)	- Recognition Programs: Implementation of recognition programs to acknowledge staff contributions and achievements.
	- Feedback Implementation: Quick actions on feedback received from staff to show responsiveness and commitment to improvement.
Post-Intervention (90-96%)	- Continuous Improvement Meetings: Regular meetings to discuss ongoing improvements and sustain engagement levels.
	- Enhanced Training Programs: Ongoing training and development programs tailored to enhance job satisfaction and skill development.

Table 12: Questionnaire sample features

Variable	Category	Number	Percentage
Age	< 45 years	89	53.0%
	≥ 45 years	79	47.0%
Experience	< 10 years	64	38.1%
	≥ 10 years	104	61.9%
Gender	Male	83	49.4%
	Female	85	50.6%
Specialization	Management	11	6.5%
	Medical	93	55.4%
	Nursing	20	11.9%
	Pharmacy	44	26.2%
Education	Undergraduate	57	33.9%
	Postgraduate	111	66.1%
Job Function	Administrative, technical/ support, quality	28	16.7%
	Clinical, patient experience	140	83.3%

function (n=140, 83.3%). The gender distribution was almost equal, with 85 females (50.6%) vs. 83 males (49.4%).

Internal Consistency of the Individual Constructs and the Whole Questionnaire Segments

The reliability of the questionnaire designed to assess various dimensions of Six Sigma DMAIC methodology, service quality, and challenges and obstacles in hospital pharmacy settings was evaluated using Cronbach's alpha coefficients (Table 13). These coefficients measure internal consistency, indicating how closely related a set of items are as a group.

For the Six Sigma DMAIC methodology, the reliability scores ranged from 0.819 for the Define stage to 0.901 for the Improve stage, demonstrating good to excellent consistency across the different phases of the methodology. The overall reliability for the entire set of 25 items assessing the Six Sigma DMAIC methodology was exceptionally high at 0.962, suggesting that the items are very well suited to evaluating the construct cohesively.

Regarding service quality, the dimensions assessed included Tangible, Responsiveness, Reliability, Assurance, and Empathy. Cronbach's alpha coefficients for these dimensions were

Table 13: Cronbach alpha (α) coefficients to evaluate the consistency and reliability of the instrument

Dimension	Cronbach α Coefficients	No. of Questionnaire Items
Define stage	0.819	1. The hospital pharmacy assesses and identifies the basic requirements of the patients. 2. The hospital pharmacy actively investigates patient concerns regarding service quality. 3. The hospital pharmacy outlines the nature of patients' complaints about the service. 4. The hospital pharmacy determines the objectives for improvement. 5. The hospital pharmacy delegates specific staff members for improvement initiatives.
Measure Stage	0.853	1. The hospital pharmacy collects data on current service quality levels. 2. The hospital pharmacy employs a variety of systems to measure data accurately. 3. The hospital pharmacy assesses the present level of service quality. 4. The hospital pharmacy calculates the frequency of service errors. 5. The hospital pharmacy identifies crucial elements of the services offered.
Analyze Stage	0.889	1. The hospital pharmacy critically reviews the data it has collected. 2. The hospital pharmacy discerns the underlying reasons for customer complaints. 3. The hospital pharmacy conducts regular evaluations of the service quality. 4. The hospital pharmacy analyzes the correlation between customer requirements and feedback. 5. The hospital pharmacy identifies areas in need of improvement.
Improve Stage	0.901	1. The hospital pharmacy conceives innovative strategies to enhance service quality. 2. The hospital pharmacy implements appropriate adjustments to improve services. 3. The hospital pharmacy rectifies the identified causes of service complaints. 4. The hospital pharmacy conducts test runs for the proposed quality enhancements. 5. The hospital pharmacy verifies the implementation of service improvements.
Control Stage	0.863	1. The hospital pharmacy oversees the implementation of changes. 2. The hospital pharmacy evaluates the effectiveness of the changes made. 3. The hospital pharmacy formulates plans to manage and sustain the changes. 4. The hospital pharmacy creates short-term wins and conducts follow-ups on the change management process. 5. The hospital pharmacy reviews and adjusts the change process as needed.
Six Sigma DMAIC Methodology	0.962	25
Tangible	0.829	1. The hospital pharmacy maintains an interior that is conducive to providing service. 2. The hospital pharmacy ensures that the physical facility is appealing to patients. 3. The hospital pharmacy utilizes suitable equipment for service delivery. 4. The hospital pharmacy incorporates modern technology in its services. 5. The hospital pharmacy encourages a professional and well-groomed appearance among pharmacists.

Empathy	0.882	1. The hospital pharmacy prioritizes giving personal attention to each patient. 2. The hospital pharmacy is attuned to and addresses the specific needs of patients. 3. The hospital pharmacy instructs its pharmacists to give personalized care to patients. 4. The hospital pharmacy upholds the best interest of the patients in its services. 5. The hospital pharmacy schedules operating hours for the convenience of patients
Assurance	0.847	1. The hospital pharmacy trains its pharmacists in patient care and kindness. 2. The hospital pharmacy ensures its pharmacists are highly qualified to provide service. 3. The hospital pharmacy fosters a trusting relationship between pharmacists and patients. 4. The hospital pharmacy supports its staff in providing excellent service. 5. The hospital pharmacy equips its pharmacists with the knowledge to respond to patient inquiries.
Reliability	0.836	1. The hospital pharmacy fulfills the services as advertised to patients. 2. The hospital pharmacy ensures services are delivered within the promised timeframe. 3. The hospital pharmacy shows diligence in responding to patient complaints. 4. The hospital pharmacy consistently performs services correctly on the first attempt. 5. The hospital pharmacy maintains a standard of consistent service.
Responsiveness	0.865	1. The hospital pharmacy informs patients about the expected service timeframes. 2. The hospital pharmacy ensures that pharmacists are available and willing to assist. 3. The hospital pharmacy prepares its pharmacists to address patient requests efficiently. 4. The hospital pharmacy commits to providing quick service to patients. 5. The hospital pharmacy is prompt in managing patient requests as they arise.
Service Quality	0.956	25
Challenges and Obstacles	0.889	1. How frequently does insufficient training pose a problem for quality projects? 2. How frequently do staff resist new work methods? 3. What is the prevalence of inadequate support for projects of high quality? 4. At what frequency does working in isolation hinder collaboration in quality improvement projects? 5. How often do poor leadership, inadequate corporate support, and insufficient rewards demotivate staff in quality initiatives? 6. How often do regulations slow down process changes? 7. How common are resource shortages impacting the quality of projects? 8. How frequently are sustainability efforts in projects ignored? 9. How frequently does the presence of mistrust impact the uptake of novel methodologies? 10. How often do communication problems happen during project implementation?

similarly robust, ranging from 0.829 (Tangible) to 0.882 (Empathy), all indicating good reliability. The composite score for the Service Quality dimension, encompassing 25 items, was also very high at 0.956, confirming the instrument's reliability in comprehensively assessing service quality factors.

Finally, the dimension assessing Challenges and Obstacles faced in implementing Lean and Six Sigma methodologies showed a Cronbach's alpha of 0.889 for the ten items. This high score suggests that the instrument reliably captures the diverse challenges and obstacles facilitators encounter.

These findings affirm the high internal consistency of the questionnaire across all dimensions, supporting its utility and reliability in capturing the intended constructs within the context of hospital pharmacy operations. This consistency ensures that the questionnaire can be effectively used for diagnostic assessments and evaluations to improve service quality and project management practices.

Descriptive Statistics of the Five DMAIC Constructs as Scale Variables

For the Define construct, the mean value for the whole sample was 21.07 ± 2.20 ; for the Measure construct, the mean value was 21.01 ± 2.33 ; for the Analyze construct, the mean value was 20.83 ± 2.54 ; for the Improve construct, the mean value was 20.78 ± 2.63 , and for the Control construct the mean value was 20.96 ± 2.44 . The Kolmogorov-Smirnov test confirmed the non-normality in the distribution of the five scale variables with p -values of <0.001 for the five constructs, as indicated in the

five histograms (Figure 23).

Descriptive Statistics of the Five Service Quality Constructs as Scale Variables

For the Tangible construct, the mean value for the whole sample was 21.20 ± 2.58 ; for the Responsiveness construct, the mean value was 21.01 ± 2.32 ; for the Reliability construct, the mean value was 20.95 ± 2.31 ; for the Assurance construct, the mean value was 21.38 ± 2.12 , and for the Empathy construct the mean value was 21.23 ± 2.33 . The Kolmogorov-Smirnov test confirmed the non-normality in the distribution of the five scale variables with P -values of <0.001 for the five constructs, as indicated in the five histograms (Figure 24).

Descriptive Statistics of The Challenges and Obstacles Construct as a Scale Variable

For the Challenges and Obstacles construct, the mean value was 38.57 ± 8.12 , and the non-normal distribution was evident by the P -value of 0.002 using the Kolmogorov-Smirnov test as shown in (Figure 25).

The Association of Implementing Six Sigma DMAIC on Service Quality Corrected for Potential Confounders by the Demographic Factors

To test the association between the Six Sigma DMAIC constructs and the Service quality constructs, linear regression analyses were used with correction for covariates having P -values <0.100 in univariate analysis.



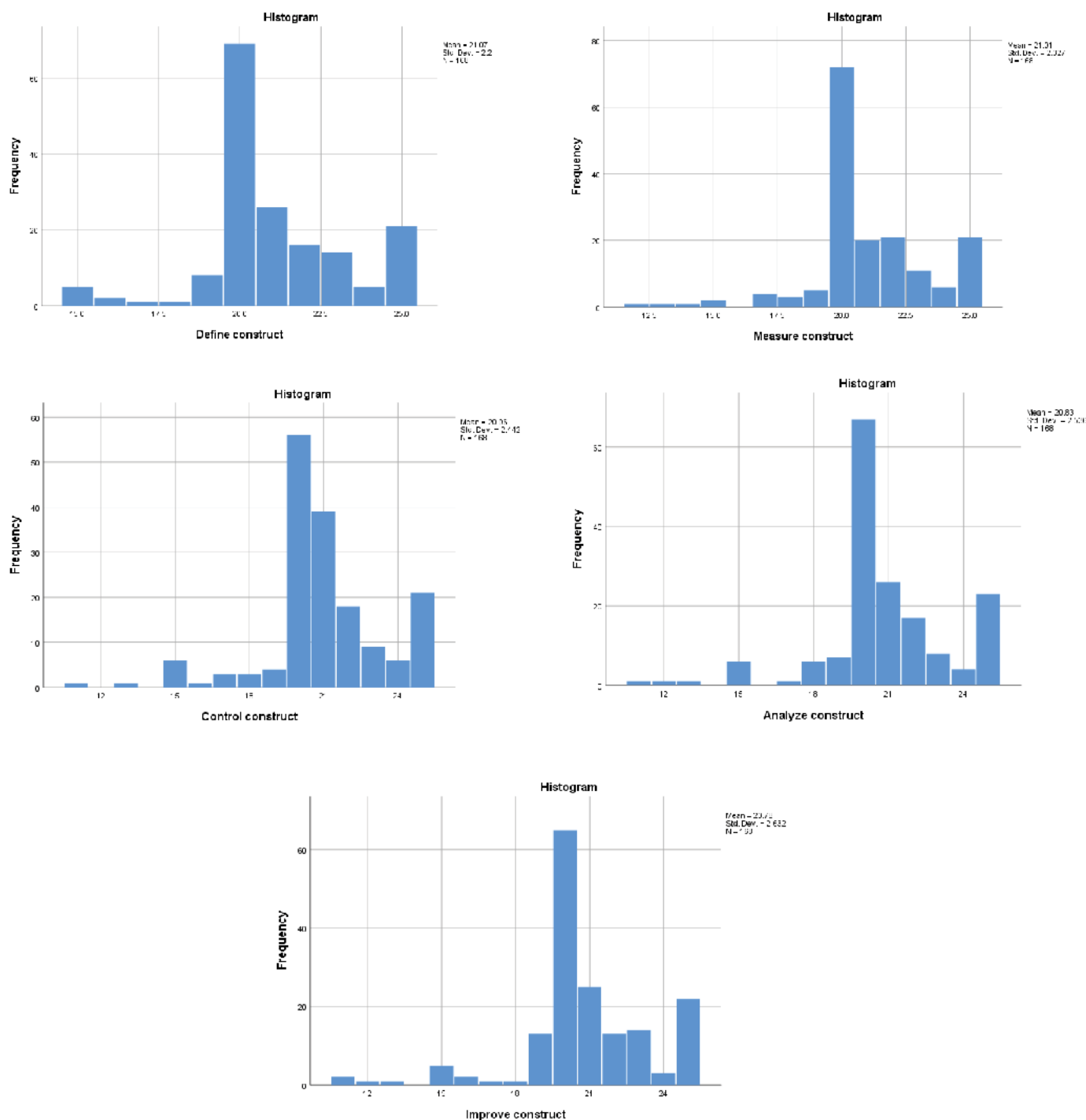


Figure 23. Five histograms of the DMAIC constructs as scale variables

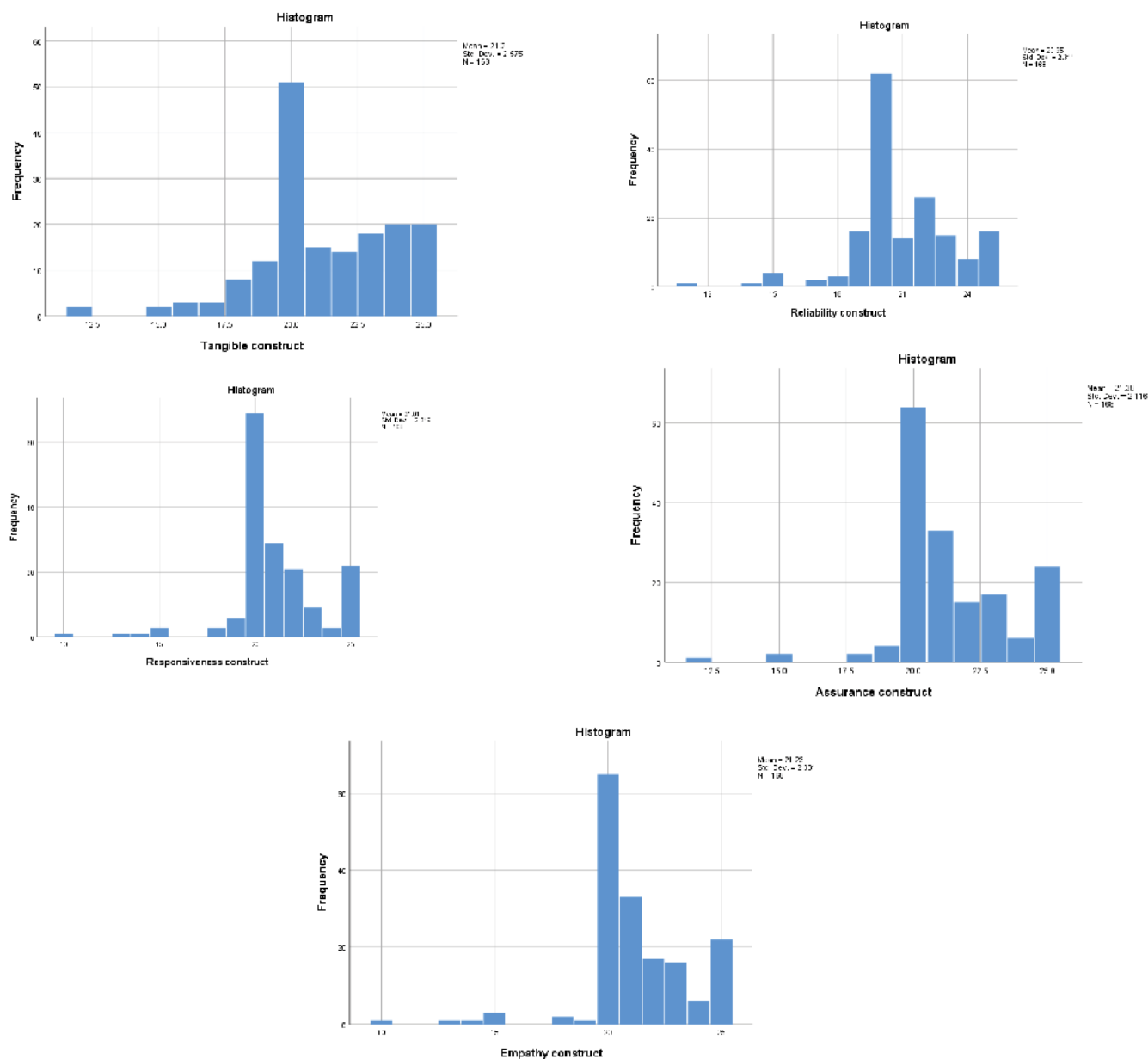


Figure 24. Histograms of the five service quality constructs as scale variables

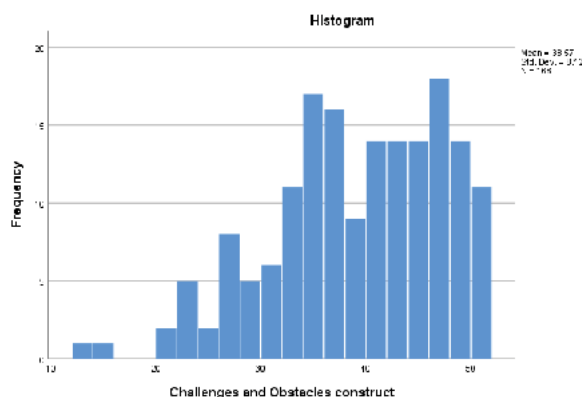


Figure 25. Histogram of the challenges and obstacles construct as a scale variable

The model summary indicates a good fit, with an R-square value of 0.408, suggesting that the model explains approximately 40.8% of the variance in the Tangible construct (Table 14) and (Figure 26). The Adjusted R-square, a more precise measure considering the number of predictors, stands at 0.386, confirming that the model reliably captures the data variability after accounting for the number of variables included.

The ANOVA results associated with the regression underline the model's statistical significance ($F=18.486$, $P<0.001$), indicating that the regression model significantly predicts the dependent variable over and above the mean model.

In terms of specific DMAIC constructs:

Define Construct: Showed a non-significant positive effect on the Tangible construct ($B=0.151$, $P=0.195$).

Measure Construct: Approached significance, suggesting a possible positive effect on improving Tangibility ($B=0.229$, $P=0.078$).

Analyze Construct: Had a non-significant negative impact ($B=-0.110$, $P=0.457$).

Improve Construct: Exhibited a significant positive impact, indicating that improvements in this construct lead to enhanced Tangibility ($B=0.284$, $P=0.041$).

Control Construct: Although contributing positively, it did not reach statistical significance ($B=0.210$, $P=0.229$).

Specialization, used as a covariate, showed no significant effect ($B=-0.100$, $P=0.561$), highlighting that the type of specialization did not significantly influence the relationship between DMAIC constructs and Service Quality regarding Tangibility.

These findings emphasized the role of various Six Sigma DMAIC process components in enhancing tangible aspects of service quality. Notably, the Improve construct appears particularly crucial in driving tangible improvements, substantiating the practical focus of this DMAIC phase on implementing effective changes. This analysis underscores the importance of strategic focus on specific DMAIC constructs to optimize service quality outcomes in organizational settings.

The regression analysis evaluated the impact of Six Sigma DMAIC constructs and various demographic variables on the Empathy construct within service quality. The model demonstrated considerable explanatory power and revealed several predictors contributing to empathy perceptions (Figure 27).

The correlation coefficient (R) of 0.774 indicates a strong positive relationship between the predictors and the Empathy construct. The model explains 59.9% of the variance in Empathy ($R^2 = 0.599$), with an Adjusted R Square of 0.576, confirming that the model is well-fitted to the data. The standard error of the estimate was 1.517, suggesting a reasonable precision in the predictions made by the model relative to the scale of the dependent variable.

Table 14: Linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (tangible construct)^a

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.639 ^a	0.408	0.386	2.018		
ANOVA ^b						
Model		Sum of Squares	df	Mean Square	F	P-value
1	Regression	451.603	6	75.267	18.486	<0.001 ^c
	Residual	655.516	161	4.072		
	Total	1107.119	167			
Coefficients ^d						
Model		Unstandardized Coefficients		Standardized Coefficients	t	P-value
		B	Std. Error	Beta		
1	(Constant)	5.438	1.596		3.407	0.001
	Specialization	-0.100	0.172	-0.037	-0.583	0.561
	Define construct	0.151	0.116	0.129	1.302	0.195
	Measure construct	0.229	0.129	0.207	1.771	0.078
	Analyze construct	-0.110	0.148	-0.108	-0.746	0.457
	Improve construct	0.284	0.138	0.291	2.062	0.041
	Control construct	0.210	0.174	0.199	1.208	0.229

^a Predictors: (Constant), Control construct, Specialization, Define construct, Measure construct, Improve construct, Analyze construct; ^b Dependent Variable: Tangible construct; ^c Predictors: (Constant), Control construct, Specialization_4, Define construct, Measure construct, Improve construct, Analyze construct; ^d Dependent Variable: Tangible construct



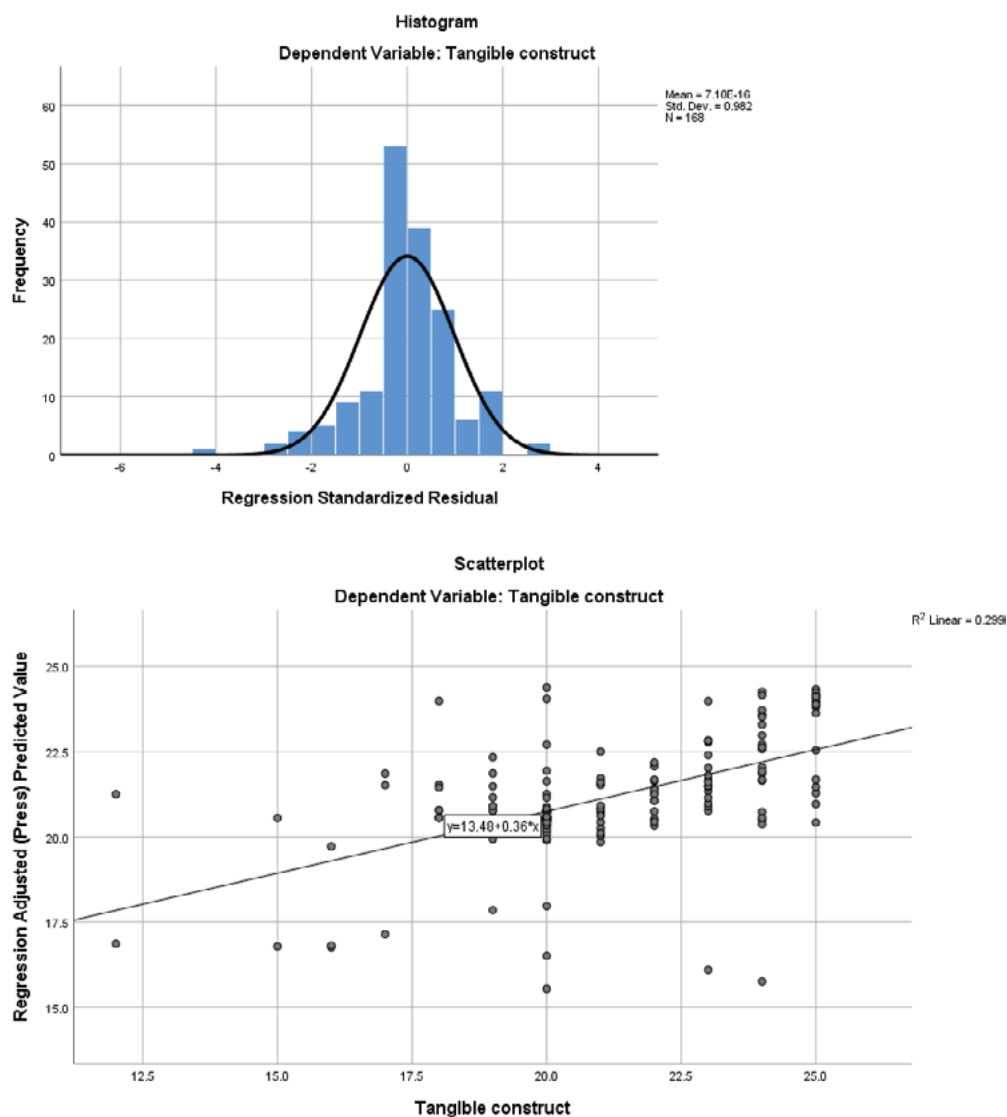


Figure 26. Histogram and scatter plot for linear regression analysis for the association of [implementing Six Sigma DMAIC on service quality (tangible construct)]

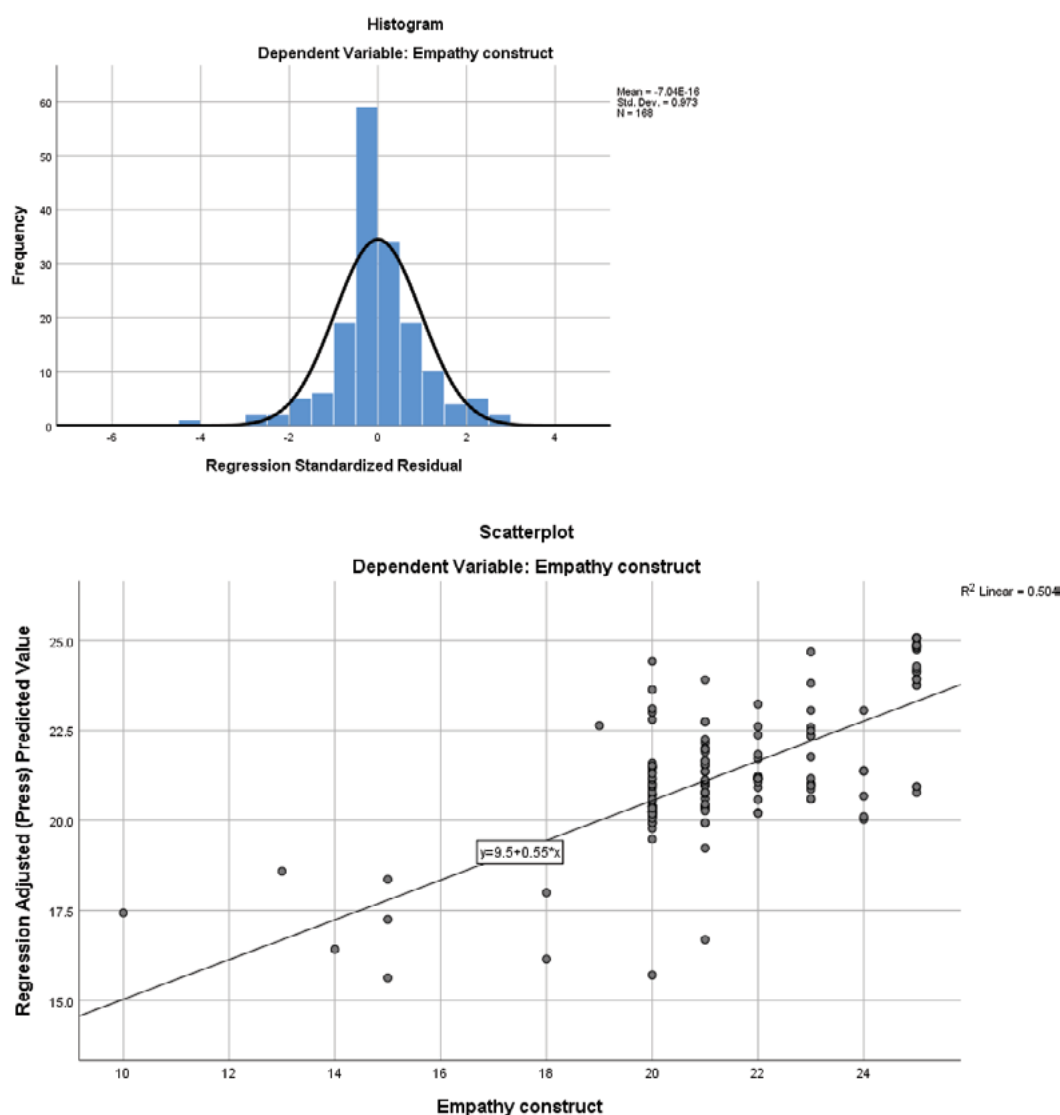


Figure 27. Histogram and scatter plot for linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (empathy construct)

The regression model was highly significant ($F = 26.246$, $P < 0.001$), indicating that the predictors collectively explain the variance in the Empathy construct significantly better than the mean model.

Coefficients Analysis (Table 15):

Measure Construct: Displayed a significant positive effect on Empathy ($B = 0.238$, $p = 0.016$). This suggests that precise and effective measurement processes are crucial in fostering empathetic engagements in service settings.

Experience: Showed a significant negative impact ($B = -0.741$, $P = 0.028$), indicating that more experienced individuals perceive or exhibit lower levels of empathy, potentially due to desensitization or routine exposure in their roles.

Define Construct: Approached significance ($B = 0.149$, $P =$

0.094), hinting that clear definitions and expectations might enhance empathy, though not conclusively significant within this model.

Improve and Control Constructs: While they showed positive coefficients, neither reached statistical significance ($P = 0.113$ and $P = 0.237$, respectively), suggesting their effects on empathy are not as pronounced or direct as those of measurement.

Age, Specialization, Education, and Analyze Construct: These variables did not significantly affect the Empathy construct, with p-values indicating that their contributions are minor or indistinct.

The regression analysis underscores the importance of measurement accuracy and experience in influencing empathy within service quality frameworks. The findings suggest that organizations should focus on enhancing measurement

Table 15: Linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (empathy construct)

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.774 ^a	0.599	0.576	1.517		
ANOVA ^b						
Model		Sum of Squares	df	Mean Square	F	P-value
1	Regression	543.718	9	60.413	26.246	<0.001 ^c
	Residual	363.686	158	2.302		
	Total	907.405	167			
Coefficients ^d						
Model		Unstandardized Coefficients		Standardized Coefficients	t	P-value
		B	Std. Error	Beta		
1	(Constant)	4.989	1.522		3.278	0.001
	Age	0.284	0.387	0.061	0.735	0.464
	Experience	-0.741	0.335	-0.155	-2.211	0.028
	Specialization	0.192	0.183	0.078	1.049	0.296
	Education	-0.041	0.337	-0.008	-0.122	0.903
	Define construct	0.149	0.088	0.14	1.685	0.094
	Measure construct	0.238	0.098	0.237	2.433	0.016
	Analyze construct	0.084	0.111	0.091	0.756	0.451
	Improve construct	0.165	0.104	0.187	1.595	0.113
	Control construct	0.156	0.132	0.164	1.188	0.237

^a Predictors: (Constant), Control construct, Experience, Education, Define construct, Specialization, Age, Measure construct, Improve construct, Analyze construct; ^b Dependent Variable: Assurance construct; ^c Predictors: (Constant), Control construct, Experience, Education, Define construct, Specialization, Age, Measure construct, Improve construct, Analyze construct; ^d Dependent Variable: Assurance construct

practices and consider the varied impacts of experience on empathy to improve this critical aspect of service quality effectively. Particular attention might also be beneficial in training and development programs to mitigate any potential decline in empathy among more seasoned employees.

The regression analysis assessed the effects of various Six Sigma DMAIC constructs and demographic factors on the Assurance construct of service quality. The analysis elucidates how these factors collectively influence the assurance provided in services (Figure 28).

The correlation coefficient ($R = 0.756$) indicates a strong positive relationship between the predictors and the Assurance construct. The model explains 57.2% of the variance in Assurance ($R^2 = 0.572$), with an Adjusted R^2 of 0.548, accounting for the number of predictors in the model and showing good model fit. The standard error of the estimate was 1.423, suggesting that the predictions are precise around the actual data points.

The ANOVA table shows that the regression model is highly significant ($F = 23.475$, $P < 0.001$). This indicates that the model predicts assurance better than a mean-only model, confirming that the included predictors help explain variations in assurance.

Coefficients Analysis (Table 16):

Control Construct: Displayed the most substantial positive influence on the Assurance construct ($B = 0.406$, $P = 0.001$). This suggests that effective control mechanisms are critical in ensuring service quality assurance.

Measure Construct: Also showed a significant positive effect ($B = 0.236$, $P = 0.011$), indicating that precise measurement processes contribute to higher service assurance.

Define, Analyze, and Improve Constructs: These constructs did not show significant effects individually on Assurance. Specifically, the Improve construct had almost no influence ($B = 0.004$, $P = 0.971$), and the Analyze construct had a slightly negative but non-significant effect ($B = -0.068$, $P = 0.514$).

Demographic Factors (Age, Experience, Education, Specialization): None of these factors significantly impacted Assurance, with p-values indicating that their individual effects were not statistically significant. This suggests that the demographic characteristics of individuals do not significantly alter how DMAIC processes influence Assurance in service quality.

The analysis demonstrates that among the DMAIC constructs, Control and Measurement are critical in enhancing Assurance within service quality frameworks. The lack of significance in

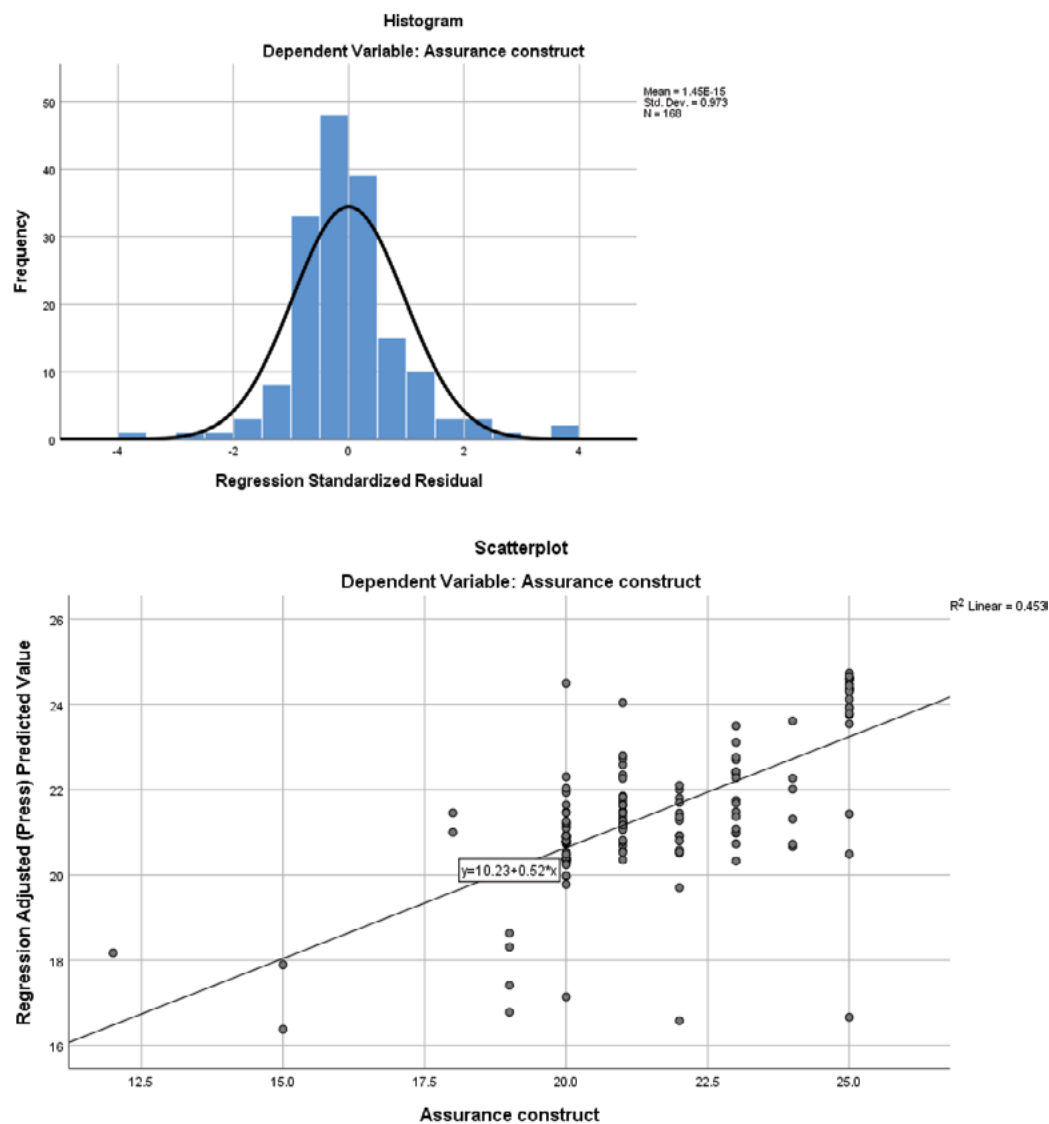


Figure 28. Histogram and scatter plot for linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (assurance construct)

Table 16: Linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (assurance construct)

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.756 ^a	0.572	0.548	1.423		
ANOVA ^b						
Model		Sum of Squares	df	Mean Square	F	P-value
1	Regression	427.741	9	47.527	23.475	<0.001 ^c
	Residual	319.879	158	2.025		
	Total	747.619	167			
Coefficients ^d						
Model		Unstandardized Coefficients		Standardized Coefficients	t	P-value
		B	Std. Error	Beta		
1	(Constant)	6.593	1.427		4.619	<0.001

	Age	-0.338	0.363	-0.08	-0.931	0.353
	Experience	-0.145	0.314	-0.033	-0.462	0.644
	Specialization	0.271	0.172	0.122	1.579	0.116
	Education	0.21	0.316	0.047	0.665	0.507
	Define construct	0.112	0.083	0.116	1.35	0.179
	Measure construct	0.236	0.092	0.26	2.574	0.011
	Analyze construct	-0.068	0.104	-0.082	-0.654	0.514
	Improve construct	0.004	0.097	0.004	0.037	0.971
	Control construct	0.406	0.123	0.468	3.288	0.001

^a Predictors: (Constant), Control construct, Experience, Education, Define construct, Specialization, Age, Measure construct, Improve construct, Analyze construct; ^b Dependent Variable: Assurance construct; ^c Predictors: (Constant), Control construct, Experience, Education, Define construct, Specialization, Age, Measure construct, Improve construct, Analyze construct; ^d Dependent Variable: Assurance construct

demographic factors suggests that the impact of DMAIC on Assurance is generally robust across different demographic groups. Organizations focusing on improving service quality through Assurance should emphasize enhancing their control and measurement practices to achieve significant improvements.

The linear regression analysis was conducted to investigate the effects of various Six Sigma DMAIC constructs, along with factors such as Education and Specialization, on the Reliability construct of service quality (Figure 29). The model showed a strong correlation coefficient ($R = 0.808$), explaining a substantial 65.3% of the variance in the Reliability construct ($R^2 = 0.653$). The Adjusted R^2 Square, refined to account for the number of predictors, stood impressively at 0.638.

The standard error of the estimate was relatively low at 1.39, indicating a good level of precision in the predictions made by the model.

The ANOVA results underscored the model's robustness, with a highly significant F-statistic ($F = 43.095$, $P < 0.001$). This confirms that the model, as a whole, significantly predicts reliability better than a mean model.

Coefficients Analysis (Table 17):

Control Construct: Exhibited the most substantial impact on the Reliability construct, with a high positive coefficient ($B = 0.44$, $P < 0.001$). This indicates that effective control mechanisms are crucial for ensuring reliability in processes.

Analyze Construct: It also showed a significant positive effect ($B = 0.243$, $P = 0.018$), suggesting that thorough DMAIC analysis enhances service quality outcomes' reliability.

Measure Construct: Although not statistically significant, this variable showed a positive trend ($B = 0.113$, $P = 0.207$), hinting that measurement precision might still play a role in influencing reliability.

Define and Improve Constructs: These did not demonstrate significant impacts on reliability, with p-values of 0.470 and 0.619, respectively, indicating that within this analysis, their roles may be less critical in directly affecting reliability outcomes.

Education and Specialization: Neither showed significant effects on reliability, with Education having a slightly negative, though non-significant, coefficient ($B = -0.409$, $P = 0.17$). This could imply that the level of formal education or field of specialization does not drastically alter how DMAIC impacts reliability. The findings emphasize that Control and Analyze are pivotal constructs in enhancing the reliability of service quality within the framework of Six Sigma DMAIC. The model's explanatory strong power and the significance of its predictors offer valuable insights for organizations aiming to enhance the reliability of their processes. The findings suggest that organizations should improve control measures and increase analytical rigor in project implementations.

The linear regression analysis explored the influence of Six Sigma DMAIC constructs along with demographic factors (Experience, Education, Age, and Specialization) on the Responsiveness construct of service quality (Figure 30). The model exhibited a high coefficient of determination ($R^2 = 0.519$), indicating that approximately 51.9% of the variance in the Responsiveness construct is explained by the predictor variables included in the model. The Adjusted R^2 value was 0.492, slightly lower than the R^2 value due to the adjustment for the number of predictors. Despite the adjustment, the adjusted R^2 still indicates a good fit for the model.

The standard error of the estimate stood at 1.653, suggesting the typical deviation of the observed values from the predicted values is approximately 1.65 units.

Using ANOVA, the regression model was statistically significant ($F=18.944$, $P<0.001$), demonstrating that the model significantly predicts the Responsiveness construct beyond what would be expected by chance alone.

In coefficients analysis (Table 18):

Define Construct: Demonstrated a significant positive impact on Responsiveness ($B=0.298$, $P=0.002$), suggesting that clearly defining processes and goals in Six Sigma projects enhances responsiveness.

Measure Construct: Also showed a significant positive effect ($B=0.275$, $P=0.011$), indicating that effective measurement of processes correlates with improved responsiveness.

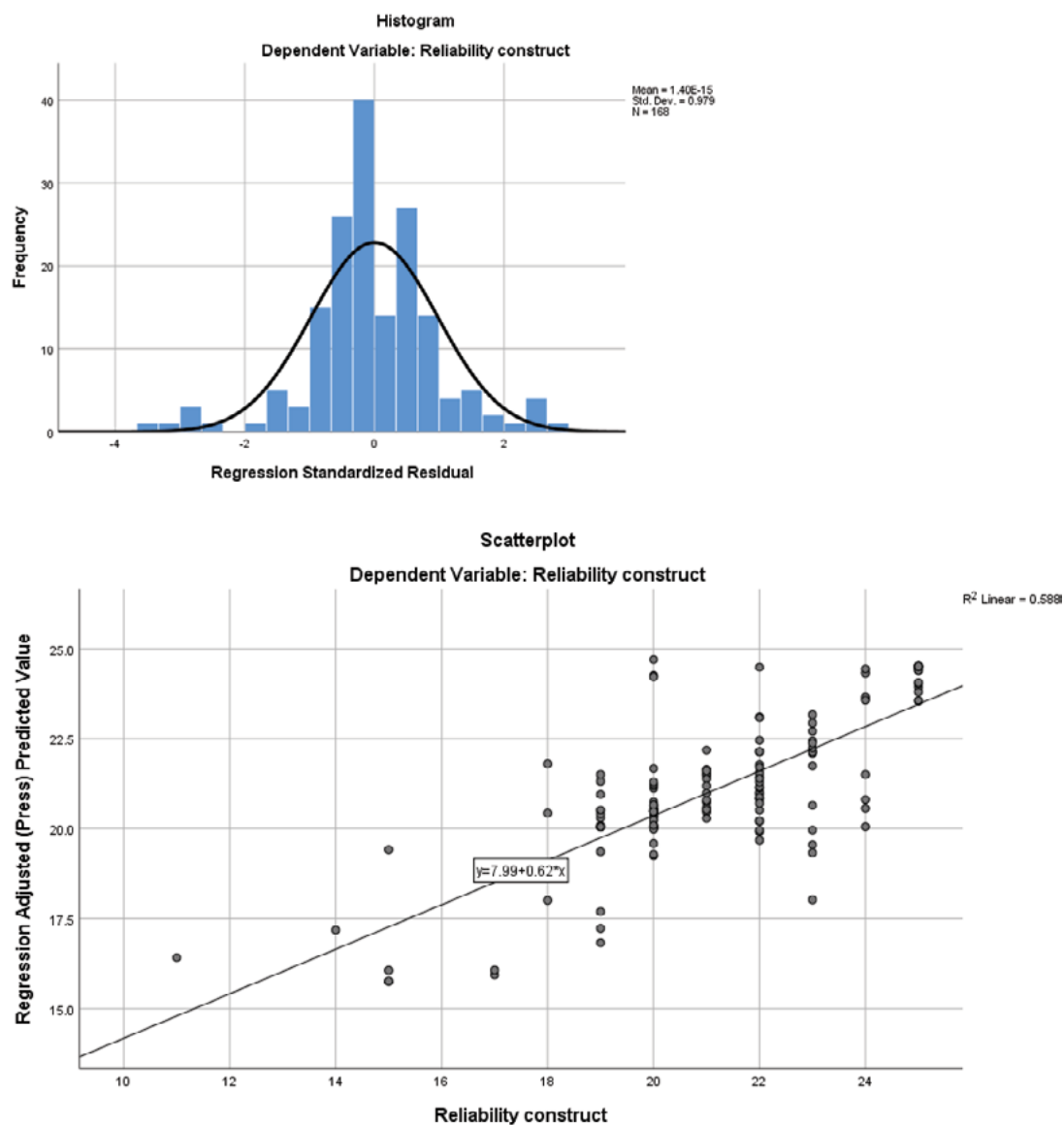


Figure 29. Histogram and scatter plot for linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (reliability construct)

Table 17: Linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (reliability construct)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.808 ^a	0.653	0.638	1.39		
ANOVA ^b						
Model		Sum of Squares	df	Mean Square	F	P-value
1	Regression	582.611	7	83.23	43.095	<0.001 ^c
	Residual	309.008	160	1.931		
	Total	891.619	167			
Coefficients ^d						
Model		Unstandardized Coefficients		Standardized Coefficients	t	P-value

		B	Std. Error	Beta		
1	(Constant)	4.664	1.309		3.562	<0.001
	Specialization	0.027	0.151	0.011	0.178	0.859
	Education	-0.409	0.297	-0.084	-1.377	0.170
	Define construct	0.058	0.08	0.055	0.725	0.470
	Measure construct	0.113	0.089	0.114	1.268	0.207
	Analyze construct	0.243	0.102	0.267	2.393	0.018
	Improve construct	-0.047	0.095	-0.054	-0.499	0.619
	Control construct	0.44	0.12	0.465	3.658	<0.001

^a Predictors: (Constant), Control construct, Education, Specialization, Define construct, Measure construct, Improve construct, Analyze construct; ^b Dependent Variable: Reliability construct; ^c Predictors: (Constant), Control construct, Education, Specialization, Define construct, Measure construct, Improve construct, Analyze construct; ^d Dependent Variable: Reliability construct

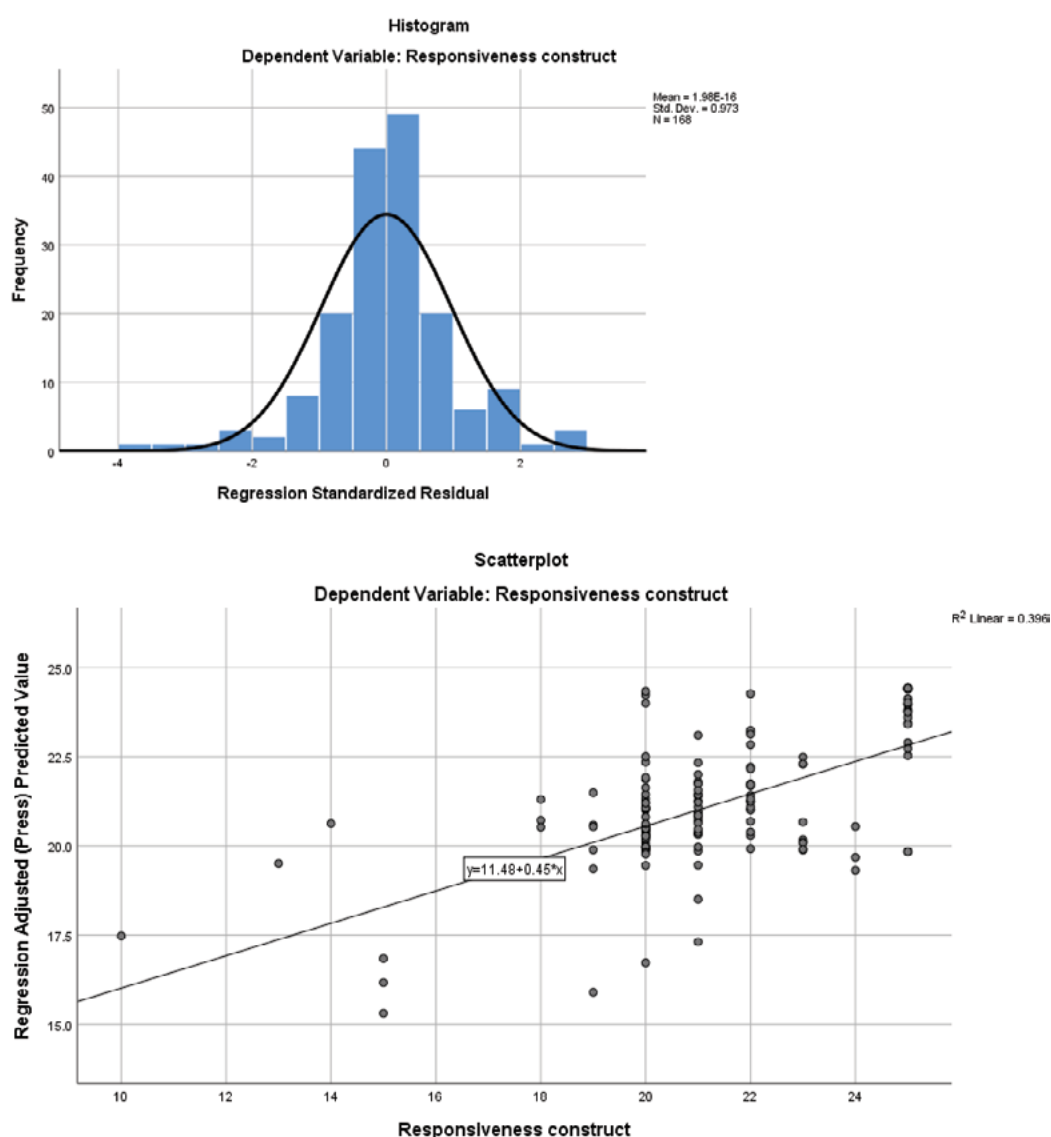


Figure 30. Histogram and scatter plot for linear regression analysis for the association of [implementing Six Sigma DMAIC on service quality (responsiveness construct)]

Table 18: Linear regression analysis for the association of implementing Six Sigma DMAIC on service quality (responsiveness construct)^f

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.720 ^a	0.519	0.492	1.653		
ANOVA ^b						
Model		Sum of Squares	df	Mean Square	F	P-value
1	Regression	466.073	9	51.786	18.944	<0.001 ^c
	Residual	431.903	158	2.734		
	Total	897.976	167			
Coefficients ^d						
Model		Unstandardized Coefficients		Standardized Coefficients	t	P-value
		B	Std. Error	Beta		
1	(Constant)	5.457	1.659		3.29	0.001
	Age	0.061	0.422	0.013	0.145	0.885
	Experience	-0.364	0.365	-0.077	-0.998	0.320
	Specialization	0.03	0.199	0.012	0.15	0.881
	Education	-0.227	0.367	-0.046	-0.618	0.538
	Define construct	0.298	0.096	0.283	3.099	0.002
	Measure construct	0.275	0.107	0.276	2.576	0.011
	Analyze construct	-0.201	0.121	-0.22	-1.661	0.099
	Improve construct	-0.101	0.113	-0.115	-0.897	0.371
	Control construct	0.506	0.143	0.532	3.527	0.001

^a Predictors: (Constant), Control construct, Experience, Education, Define construct, Specialization, Age, Measure construct, Improve construct, Analyze construct; ^b Dependent Variable: Responsiveness construct; ^c Predictors: (Constant), Control construct, Experience, Education, Define construct, Specialization, Age, Measure construct, Improve construct, Analyze construct; ^d Dependent Variable: Responsiveness construct

Control Construct: Provided the most substantial positive contribution to the model ($B=0.506$, $P=0.001$), underscoring the importance of maintaining control in ongoing processes to boost responsiveness.

Analyze Construct: This predictor approached statistical significance ($B=-0.201$, $P=0.099$), with a negative coefficient suggesting that analysis activities might slightly detract from responsiveness, potentially due to the time and resources consumed during detailed analyses.

Improve Construct: This did not show a significant effect ($B=-0.101$, $P=0.371$), indicating no apparent impact of improvement efforts on responsiveness within the scope of this model. Demographic Factors: Age, Experience, Education, and Specialization (e.g., B for Experience = -0.364 , $P=0.320$) did not significantly affect Responsiveness, suggesting that the demographic background of individuals does not heavily influence how responsive they are within the context of Six Sigma projects.

The regression model illustrates that certain DMAIC constructs, particularly Define, Measure, and Control, are crucial for enhancing Responsiveness in service quality contexts. These findings highlight areas where management focus could intensify to foster improved responsiveness in organizational settings, mainly through clear definition, precise measurement, and stringent control of processes.

DISCUSSION

The healthcare sector has not traditionally been a leader in advancing processes, improving service quality, and managing change.⁶⁶ It is often perceived as lagging behind other industries in terms of information technology adoption and embracing of methodologies such as Lean and Six Sigma, which occurred long after other industries had implemented them.⁶⁷ Despite significant medical technology advancements, the healthcare industry has been slower to address cost containment, service quality, and efficiency metrics.^{68, 69}

Business performance is characterized by a collection of attributes used to evaluate the productivity and competence of employees' actions.⁷⁰ This major project was effectively executed by utilizing the DMAIC framework and Lean Six Sigma tools, including process mapping, Pareto analysis, cause and effect analysis (Ishikawa diagram), supplier, input, process, output, and customer (SIPOC), root cause analysis (RCA), failure mode and effects analysis (FMEA). Additionally, three critical-to-quality specifications (CTQS) were initially identified to assess the project's success.

Impact of Lean and Six Sigma Methodologies on Three Selected Operational CTQs/KPIs Efficiency in Hospital Pharmacy

The DMAIC method offered a framework for managing issues within existing business protocols, utilizing tailored tools,



techniques, and concepts for each unique case or project. Executing Lean Six Sigma methodologies allowed the hospital pharmacy to achieve a notable transformation, leading to sustainable enhancements in its daily operations. The project also bolstered the LSS mindset within the pharmacy department, underscoring the ability to prioritize and rectify efficiency issues with a view to achieving cost-effective solutions. This, in turn, empowered the workforce to champion and disseminate enhancements throughout the hospital, demonstrating tangible, value-adding benefits.⁷¹

Implementing Lean and Six Sigma methodologies at the Mediclinic Parkview Hospital Pharmacy has significantly improved operational efficiency and quality metrics. This methodology has positively impacted three key performance indicators (KPIs) essential for the hospital pharmacy's performance. This alignment with Lean and Six Sigma principles has led to notable improvements across critical-to-quality (CTQ) metrics.

Waiting times at the pharmacy were significantly decreased from an average of 25 minutes to approximately 6 minutes through the implemented interventions. This exceeded the set efficiency targets and led to improved patient satisfaction. Reduced waiting times improved the patient experience and resulted in financial gains by increasing the number of patients served and reducing operational costs.

Efforts to improve patient satisfaction (as measured by the Net Promoter Score) resulted in a notable increase, with the NPS rising from 20-24% to 52%, approaching the desired level of 53%. These enhancements in patient satisfaction resulted from ongoing enhancements in service delivery, which translated to a significant annual revenue increase due to improved patient retention.

Employee Engagement focused on enhancing staff morale and involvement. The measures implemented resulted in an increase in Gallup Q12 survey scores from 3.49 to 4.5. Improved engagement strategies led to a notable decrease in turnover and a rise in productivity, both crucial for maintaining operational efficiency and ensuring the quality of patient care. This enhancement in staff morale is projected to have saved the hospital per year in costs related to turnover.

Impact of Lean Six Sigma DMAIC on Service Quality Constructs

Analyzing the results, which examined the influence of Six Sigma DMAIC constructs and various demographic factors on different service quality dimensions (Tangible, Empathy, Assurance, Reliability, and Responsiveness), several key insights and patterns emerge:

1. Significance of DMAIC constructs across different service quality dimensions

Control Construct: Consistently influential, showing significant positive effects across multiple dimensions such as Tangible, Assurance, and Empathy. This suggests maintaining control over processes is crucial for enhancing overall service quality.

Measure Construct: Significant in improving both Tangible and

Empathy constructs. Accurate and thorough measurement is fundamental for organizations aiming to improve service quality.

Improve Construct: Showed variable impact, significant in some contexts (e.g., Tangible) but not others (e.g., Empathy). This indicates that the effects of improvement initiatives might depend heavily on the specific service quality dimension being targeted.

2. Impact of demographic factors

Demographic variables like Age, Experience, Education, and Specialization generally had less consistent impacts across the service quality dimensions, with a few exceptions:

Experience: It negatively affected the Empathy construct, suggesting that more experienced individuals might perceive or exhibit lower levels of empathy.

Age and Education generally did not have significant effects, implying that these factors might not play a crucial role in influencing service quality perceptions related to Six Sigma initiatives.

3. Overall model effectiveness

The models generally showed good explanatory power, with R-squared values indicating that the models accounted for a substantial portion of the variance in the dependent variables. For example, the Tangible and Empathy constructs models explained about 57% to 60% of the variance, suggesting overall solid model performance.

4. Analytical insights

The consistent significance of certain constructs (like Control and Measure) across different models suggests that these elements of the DMAIC process are universally crucial for enhancing service quality.

The variability in significance and impact of the Improve and Analyze constructs across different service quality dimensions indicates that the effectiveness of these DMAIC phases may need to be contextually adjusted based on specific service quality goals.

5. Implications for practice

The findings underscore the importance of a focused approach in implementing Six Sigma methodologies, especially on elements like Control and Measurement, which appear broadly beneficial.

Organizations should consider the specific impacts of DMAIC phases and tailor their process improvement strategies according to which aspects of service quality they aim to enhance.

Training and continuous development in DMAIC methodologies should address the varied impacts across different demographic groups and service quality dimensions to optimize outcomes.

In general, the analyses provided valuable insights into how Six Sigma DMAIC constructs differentially affect various service



quality dimensions and how demographic factors play into these dynamics. These findings can guide organizations in refining their quality improvement initiatives to suit their specific service contexts and workforce compositions. Lean Leadership was pivotal in fostering a structured, team-driven approach to enhance service quality outcomes.

Study Limitations

Despite the accuracy of the data obtained from the pharmacy database, this study is limited by its use of a study design from a single healthcare facility. Self-administered questionnaire provided valuable insights into participants' perceptions and experiences; however, it is susceptible to response bias.

Recommendation for Future Studies

Future research could explore new theories and methods in operations management, specifically for hospital pharmacies, which might help to improve the quality of pharmacy and healthcare services. From an academic perspective, it is necessary to incorporate subjects in operations management, such as Lean Six Sigma, into the academic program of pharmacy schools, which could significantly improve the practical educational structure. Students possessing essential skills in process enhancement, productivity, and quality control are essential in the present healthcare setting. It would also be beneficial for future studies to address practical challenges and objective factors in implementing Lean and Six Sigma. The economic impact of LSS on healthcare processes warrants further investigation in future studies. The practical significance of time-driven activity-based costing (TDABC) could be explored further. Potential future work may also incorporate the costing process into a highly automated Artificial Intelligence or visual management system, allowing employees to quantify the advantages more effectively. Additionally, there is a clear need for hands-on research to understand how innovative management systems, along with Artificial Intelligence (AI) and robotics, can transform pharmacy operations.⁷²

CONCLUSIONS

With the pressing need for efficient resource utilization, patient satisfaction, and employee engagement in the contemporary healthcare system, the adoption of an innovative pharmacy quality improvement strategy to achieve precise results was both necessary and urgent. Lengthy waiting times in hospital pharmacy was a significant concern, delaying treatment, affecting patient expectations, increasing healthcare costs, and causing revenue losses.

Applying a quality improvement methodology grounded in the Lean Six Sigma DMAIC principles significantly enhanced the operational efficiency of hospital pharmacy services. This comprehensive framework provided a structured approach for identifying and mitigating inefficiencies, elevating key quality indicators. The successful execution of these modifications required a commitment from leadership and a collaborative effort among all team members.

AUTHORS CONTRIBUTIONS

Dr. Mohammed Sallam: Conceptualization, data analysis, data visualization, supervision, original draft manuscript preparation, final review.

Dr. Albert Oliver: Data collection, validation, review and editing manuscript.

Dr. Doaa Allam: Data collection, review and editing manuscript.

Dr. Rana Kassem: Data collection, review and editing manuscript.

All authors read and approved the final manuscript

CONFLICT OF INTEREST

There is nothing to declare.

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