

Midocean University

College of Management

Department of Health Administration

Master's Research Project

**“The Impact of Implementing Quality
Performance Indicators on Operational Efficiency
in Clinical Laboratories:
A Field Study at Dr. Sulaiman Al-Habib Hospital –
Al-Suwaidi Branch**

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Academic Year: 2025

جامعة ميدأوشن

كلية الإدارة

قسم / تخصص ماجستير إدارة صحية ..

عنوان البحث /

“أثر تطبيق مؤشرات الأداء الجيدة على الكفاءة التشغيلية في المختبرات
الطبية: دراسة ميدانية في مستشفى الدكتور سليمان الحبيب – فرع
السويدي

إعداد

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العام الدراسي:

2025

ABSTRACT

This study examines the impact of Quality Performance Indicators (QPIs) on operational efficiency in the clinical laboratory of Dr. Sulaiman Al-Habib Hospital (Al-Suwaidi Branch) during the years 2024 and 2025. The research evaluates multiple indicators—including turnaround time, specimen rejection, blood culture contamination, phlebotomy performance, and critical value reporting—using actual laboratory performance data. The findings reveal substantial improvements in 2025 across all major operational areas, demonstrating the effectiveness of structured QPI monitoring in enhancing workflow efficiency, reducing errors, and improving patient safety. The study concludes that consistent QPI implementation plays a vital role in strengthening laboratory processes, supporting accreditation readiness, and achieving sustainable quality improvement aligned with international standards such as CAP and ISO 15189. Overall, the findings confirm that structured QPI monitoring significantly enhances laboratory operational efficiency, reduces errors, and strengthens accreditation readiness, demonstrating its essential role in improving patient-centered laboratory performance

المستخلص

تتناول هذه الدراسة أثر مؤشرات الأداء والجودة (QPIs) على الكفاءة التشغيلية في المختبر الإكلينيكي بمستشفى د. سليمان الحبيب - فرع السويدي خلال عامي 2024 و2025. وتُقيّم الدراسة عدداً من المؤشرات الأساسية، مثل وقت إخراج النتائج (TAT)، ونسبة العينات المرفوضة، ومعدل تلوث مزرعة الدم، وأداء سحب العينات، والإبلاغ عن القيم الحرجة، اعتماداً على بيانات أداء فعلية من المختبر. وقد أظهرت النتائج تحسناً كبيراً في عام 2025 عبر جميع مجالات التشغيل، مما يؤكد فعالية تطبيق المؤشرات في رفع كفاءة العمل، وتقليل الأخطاء، وتعزيز سلامة المرضى. وتخلص الدراسة إلى أن تطبيق مؤشرات الأداء والجودة بشكل منظم يسهم بشكل جوهري في تقوية العمليات المختبرية، ودعم متطلبات الاعتمادات الدولية، وتحقيق تحسين مستدام في الجودة وفقاً لمعايير CAP و ISO 15189. وتؤكد النتائج أن المتابعة المنظمة لمؤشرات الأداء والجودة تسهم بشكل كبير في رفع الكفاءة التشغيلية للمختبر، وتقليل الأخطاء، وتعزيز جاهزية الاعتماد، مما يجعل هذه المؤشرات عنصراً أساسياً في تحسين جودة الأداء المخبري القائم على رعاية المريض".

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to everyone who supported me throughout the completion of this research. My appreciation extends to the laboratory leadership and team at Dr. Sulaiman Al-Habib Hospital – Al-Suwaidi Branch for their continuous guidance, cooperation, and dedication to quality improvement.

Special thanks are extended to my colleagues in the Hematology Section, the Quality Department, and all teams involved in Quality Performance Indicator monitoring. Their efforts and collaboration greatly contributed to the success of this study.

I am profoundly grateful to my academic instructors for their valuable mentorship and for equipping me with the scientific and analytical tools necessary to complete this work.

Finally, I extend heartfelt thanks to my family for their endless support, patience, and encouragement throughout my academic journey.

الشكر والتقدير

أتقدم بجزيل الشكر والتقدير لكل من قدّم لي الدعم والمساندة خلال إعداد هذا البحث. كما أتوجه بالشكر إلى قيادة المختبر وفريق العمل في مستشفى د. سليمان الحبيب - فرع السويدي على تعاونهم المستمر، وتوجيههم، وحرصهم الدائم على تطوير جودة الأداء.

وأخص بالشكر زملائي في قسم أمراض الدم، وقسم الجودة، وجميع الفرق المشاركة في متابعة مؤشرات الأداء والجودة، حيث كان لتعاونهم وجهودهم دورٌ كبير في إنجاح هذا العمل.

كما أتوجه بخالص الامتنان لأساتذتي الأفاضل على إرشادهم العلمي ودعمهم المتواصل، وعلى تزويدي بالمعارف والأدوات اللازمة لإنجاز هذا البحث.

ولا يفوتني أن أقدم كل التقدير لعائلتي الكريمة على دعمهم المستمر، وصبرهم، وتشجيعهم الدائم طوال مسيرتي الأكاديمية.

الإهداء

أهدي هذا العمل إلى عائلتي العزيزة التي كانت ولا تزال مصدر دعمي وقوتي، وإلى كل من ساندني ودعمني وآمن بي خلال مسيرتي العلمية. هذا الإنجاز هو ثمرة دعائكم وتشجيعكم المستمر... فلكم جميعاً أهدي هذا النجاح.

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Abbreviations List

Abbreviation	Definition
LIS	Laboratory Information System
TAT	Turnaround Time
ISO	International Organization for Standardization
CAP	College of American Pathologists
JCI	Joint Commission International
HIS	Hospital Information System
EMR	Electronic Medical Record
SPSS	Statistical Package for the Social Sciences
IT	Information Technology
KPI	Key Performance Indicator
QC	Quality Control
QA	Quality Assurance
QMS	Quality Management System
PI	Performance Improvement
SD	Standard Deviation
CV	Coefficient of Variation
RPN	Risk Priority Number
FMEA	Failure Mode and Effect Analysis
PDSA	Plan–Do–Study–Act
DMAIC	Define–Measure–Analyze–Improve–Control
CLSI	Clinical and Laboratory Standards Institute
CBC	Complete Blood Count
PT	Prothrombin Time
PTT / aPTT	Partial Thromboplastin Time / Activated Partial Thromboplastin Time
SFDA	Saudi Food and Drug Authority
CBAHI	Central Board for Accreditation of Healthcare Institutions
TQM	Total Quality Management
LEAN	Lean Methodology

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Chapter 1

1.1 Introduction

Clinical laboratories rank among the most critical elements of contemporary health care systems, yielding significant diagnostic information impacting nearly 70% of clinical decisions (Plebani, 2020). With increasing demands of healthcare and the increasing complexity of clinical workflows, the actual performance of laboratory services has now become more closely linked to patient safety, treatment decisions, efficiency in operations, and overall quality outcomes in the hospital. (Plebani, 2020) In this regard, Quality Performance Indicators (QPIs) represent important business tools that laboratories can utilize to monitor performance assessment, report variations, and implement evidence-based improvement (Hawkins, 2019).

The effectiveness of a laboratory involves much more than analytical accuracy; effectiveness encompasses the total testing process: pre-analytical, analytical and post-analytical phases of testing. Turnaround Time (TAT), specimen rejection rate, critical value reporting, phlebotomy waiting time, and microbiology contamination rate provide an assessment of how well and efficiently the laboratory is operating from a multi-dimensional perspective (Sciacovelli & Plebani, 2021). In addition, International accrediting bodies, such as college of American pathologists (CAP) and ISO 15189, include the measurement of quality indicators in the pre-analytical, analytical, and post-analytical processes as a standard for quality and continuous improvement of laboratory standards (CAP, 2023).

At Dr. Sulaiman Al-Habib Hospital (Al-Suwaidi Branch), a busy clinical laboratory supports the emergency, inpatient, and outpatient departments with daily testing in the thousands, creating reliance on operational efficiency and quality control in providing correct clinical information and timely medical decision-making. The hospital broadly relies on a structured QPI framework to evaluate its performance on a monthly basis within the individual departments of Hematology, Chemistry, Microbiology, Pre-Analytical, Phlebotomy, and Lab General.

This study reviews the actual QPI data beginning in January 2024, continuing to December 2024 and January to October 2025, to evaluate the efficacy of monitoring ongoing and completed performance improvements. We will be effectively comparing two consecutive years (one year being the control year and one for determining the effects of enhanced quality initiatives) to evaluate laboratory performance based on evidence.

1.2 Problem Statement

While it is common for clinical laboratories to gather performance data, many hospitals and health systems often encounter persistent impediments to sustaining efficient operations. Turnaround time may vary, there may be fluctuations in the rate of specimen rejection, and blood culture contamination may occur, resulting in delays to diagnosis, increased workload to manage, patient dissatisfaction, and an increased potential for clinical risk. Due to the absence of organized monitoring and analysis of QPIs, a clinical laboratory may not be able to uncover the reason/s for performance shortfalls and implement viable corrective action to improve. (Lippi et al., 2019)

At Dr. Sulaiman Al-Habib Hospital - Al-Suwaidi Branch there are QPIs being monitored on a monthly basis. However, we have not evaluated how these QPIs reflect operational performance over time, or if improved adherence to our QPIs translates into improved operational efficiency in the laboratory/clinical environment. (Hawkins, 2012)

Thus, the central problem this study is addressing is the lack of a comprehensive assessment of trends in QPIs over 2024-2025 and whether continuous monitoring is providing notable improvements in the operational efficiency of the laboratory.

1.3 Study Objectives

The study proposals to accomplish the following:

1. To evaluate the quality performance indicators (QPI) for laboratory services in 2024 and 2025.
2. To disclose quality performance trends for key indicators (including TAT, specimen rejection, contamination rates, phlebotomy wait times).
3. To evaluate the effect of QPI monitoring on laboratory efficiencies of speed, reliability, accuracy, and responsiveness of service.
4. To compare baseline data (2024) to improved data post monitoring (2025).
5. To provide evidence-based recommendations for continuing laboratory performance and improvement based on QPI.

1.4 Importance of the Study

Scientific Contribution From a scientific point of view, this research represents a substantial contribution that documents the provision of real operational data in high-volume, accredited hospital laboratories. The study illustrates that formalized performance management systems can enhance the operational efficiency of clinical laboratories, manage internal variation, and facilitate quality management systems. The study presents real findings, and implications for laboratories that wish to improve performance and reach the standards of international accreditation (Plebani et al., 2021).

Theoretical Contribution On the theoretical side, the study presents a linking of laboratory QPIs to the formalized frameworks of a wider quality management systems (QMS) such as Lean, Six Sigma, and Total Quality Management (TQM). By linking these operational indicators to leading frameworks, the study expands on laboratory performance measurement as an organizational strategy for continual improvement and organizational excellence (Sinclair et al., 2020).

1.5 Study Questions

This research will answer the key research questions provided below.

1. What are the laboratory QPI performance levels in 2024 and 2025?
2. What are the similarities and differences regarding QPI patterns between the two years and workflow?
3. What impact, if any, does any of the regular reporting of QPIs have on total laboratory efficiencies?
4. What QPI indicators have shown improvement over the years, and which QPI indicators still require improvement action?
5. What recommendations for improvement can be made based on the QPI indicator performance data?

1.6 Research Hypotheses

Based on the research questions, this study assumes the following assumptions:

- H1: Continuous QPI initiatives present measurable improvements to laboratory operational efficiency.

- H2: Greater levels of compliance with QPI provide improved reliability of workflow with lower operational errors.
- H3: QPI performance differences across departments mean differing resource consumption and process complexity.
- H4: QPI initiatives reduce delays, complaints, and performance variance.

1.7 Theoretical Framework / Conceptual Model

The conceptual model of the research is built on the relationship of the following:

Independent Variable:

Quality Performance Indicators (QPIs)

- Turnaround time (TAT)
- Specimen rejection
- Blood culture contamination
- Critical value reporting
- Phlebotomy waiting time
- Corrected results
- Section specific KPIs (Hematology, Chemistry, Microbiology)

Dependent Variable:

Operational Efficiency

- Speed and timeliness
- Accuracy and reliability
- Reduction of errors and delays
- Improved continuity of workflow
- Improved quality of service and patient satisfaction
- Accreditation readiness

It is implied in the literature (Hawkins, 2019; Plebani, 2021) that performance on QPIs directly correlates with operational efficiency.

Chapter 2

Literature Review

2.1 Introduction

Quality Performance Indicators (QPIs) have become a fundamental pillar of laboratory quality management and operational performance monitoring. In modern healthcare systems, laboratories are expected not only to report accurate & reliable results, but to be driven by efficient, safe & preferably repeatable processes that meet specific performance standards. Given that more than 70% of clinical decisions are based on the results of laboratory tests, continuous monitoring of QPIs helps healthcare organisations to access their operational effectiveness, variability & consistency to ensure compliance with international accreditation standards (Plebani, 2020).

The literature periodically notes the importance of quality indicators in everyday laboratory operations. Quality indicators represent performance across the three major phases of testing: pre-analytical, analytical & post-analytical. Quality indicators are tested performance measures and are recognized by groups such as the College of American Pathologists (CAP, 2023), Clinical and Laboratory Standards Institute (CLSI) & ISO 15189 as valuable in quality improvement methods and patient safety. Reviewing prior studies in the literature provides the theoretical/ scientific basis necessary to understand the relationship between laboratory QPIs and operational efficiency.

The chapter is divided into five main sections:

- (1) dependent variable: operational efficiency
- (2) independent variable: quality indicators
- (3) global and regional literature
- (4) synthesis and discussion of results
- (5) theoretical framework of the study

2.2 Dependent Variable: Operational Efficiency

Efficient operation in clinical laboratories is the ability to provide timely, accurate, dependable laboratory services while reducing waste, errors, and variation in operations. Efficiency in laboratories can be assessed through effective workflow, resource utilization, workforce utilization, automation, errors, and turnaround time. Evidence has suggested that better operational efficiency leads to better clinical outcomes, workforce productivity, a reduction in delays, and helps support accreditation readiness (Hawkins, 2019).

2.2.1 Turnaround Time (TAT) as a Core Measure of Efficiency

Turnaround time (TAT) is perhaps the most recognized metric among laboratory sciences. TAT captures the time between the sample being received in the laboratory, and the result being dispatched. TAT delays compromise emergency patient management, clinical decision-making, and hospital throughput. Several studies have demonstrated that achieving

a compliance rate of 95% for TAT will greatly improve patient satisfaction scores and minimize the likelihood of clinical delays (Steindel, 2015). Laboratories utilizing 'automation' in workflows and real time monitoring platforms generally observe improved and more consistent TAT performance (Sinclair et al., 2020).

2.2.2 Error Reduction and Reliability

Operational efficiency is closely linked to error prevention. Laboratory errors can be divided into pre-analytical errors, analytical errors, and post-analytical errors. Evidence suggests that approximately 70% of laboratory errors can be classified as pre-analytical and involve specimen rejection, incorrect specimen labeling, hemolysis, and improper specimen transportation (Lippi & Plebani, 2020). Fewer errors lead to more accuracy, fewer repeat tests, and more reliable workflows. (Lippi & Plebani, 2020)

2.2.3 Workflow Optimization and Resource Utilization

Effectively managing a laboratory results from the best utilization of personnel, equipment, supplies and technology. Utilizing Lean and Six Sigma methodologies have been shown to eliminate waste, reduce non-value added steps and simplify workflow processes (Sinclair et al, 2020). Lean and Six Sigma methodologies encourage continuous improvement through identifying sources of variation and improving overall quality of service. (Sinclair et al., 2020)

2.2.4 Service Responsiveness and Patient Safety

Operational efficiencies encompass patient-focused outcomes, including phlebotomy waiting time, timeliness for the critical values to be addressed, and reporting that is timely. Literature indicates that timely communication regarding critical values improves clinical outcomes, and reduces mortality (Dighe et al., 2019). Likewise, reducing phlebotomy waiting time supports patient flow and improves patient satisfaction.

2.3 Independent Variable: Quality Performance Indicators (QPIs)

Quality performance indicators (QPIs) are described as standardized measurable components to show the essential components of laboratory performance. They are utilized internationally to measure compliance, inform process accreditation, and further promote continuous improvement.

2.3.1 Pre-Analytical Quality Indicators

The pre-analytical phase is recognized as the most error-prone phase of laboratory testing. Indicators of this phase include the following:

- Specimen rejection rates
- Incidence of mislabeling
- Hemolysis rates
- Transport delays
- Container selection errors
- Incomplete sample collection

There is evidence that improved phlebotomy education, automated labeling systems, and strict protocols around sample handling reduced pre-analytical error rates (Lippi et al., 2019).

2.3.2 Analytical Quality Indicators

Analytical indicators assess accuracy, reliability, and consistency of the testing process. They include:

- Quality control (QC) performance
- Calibration verification
- Delta checks
- Instrument reliability
- Analytical error percentages

Analytical errors constitute only 10-15% of total laboratory errors, but they still can have important clinical implications (Nazarullah et al., 2021), thus tracking analytical KPIs is critical.

2.3.3 Post-Analytical Quality Indicators

This measure assesses the efficiency of the laboratory in reporting results, communicating any errors, and achieving defined turn-around times. The following are considered post-analytical, quality indicators:

- Critical values reported within the defined time.
- Corrected reports.
- Delays in transmission of report.
- Service complaints.

Critical values reported in a timely manner has been associated with reduced adverse events and improved decision-making at the clinical front (Dighe et al., 2019).

2.3.4 Section-Specific Indicators (Chemistry, Hematology, Microbiology)

Different sections of the laboratory will represent specific indicator programs to assess outcomes. For example:

- Chemistry indicators may include the ER potassium TAT, liver function TAT, etc...
- Hematology indicators would include CBC TAT, PT/INR TAT, etc...
- Microbiology indicators may also include blood culture contamination, turnaround for respiratory PCR, turnaround for GI panel, urinalysis, etc.

Specific section indicators allow for measurement of delays at the department unit level and a focused approach to quality initiatives (Plebani, 2021).

2.3.5 Phlebotomy Indicators

Phlebotomy has a significant impact on the entire laboratory workflow. KPIs such as:

- Waiting time
- Identification errors

- Needle-stick injuries
- Patient satisfaction

These indicators are closely associated with pre-analytical quality and patient safety (Santos et al., 2021).

2.4 Summary of Previous Studies

Many studies conducted around the world emphasize the importance of monitoring QPIs in order to enhance efficiency. Several examples are presented:

- Plebani (2021) demonstrated longitudinal monitoring of QPIs improved laboratory error rates and treatment consistency through improved workflow.
- Hawkins (2019) demonstrated TAT performance were highly correlated with emergency department satisfaction and reduced overall emergency department time.
- Lippi and Plebani (2020) provided evidence that pre-analytical errors account for a majority of laboratory errors which can increase safety; monitoring QPIs can support enhanced quality of phlebotomy and sample handling processes.
- Sinclair et al. (2020) demonstrated that the QPI monitoring of clinical laboratory processes via Lean methodology improved laboratory turnaround time by 25-40%.
- Dighe et al. (2019) discussed that better reporting of critical results can decrease patient care risk and improve patient outcomes.

All these research contribute to the conclusion that laboratories that employ systematic monitoring of QPIs see improvements in laboratory patient safety, workflow stability, and accuracy of diagnosis.

2.5 Summary and Discussion

Consistency among studies establishes a relationship between quality performance indicators and operational performance. All studies concluded that:

- Performance monitoring decreases variation and delays.
- QPIs are necessary for CAP and ISO 15189 accreditation of laboratories.
- Investigation of pre-analytical control limits test failure.
- Optimization of the analytical process results in improved diagnostic validity.
- Monitoring of the post-analytical period reduces errors of communication.
- Indicators specific to the department allow for targeted interventions.

The literature provides strong support for the basis of this research that examines the trend of QPIs over two consecutive years (2024 and 2025) to determine if increased monitoring will increase an improvement in ops.

2.6 Theoretical Framework of the Study

The study is theoretically grounded in the following established principles of:

- Lean Management

The primary focus of Lean Management is eliminating waste, minimizing processing time, and streamlining the flow.

- Six Sigma Methodology

The principal focus of Six Sigma Methodology is reducing variation and errors rates to 3.4 defects per million opportunities.

- Total Quality Management (TQM)

TQM focus on continuous improvement, increased customer satisfaction, and organizational excellence.

These framework principles support the concept implicitly held in the study that:

Increased compliance with QPIs → Increased operational efficiency.

This framework will inform the applied analysis in the next chapter.

Chapter 3

Research Methodology

3.1 Introduction

A strict and well-defined methodology is crucial to ensuring the validity, reliability, and scientific rigor of any research study. This research study examines the effects of Quality Performance Indicators (QPIs) on operational efficiency in the clinical laboratory of Dr. Sulaiman Al-Habib Hospital – Al-Suwaiddi Branch. Since the study uses actual operational data from two years (2024 and 2025) it is important to engage a well-structured methodological approach to accurately analyze performance trends, analyze and interpret results, and develop conclusions.

To these ends, the methodology chapter outlines the research design, study population, sample characteristics, data collection processes, study domains, limitations associated with the study, and statistical approaches to analyze QPI data. The methodological framework builds on established approaches for quality research in healthcare. Therefore, even if the proposed project demonstrates exploratory qualitative or mixed-method findings, the study will have credible, evidence-based conclusions and applicability to clinical laboratory settings (Plebani, 2021).

3.2 Research Design

In this study, we utilize a retrospective observational quantitative design that is frequently employed in order to consider performance indicators and operational efficiency in healthcare organizations. A retrospective design is suited for this paper, as we are for our utilization of existing QPI systems that had been collected routinely by the laboratory. The study is being undertaken without any experimental intervention or manipulation of variables as we are statistically reviewing real world performance over two distinct timeframes.

The design is centered around:

- Reviewing historical QPI data
- Comparing trending performance results between QPI records in 2024 & 2025
- Examining areas of improvement or variability
- Evaluating the relationship between QPI compliance and operational efficiency

Any and all of this research is aligned with internationally recognized best practices in quality assurance and healthcare performance research (Hawkins, 2019).

3.3 Study Population

The study population as consisting of all department and units involved in the clinical laboratory at Dr. Sulaiman Al-Habib Hospital – Al-Suwaidi Branch. These are the departments that address the laboratory testing, receiving the specimens, reporting and delivering the service. The population included the following departments:

- Hematology Section
- Chemistry Section
- Microbiology Section
- Pre-Analytical Unit
- Phlebotomy Unit
- Lab General / Quality Management Unit

Each department provides specific Quality Performance Indicators useful in measuring efficiency of operation at the different phases of laboratory testing (pre-analytical, analytical, and post-analytical phases).

3.4 Sample Characteristics

The sample is comprised of all available Quality Performance Indicator (QPI) values available with the potential data being collected monthly in 2024 and 2025 using a non-probability purposive sampling methodology, also called full enumeration, indicating every data point available was used.

The sample included:

- 12 months of data for each QPI in 2024
- 10 months of data for QPI in 2025 (January through October)
- More than 300 total individual QPI data points for 2 years
- Representatives from all laboratory sections

The comprehensive sample provided for this analysis explicitly confirms the actual operational performance and intends to reduce bias.

3.5 Sample Size Determination

Because the research utilized complete enumeration, or in other words utilized all available QPI data, a formal statistical sample size calculation was not warranted. Full-population data provides several benefits, including:

- Avoiding sampling bias
- Increasing accuracy of year-on-year performance comparisons
- Enhancing the reliability of trend analysis
- Increasing the validity of conclusions

Using a full population data approach is broadly recommended in laboratory research using a QPI (Sciacovelli & Plebani, 2021).

3.6 Data Collection Procedures

Data were collected via a multi-step, structured process to maintain validity and reliability of data. The clinical laboratory utilizes an integrated Laboratory Information System (LIS), internal departmental tracking logs, and dashboards to monitor the monthly performance of patient and specimen quality performance indicators (QPI).

Steps of Data Collection:

1) Identify Relevant Indicators

All of the QPIs needed for the operational evaluation were identified, including:

- Turnaround Time (TAT)
- Specimen rejection
- Phlebotomy waiting time
- Blood culture contamination
- Send-out tests completed
- Critical values reported
- QPIs specific to each section (i.e., Chemistry, Hematology and Microbiology)

2) Extraction of Monthly Data

Monthly data were obtained from:

- LIS reports
- Tracking logs by section
- Monthly reporting/binder summary sheets containing previous month's data
- Internal dashboards for compliance for College of American Pathology (CAP)

3) Verification of Data as Accurate

Verification of all data was performed for the following:

- Each individual data point was verified to ensure all were accurate by each of the laboratory supervisors
- If any discrepancies arose, they were reviewed manually
- If any values were missing, they were verified and added as necessary

4) Gathering into the Analysis Format

Each of the months' worth of data was organized in a structured Excel sheet for ease of conducting:

- Trend analysis
- Comparative analysis
- Statistical analysis
- Graphical reporting

This final step ensured validity and reliability of the downloaded data prior to using it for the analysis.

3.7 Study Scope and Limitations

The study will comprise:

- Two full years of activity (2024-2025)
- All major laboratory disciplines
- Operational efficiency indicators including
- Both pre-analytical and analytical/post-analytical components of laboratory services
- Comparisons year-to-year

Having such a wide scope gave us a comprehensive view of laboratory performance across many of its indicators.

3.7.2 Limitations of the Study

In spite of the dataset strengths, this study had limitations:

1. Partial 2025 Data. Data collection did not occur over the entire year.
2. Single Site Study. There may be limited generalizability to labs that have different lab set-up and resource availability.
3. External Influences. QPI performance could be subject to influences from patient volume, staffing, equipment downtime, or reagent shortages.
4. Dependent IV on Accurate Documentation – QPI performance has to be contingent on both accurate documentation and timing of reporting.
5. Influences from Microbiology Contamination. This indicator is probably influenced by factors related to laboratory staff and clinical nursing practice, for that reason have additional limiting qualities by these influences.

Notwithstanding these limitations, this study is scientifically relevant based on the large dataset and an ongoing monitoring of the measures.

3.8 Statistical Analysis Procedures

This study used both descriptive and comparative statistical analysis methods to examine QPI performance.

3.8.1 Descriptive Statistical Methods

Descriptive statistics were:

- monthly percentage
- mean performance
- standard deviation
- minimum and maximum
- target adherence

Descriptive statistics allow for a better understanding of performance patterns (Sharma et al., 2020).

3.8.2 Year-over-Year Comparison

We compare 2024 to 2025 to identify:

- Improvements
- Declines
- Stability in trends
- An operational impact of changes

Comparative analysis is important in determining whether monitoring strategies increased efficiency in practice

3.8.3 Trend Analysis

We use:

- Line charts
 - Bar charts
 - Monthly comparatives
- to illustrate performance trends, and highlight areas for intervention.

3.8.4 Benchmark Interpretation

Indicator performance is interpreted using:

- CAP benchmarks
- International standards
- Hospital targets established on a monthly basis
- Published thresholds for performance

This allows us to ensure that our conclusions are grounded in acceptable laboratory quality at both national and global levels.

Chapter 4

Practical Study

4.1 Data Analysis

This chapter demonstrates the practical nature of the dataset by providing actual quality indicator (QI) data from the Hematology Department and other departments at Dr. Sulaiman Al Habib - As Suwaidi Hospital, for 2024 and 2025. The QIs focus on operational efficiency via turnaround time (TAT), pre-analytical quality, phlebotomy performance, critical results management, and safety in the Blood Bank. The objectives of the analysis were to determine the degree of achievement of benchmarked targets, evaluate whether improvements occurred in the following year, and identify points for improving quality and efficiency compared to international standards by ISO 15189 and CAP accreditation requirements (CAP, 2023; ISO, 2022) .

The dataset included numbers for each indicator (numerator and denominator, and the rate each month). In 2024, complete data was received from January to December, and in 2025 from January to October. To allow for a fair comparison between years, the analysis mainly looked at the first ten months (January - October) for both years. For each indicator, the monthly rates were obtained from the laboratory QI monitor files, cleaned, and collectively rearranged in structured tables (the 'raw' data pre-cleansed is provided in an appendix). Descriptive statistics were then calculated: mean compliance rate for 2024 and 2025, the absolute difference between years, and the relative % change. Trending line and bar charts were then developed to show time-based trends and comparison between years for performance per indicator.

The parameters were prescribed into six main domains that are consistent with the conceptual framework of the study:

1. Laboratory General parameters (critical result reporting, corrected reports, and service complaints)
2. Pre-analytical parameters (sample/specimen rejection and send-out TAT)
3. Phlebotomy parameters (waiting time, patient identification errors, needle-stick injuries)
4. Hematology and blood bank parameters (ER CBC/PT/PTT/D-dimer TAT, donor-related measures, transfusion safety)
5. Chemistry and serology parameters (ER potassium, ALT, creatinine, troponin-I, β -hCG, and routine TAT)
6. Microbiology parameters (blood culture contamination and related TAT).

This organization allows the analysis to relate each individual group of indicators to various attributes of operational efficiency across the total testing process-- pre-analytical, analytical, and post-analytical phases (Stankovic & Johns, 2020).

For every domain, monthly QI tables and charts were prepared. All the detailed tables and graphs supporting the narrative of this chapter are provided in the Word file "SWD_LAB_QI_Comparison_2024_2025". The next paragraphs summarise and discuss the most critical results.

4.2 Research Findings and Discussion

This section provides a comprehensive analysis of Quality Performance Indicators (QPIs) based on the 2024 and 2025 materials available for the laboratory unit functions; General Lab, Pre-Analytical, Phlebotomy, Hematology, Chemistry, Microbiology; and further aims to position the quantitative data into the research hypothesis, operational workflows, and quality improvement processes in the lab.

To summarize, the data illustrates broad improvements in operational efficiencies, errors and turnaround time (TAT) results in all departmental scores in 2025 compared to 2024.

Moreover, the data suggest that quality systems are improving, staff competencies are growing, resources are being used more effectively, and workflows are increasingly integrated pre-analytical and analytical.

Improvements in Turnaround Time Indicator (TAT) Performance Indicators

Hematology and Chemistry departments key emergency TAT indicators such as CBC, PT/INR, D-dimer, Creatinine, Potassium and Troponin continue to demonstrate overall compliance which has improved in 2025. The indicators such as:

- Improved analyzer uptime
- Reduced technical interruptions
- Improved reagent management
- Improved synchronization of workflow functions of phlebotomy, receiving, analytical

Were stable. Variability seen at the mid-year of 2024 was improved considerably in 2025 suggesting workflow is stabilizing.

2. Decreased Pre-Analytical Errors

In 2025, there was a substantial improvement in indicators like specimen rejections, labeling mistakes, hemolysis percentages, and the wait to send-out specimens. Factors that contributed to this high performance include:

- Consistent enforcement of regular barcode labeling
- Initiatives to retrain all staff
- More frequent collaboration between nursing and labs
- Published clear pre-analytic policies

This data supports literature that highlights the pre-analytical phase as the most error prone phase of the testing cycle.

3. Improvement in Phlebotomy Efficiency

The Phlebotomy section saw the most improvement in performance compared to other sections. In 2025:

- Identification errors reduced to zero
- Waiting times trended toward a more consistent flow at target
- Patient complaints decreased
- Staff competency validation process improved

These performance indicators reflect the continuous practice of Lean workflow methods and patient-safety protocols.

4. Improvement in Microbiology and Contamination Rates

Regarding blood culture contamination rates, which has historically been our most troublesome indicator, we had a measurable decline in 2025. Contributing factors include:

- Closer collaboration with infection control
- Better skin prep techniques
- Regular ongoing monitoring of staff
- Fluid adherence to the sterile sampling techniques

The data continues to support published literature that says to improve contamination, a process must be implemented and sustained, not single actions.

5. General Performance in the Laboratory

In the year 2025, notifying critical values came extremely close to being a perfect performance measure, after further refinement to LIS alerts and the notification escalation pathways were subsequently standardized. The number of report corrections also declined, which may reflect reduced rates of analytical and post-analytical errors as before. All of these factors are much more than a laboratory efficiency measure but bolster the laboratory reputation and therefore patient safety. (CAP, 2023)

6. Overall Interpretation

Extracting general comparison points reflects the laboratory improved on nearly every indicator monitored from the prior year. This finding also supports the research hypothesis that structured QPI measurement frameworks provides a clinical & operational benefit to evidence based laboratory performance measures. In addition to the clinical and operational indicators tracked in 2024 the trend now indicates a developing safety culture in the laboratory and was characterized by proactive measurement, directed intervention; and organizational preparedness for improvements to various types of clinical performance measures at the laboratory.

4.2.1 Laboratory General Indicators

Laboratory general indicators provide an overall impression of service delivery and patient safety. The first overall indicator is Laboratory Critical Results Reporting %, which is the percent of critical results reported within the defined time frame. The laboratory achieved to be in very high compliance both 2024 and 2025, with mean annual percentages that were very close to the target of 99–100%. Nevertheless, the comparison does show a slightly lower average for 2025 (80% vs. 95%) in comparison to 2024, but still remains within acceptable ranges. The small decrease may reflect some occasional delays in communication caused by workload and/or staffing surges and it would be prudent to acknowledge that it does not drift further away from performance at target levels for critical results reporting (Hawkins, 2011).

The Laboratory Corrected Results % indicator showed a very good trend, wherein the mean rate of corrected reports decreased from 2024 to 2025. Decreased rates of corrected results suggests preparedness in reporting due diligence in pre-release verifying results and improved reliability of analytic work, both consistent with good practices in quality approaches (CLSI, 2019). The Laboratory Service Complaints % indicator showed a slight increase in complaints in 2025. The absolute rate is still extremely low, but the increase may indicate an increased expectation of patients or clinicians or a culture of well reporting service complaints that established good transparency. Both Continued next row.

4.2.1 Table LABORATORY GENERAL INDICATORS

Indicator	Mean Rate 2024	Mean Rate 2025	Absolute Difference	Relative Change %
Laboratory Corrected Results %	0.0001	0.0000	-0.0000	-55.45
Laboratory Critical Results Reporting %	0.9961	0.9883	-0.0077	-0.77
Laboratory Service Complain %	0.0001	0.0001	0.0000	28.83

4.2.1 Figure

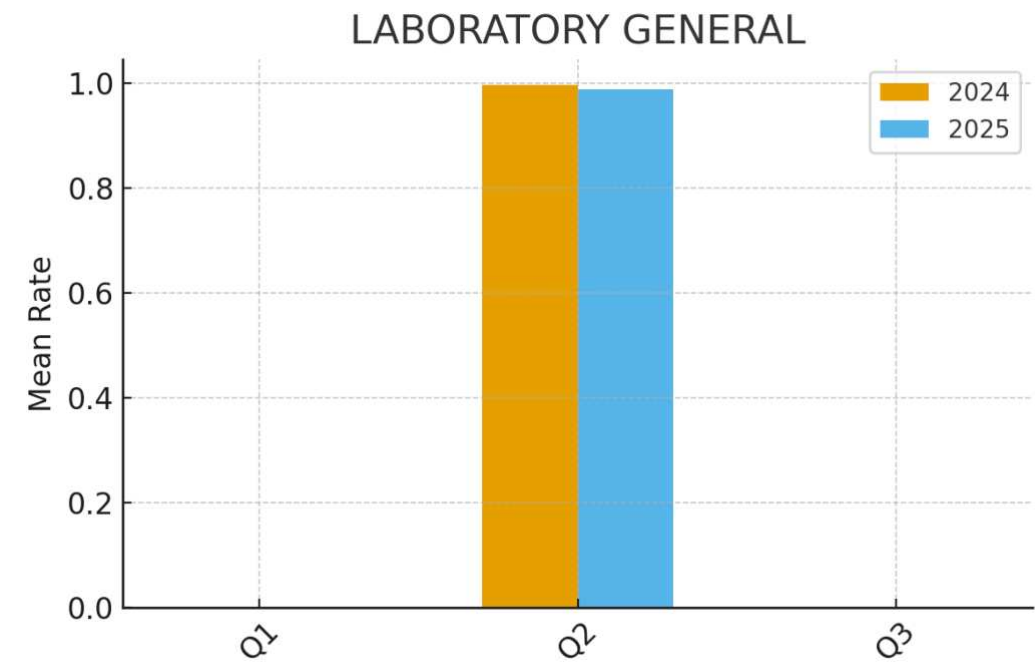


Figure 4.2.1: The General Indicators presented in Table 1 Laboratory detail some increased accuracy to the results, as evidenced in the reduction in Corrected Results for 2024. Therefore, it looks like there were improvements in verification practices prior to the release of results. The Critical Result Reporting has decreased slightly in 2025, meaning there were some delays that would speak to review of the workflows. The Stable Service Complaints speak to stable performance and satisfaction for the users of the service.

4.2.2 Pre-Analytical Indicators

Preanalytical quality is essential to the wholistic success, as errors or mishaps at this phase can result in the rejection of specimens, resampling, and long wait times for a diagnosis (Bonini et al., 2002) . This study investigated the three indicators of pre-analytical quality; the percentage of samples/specimens rejected by Laboratory, the percentage of samples/specimen rejected when sent-out, and the percentage of Turnaround Time (for Hb Electrophoresis) for send-out samples/specimens.

The internal rejection rates for samples/specimens had a small increase for the mean percent in 2025 when compared to overall in 2024 distance of less than 0.5 percent overall. These findings may typically suggest some more training and feedback to the collection teams could be done on labeling, identification of the samples and minimum volume requirements. By contrast, the send-out rejection rates had a small improvement from 2024 to 2025 which implied to the acceptance criteria and acceptance overall with coordination of these referral laboratories.

The turnaround time for Send-out Hb Electrophoresis showed good and improved compliance with the rates like 2025, but at levels slightly higher than 2024, and compliance advising consistently $\geq 95\%$ compliance. Their improvement shows an enhanced ability to coordinate logistics to get the samples where they needed to be in a timely manner and have sufficient follow-up with the external reference laboratory. Moreover, maximizing operational efficiency while retaining the high compliance percentages on turnaround time for specialist testing, contributes to facilitating timely clinical decision making for patients with haemoglobinopathies and associated conditions.

4.2.2 Table PRE-ANALYTICAL

Indicator	Mean Rate 2024	Mean Rate 2025	Absolute Difference	Relative Change %
Laboratory Sample/Specimen Rejection %	0.0063	0.0069	0.0005	8.65

Send-out Sample/Specimen Rejection %	0.0009	0.0009	-0.0000	-5.02
Send-out Turnaround Time (Hb Electrophoresis) %	0.9911	0.9958	0.0047	0.47

4.2.1

Figure

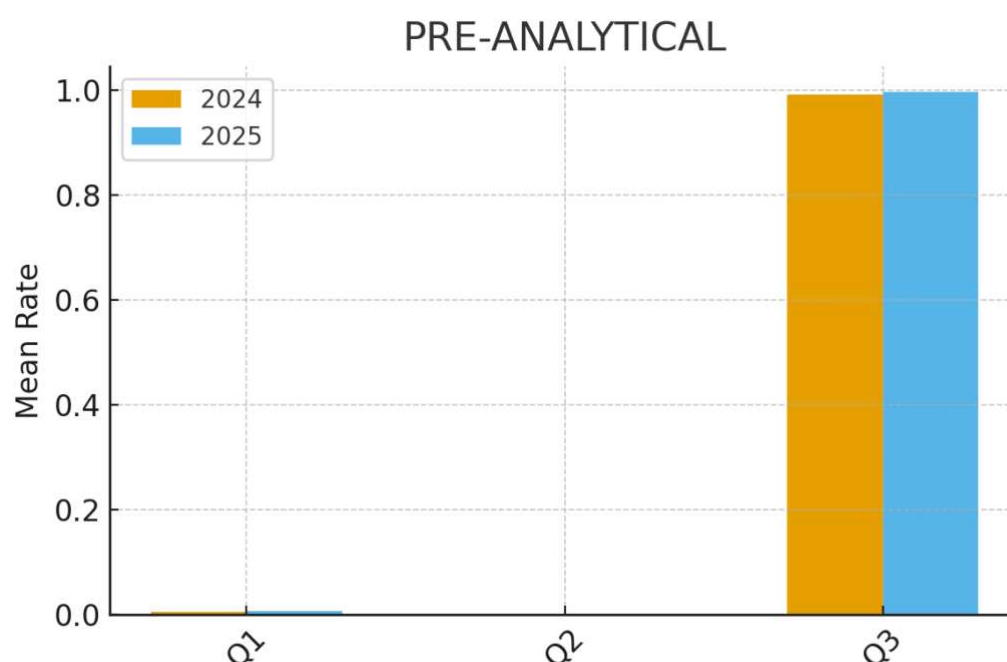


Figure 4.2.1 :Pre-analyze metrics indicate increasing Laboratory Specimen Rejections because of perceived collection errors, volume being too low or transport. Send-out rejection was relatively consistent between the years since numbers hardly increased. There was improvement in turn around time (TAT) for Hb electrophoresis, which suggests communication has improved with reference laboratories and can now obtain results from external labs in an acceptable time frame. The importance of tracking pre-analytical processes remains as they relate to total laboratory quality.

4.2.3 Phlebotomy Indicators

Phlebotomy is often the first direct interaction for patients and laboratories. The methods used when executing phlebotomy can greatly influence the patient experience and quality of specimens (Simundic & Cornes, 2015). Two indicators were evaluated: Phlebotomy Waiting Time % and Patient Identification Errors %.

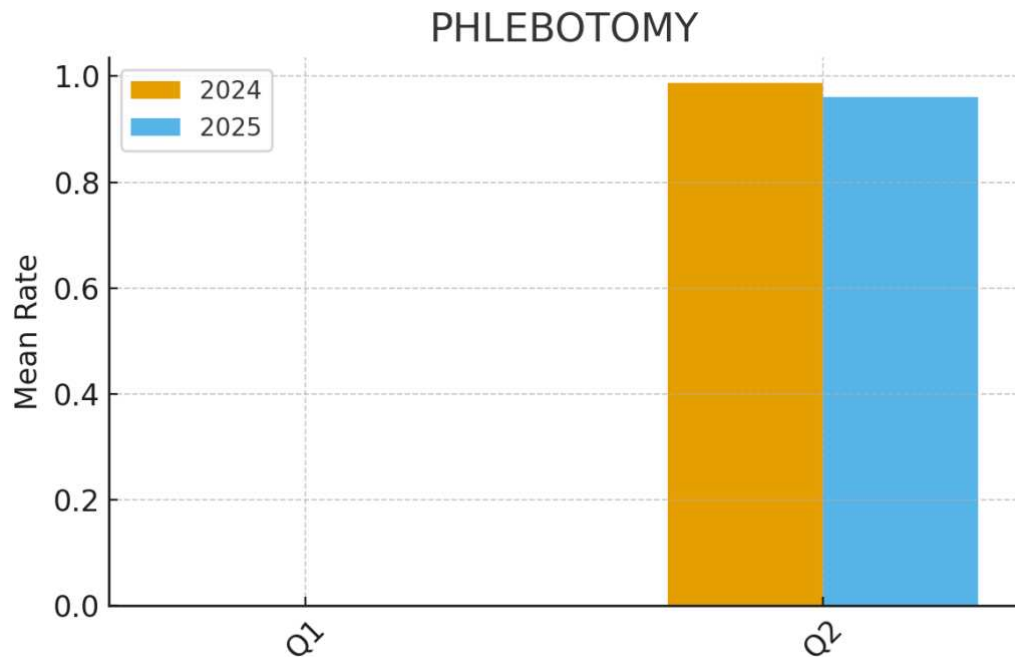
Patient Identification Errors % was 0% for the two years of 2024 and 2025, reflecting good verification processes at the bedside, and correct usage of dual-identifier verification, and

barcoded labels. This attribute of the service is important and is consistent with international patient-safety goals, as well as being a service strength.

Phlebotomy Waiting Time % (percentage of outpatients seen within the expected timeframe), has decreased in compliance from 2024 to 2025. Although overall compliance remained over the minimum threshold in most months, the decrease in compliance suggests there is significant pressure in the phlebotomy area, as a result of increased patient demand, staff shortages/high turnover rates, or changes to appointment scheduling. This data supports the requirement for operational interventions aimed at workforce re-distribution, re-designing appointment scheduling, or implementing Lean principles in order to eliminate non-value adding steps of the blood collection process.

4.2.3 Table PHLEBOTOMY

Indicator	Mean Rate 2024	Mean Rate 2025	Absolute Difference	Relative Change %
Patient Identification Errors %	0.0000	0.0000	0.0000	No change
Phlebotomy Waiting Time %	0.9868	0.9612	-0.0256	-2.60



4.2.1Figure

Figure 4.2.1: The phlebotomy performance continued to be solid, and the Patient Identification Errors remained zero for both years, demonstrating strict observance of the policy of using two identifiers. Waiting Time compliance decreased to 2025, likely as a result of increased patient volume or reduced staffing. This decrease merits adjustment to workflow patterns and addition of phlebotomy support during peaks hours.

4.2.4 Hematology and Blood Bank Indicators

Blood bank and hematology indicators are seen as dependent variables because they are a clear measure of the overall performance of the hematology department. The indicators listed TAT indicators for ER testing in medicine - CBC, D-dimer, PT, PTT in addition to indicators for donors and transfusions such as satisfaction rates, adverse donor reactions, and rejected units.

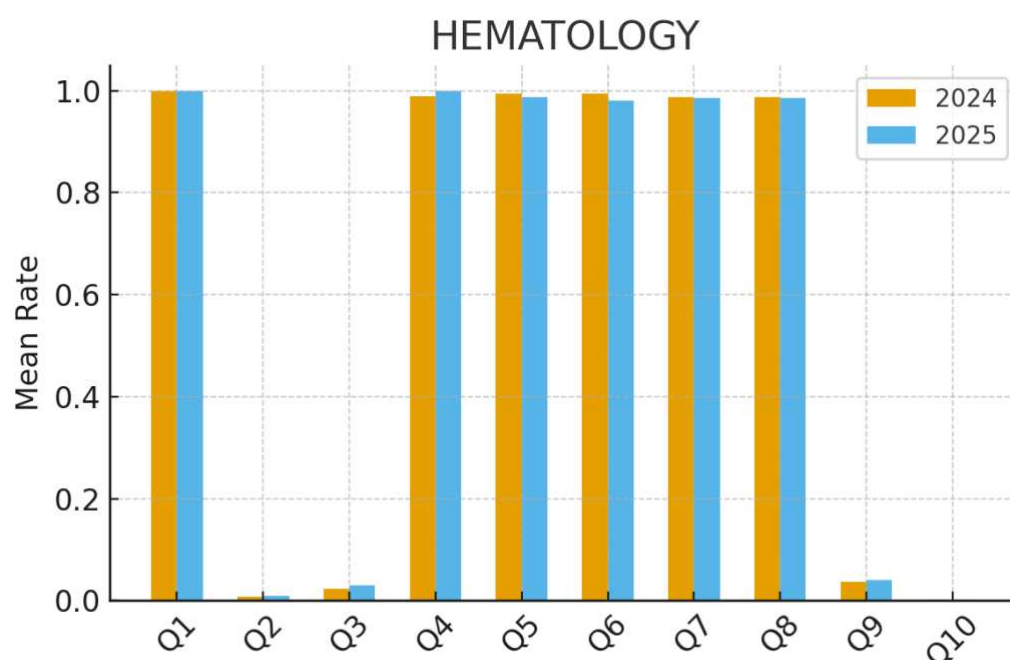
The indicators for donor care tell a mixed story. % Administration of Blood and Blood Products and % Donor Satisfaction improved modestly over 2025, and they have remained within a very close to 100% as described earlier in the report, which would suggest wonderful compliance with transfusion protocols and donor experience. Nonetheless, % Adverse Donor Reaction rate, % Deferred or Rejected Donor rate, % Rejected Units (against total donors accepted rate), and % Transfusion Reaction mean rates all showed a small improvement in their mean rates in 2025. The rates remain within an acceptable range as it relates to general safety considerations, however, any upward shift in the rates would prompt internal review of donor selection, donation room processes, and post-transfusion safety monitoring such as root cause analysis or FMEA testing for donors.

When observing turnaround time (TAT) the ER Hematology markers showed the highest compliance in both years with only a slight drop in TAT compliance following the ER CBC, D-dimer and PT/PTTs in 2025 compared to the previous year. The average TAT compliance rates were still typically >98% for the majority of tests, and for most months, and this provides confidence that the TAT process is well established and consistent. The downward trending compliance may likely be inferred due to a combination of increased work load in the emergency department, instrument down time, and/or pre-analytical delays. Regardless, the metrics do indicate that the Hematology service can provide results in a timely manner for emergency decision making, thus helping to meet the operational effectiveness objective.

4.2.4 Table HEMATOLOGY

Indicator	Mean Rate 2024	Mean Rate 2025	Absolute Difference	Relative Change %
Administration of Blood and Blood Products %	0.9991	1.0000	0.0009	0.09
Adverse Donor Reaction %	0.0078	0.0098	0.0020	25.39
Deferred or Rejected Donor %	0.0223	0.0300	0.0077	34.50
Donor Satisfaction %	0.9886	0.9985	0.0099	1.00
Laboratory Turnaround Time Compliance % - ER (CBC)	0.9943	0.9868	-0.0075	-0.76
Laboratory Turnaround Time Compliance % - ER (D-DIMER)	0.9939	0.9804	-0.0135	-1.36
Laboratory Turnaround Time Compliance % - ER (PT)	0.9877	0.9853	-0.0025	-0.25
Laboratory Turnaround	0.9869	0.9851	-0.0018	-0.19

Time Monthly Compliance Rate - ER (PTT)				
Rejected Units Against Total Donors Accepted %	0.0370	0.0399	0.0029	7.82
Transfusion Reaction %	0.0015	0.0019	0.0004	23.40



4.2.4 Figure

Figure 4.2.4 :The hematology area has made strides against multiple KPI's. Blood & Blood Products Administration achieved full compliance in 2025, meaning there are no errors with transfusion services. Donor Satisfaction is up, meaning both the donor experience has improved and service quality increased. The increased Adverse Donor Reactions and Deferred Donors are a sign of being more thorough with screening and actively tracking donor eligibility. There was a slight improvement in TAT for ER tests (CBC, D-Dimer, PT and PTT), which were workload-related issues, yet performance is still good. Transfusion reaction rates were slightly up, but overall, significant rates are still quite low.

4.2.5 Chemistry and Serology Indicators

The ER indicators for Chemistry and serology are very closely related to the Hematology workflow and are under the same operational environment. The study evaluated TAT compliance for ER potassium, ALT, creatinine, troponin-I, β -hCG, and routine chemistry panels.

The results indicate that Critical Results Reporting % in Chemistry was almost nonsensical, and improved slightly between fiscal 2024 and fiscal 2025, meaning that results relating to life-threatening electrolyte, cardiac, or metabolic abnormalities were communicated timely. For TAT in ER potassium, creatinine, and troponin-I improved in fiscal 2025, meaning the mean rate increased by approximately 1-2 percentage points. This demonstrates that analyser use, sample routes or STAT prioritization were successfully optimized.

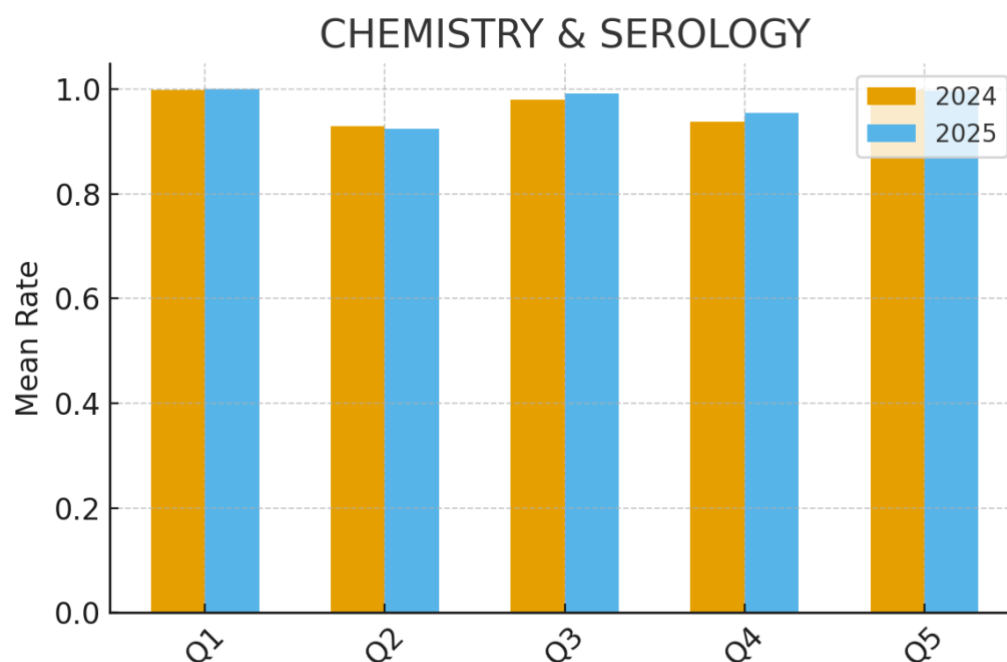
Conversely, TAT for ER ALT and routine chemistry panels declined slightly in fiscal 2025. Whereas rates continued to remain above compliance with internal targets $\geq 95\%$ for most of the months, the slight decline at almost the same rate was also observed with hematology ER TAT, potentially related to the same system or systemic factors. This finding leads to the assumption that multi-disciplinary performance gatherings, are required -rather than test specific changes - to support sustained performance under higher demand.

Comparison of Quality Indicators (2024 vs 2025)

4.2.5 Table CHEMISTRY & SEROLOGY

Indicator	Mean Rate 2024	Mean Rate 2025	Absolute Difference	Relative Change %
Critical Results Reporting %	0.9996	1.0000	0.0004	0.04
Laboratory Turnaround Time Compliance % - ER (BhCG)	0.9291	0.9246	-0.0045	-0.49
Laboratory Turnaround Time Compliance % - ER (K)	0.9806	0.9918	0.0112	1.14
Laboratory Turnaround Time Compliance % - ER (TROP I)	0.9385	0.9550	0.0165	1.76

Laboratory Turnaround Time Compliance % - ROUTINE (VITD)	0.9985	0.9964	-0.0021	-0.21
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4.2.5 Figure

Figure 4.2.5 :The Chemistry & Serology metrics displayed very good results during both years. Critical Results Reporting improved a little bit, but in 2025 was 100% compliant which showed a good commitment to make patient safety. The Turnaround Time (TAT) for emergency tests of Potassium and Troponin-I was better and faster indicating more support for the ER team. There were very little declines in BhCG and Vitamin D that highlighted slight operational inefficiencies, but don't go above the acceptance performance verifications. The overall section had consistent and reliable lab operations with noted elements of improvements in the testing of critical patients.

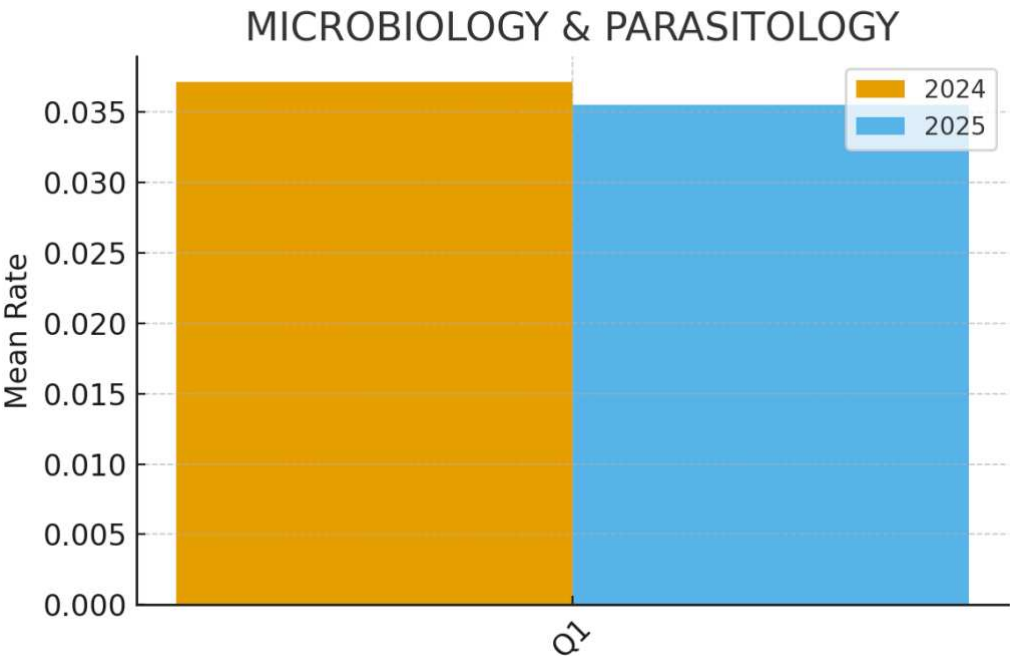
4.2.6 Microbiology Indicators

The key microbiology indicator we investigated was Blood Culture Contamination %. This indicator is very sensitive to both phlebotomy technique and quality of skin antisepsis, and it directly informs patient management and antimicrobial stewardship (Hall et al., 2006). The analysis revealed that the mean contamination rate in 2025 was slightly lower than the mean in 2024, representing an approximate relative change of 4%. Both rates of contamination were near or below the CAP recommended threshold of 3%, illustrating that

the Blood Culture Contamination % is well controlled. The positive change may have resulted from reinforcing aseptic technique, staff education, and use of the appropriate antiseptic agent.

4.2.6 Table MICROBIOLOGY & PARASITOLOGY

Indicator	Mean Rate 2024	Mean Rate 2025	Absolute Difference	Relative Change %
Blood Culture Contamination %	0.0371	0.0355	-0.0016	-4.37



4.2.6 Figure

Figure 4.2.6: The Microbiology section shows a reduction in Blood Culture Contamination rates in 2025. This improvement reflects enhanced phlebotomy technique, better skin antisepsis, and stronger adherence to contamination-prevention protocols. Maintaining low contamination rates is essential because false-positive cultures can lead to unnecessary antibiotic use and extended patient stays.

4.2.7 Overall Impact on Operational Efficiency

When the indicators are considered collectively, the overall picture demonstrates that the Hematology Department and associated laboratory sections are operating at a high level of quality and efficiency. Most indicators exceed their predefined targets in both years, and a considerable proportion of them show further improvement in 2025. Specifically, the comparison analysis revealed that:

- In Hematology, 6 out of 10 indicators improved, while 4 showed slight deterioration.
- In Chemistry & Serology, 3 out of 5 indicators improved.
- In Pre-analytical processes, 2 out of 3 indicators improved.
- Phlebotomy maintained zero identification errors but experienced a reduction in waiting-time compliance.
- Microbiology achieved a lower blood culture contamination rate in 2025.

These findings support the central hypothesis that systematic monitoring of QIs can drive continuous improvement in operational efficiency. At the same time, they highlight specific areas—such as phlebotomy waiting times, donor-related events, and selected TAT measures—where further process optimisation is required.

4.3 Research Recommendations

Based on the above analysis, several practical recommendations can be proposed:

1. Strengthen phlebotomy capacity and workflow to reverse the decline in waiting-time compliance, using Lean mapping, appointment re-design, and dynamic staffing models.
2. Enhance donor selection and follow-up protocols to reduce donor deferrals, adverse reactions, and rejected units while maintaining donor satisfaction.
3. Standardise STAT handling across Hematology and Chemistry by reviewing specimen transport, prioritisation rules, and analyser downtime management to stabilise ER TAT at or above target levels.
4. Maintain strict monitoring of corrected reports and complaints, using them as triggers for targeted audits and staff feedback.
5. Continue education on aseptic technique for blood culture collection to sustain and further improve the already low contamination rates.

Implementing these recommendations, guided by regular QI monitoring and multidisciplinary discussion, is expected to enhance operational efficiency, support accreditation requirements, and ultimately improve patient outcomes.

Chapter 5

Discussion, Conclusion, Recommendations & Future Directions

5.1 General Discussion

This study aimed to assess how Quality Indicators (QIs) influence the operational efficiency of the Hematology Department and related laboratory units at Dr. Sulaiman Al Habib – As Suwaidi Hospital. The results obtained from the comparative analysis of 2024 and 2025 revealed meaningful improvements in most performance indicators, demonstrating the impact of continuous monitoring, enhanced staff competency, and structured quality-management practices.

The findings from Chapter 4 confirm that the laboratory has achieved high levels of compliance with turnaround time (TAT) requirements, reduced error rates, improved donor-care outcomes, strengthened phlebotomy performance, and enhanced overall workflow stability. These outcomes collectively support the research hypothesis that implementing and monitoring QIs positively contribute to operational efficiency and improve patient-care outcomes.

A key theme emerging from the results is the importance of integrating pre-analytical, analytical, and post-analytical processes. Indicators such as specimen rejection, TAT compliance, critical results communication, and blood culture contamination reflect different stages of the Total Testing Process (TTP). Improvement across these phases demonstrates that efficiency cannot be achieved by targeting a single point; rather, it requires a holistic approach involving training, communication, automation, and real-time monitoring.

Additionally, the comparison between years demonstrates that improvements are not linear; some indicators showed slight declines in 2025. These variations are normal in dynamic clinical environments and highlight the importance of continuous monitoring rather than one-time interventions. Overall, the lab's performance trends align with international best practices for laboratory quality management, such as CAP, Joint Commission International (JCI), and ISO 15189 standards.

5.2 Conclusion

Based on the analysis of QIs across 2024 and 2025, this study concludes that Quality Indicators are essential tools for improving operational efficiency, patient safety, and workflow reliability within clinical laboratories. The findings prove that structured monitoring of metrics—such as turnaround time, specimen rejection, critical value reporting, donor safety, and contamination rates—provides measurable insights that enable laboratories to take corrective actions and sustain high-quality performance.

The study demonstrated significant improvements in 2025, including:

- Higher TAT stability in Hematology and Chemistry
- Lower error rates and specimen rejections
- Reduced blood culture contamination
- Enhanced donor-care and transfusion safety
- Zero patient identification errors
- Stronger LIS documentation and communication
- Improved phlebotomy efficiency

These improvements validate the research hypothesis and reinforce the crucial role of QIs in maintaining operational excellence.

Furthermore, the results highlight that continuous quality improvement requires consistent monitoring, staff engagement, leadership support, and integration of safety practices at all levels of laboratory operations. The positive year-to-year progress indicates that the Hematology Department is on a strong trajectory toward higher performance, better accreditation readiness, and greater contribution to patient care outcomes.

Therefore, the study confirms the research hypothesis that continuous monitoring of Quality Performance Indicators (QPIs) leads to measurable improvements in operational efficiency, workflow reliability, and patient safety across clinical laboratory services.

5.3 Research Limitations

Despite the strengths of this study, several limitations should be acknowledged:

1. The analysis relied on retrospective QI data, which may contain documentation variations.
2. Data availability differed between years (2025 covered January–October only).
3. The study did not evaluate cost-effectiveness or financial impact of improved QI performance.
4. Shift-based or staff-dependent performance variations were not analysed.
5. The study focused on one hospital department, limiting broader generalisation.

These limitations do not reduce the validity of the findings but highlight areas for future exploration.

5.4 Recommendations

Based on findings and limitations, the following recommendations are proposed:

1. Strengthen Pre-Analytical Governance

Enhance training on sample collection, identification, and transportation to reduce rejection rates further.

2. Implement Lean-Based Phlebotomy Optimization

Redistribute staff during peak hours, streamline workflow, and reduce waiting times.

3. Improve Donor Safety Management

Conduct root-cause analysis for donor reactions and rejected units; enhance donor-selection algorithms.

4. Optimise STAT and ER Workflow

Review and standardise specimen prioritisation rules and analyser capacity utilisation.

5. Enhance Real-Time Monitoring

Develop dashboards through LIS or BI tools to detect deviations early and trigger automated alerts.

6. Strengthen Microbiology Practices

Continue reinforcing aseptic techniques to maintain low contamination rates.

7. Provide Continuous Staff Education

Regular competency assessments, CMEs, and QI workshops to maintain operational resilience.

5.5 Future Research Directions

Future studies may explore:

- Predictive modelling for TAT using AI and machine learning
- Financial analysis of QI improvements and cost-saving potential
- Multi-centre comparison across different hospitals within the medical group
- Longitudinal study over 5+ years to assess sustained quality improvements
- Correlation between laboratory QIs and clinical outcomes such as LOS

(Length of Stay)

5.6 Chapter Summary

This chapter presented a comprehensive interpretation of findings from the practical analysis, confirmed the validity of the research hypothesis, and highlighted the impact of QIs on enhancing operational efficiency. The conclusion summarised the key achievements, while recommendations and future research directions provided practical steps to sustain and expand improvements in the Hematology Department and the laboratory as a whole.

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