

# A Comparative Study And Proposed Laboratory Sample Reception Errors In Saudi Hospitals

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## Introduction and Research Problem

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### Laboratory Results Accuracy and Importance

The accuracy of laboratory results is considered the cornerstone of effective medical diagnosis and safe patient care, as critical therapeutic decisions are based on these results, directly affecting patient health and treatment course.



#### Pre-analytical Phase Errors

Studies indicate that errors in the pre-analytical phase, specifically in laboratory sample reception, are the most common and influential on the quality of final results, consequently affecting patient diagnosis and treatment.



#### Impact of Errors on Patients

These errors directly affect patient safety through delayed diagnosis, incorrect diagnosis, or inappropriate treatment, which may lead to extended hospital stays or health complications.

## Important Statistics





Local studies in Saudi hospitals show sample rejection rates ranging from 2.25% in a study conducted in Jazan to 12.1% in another study in Makkah, indicating the magnitude of the problem and its impact on healthcare quality.

## Research Objectives and Methodology

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### Research Objectives

-  Analyze laboratory sample reception errors in Saudi hospitals, classify them, and determine their occurrence rates.  Compare the results of Saudi hospitals with international standards and results to evaluate the current situation.
  -  Explore the root causes of pre-analytical phase errors in Saudi laboratories.
  -  Suggest practical solutions and recommendations to improve sample reception quality and reduce associated errors.
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### Research Methodology

- Review and analysis of local studies in various hospitals in Saudi Arabia (such as studies from Jazan and Makkah).
  - Data collection from multiple sources on error types, rejection rates, and contributions from different hospital departments. 
  - Statistical comparisons between local data and international data from countries such as Turkey, Iran, Greece, India, and Ghana.  Analysis of quality indicators and evaluation of current practices according to international standards.

## Sample Identification and Classification Errors



### Patient Misidentification

Occurs when a sample is linked to the wrong patient, leading to:

- Incorrect diagnosis
- Inappropriate treatment
- Health risks for the patient

16% of blood collection errors occur due



### Incorrect Labeling

These errors include:

- Placing one patient's sample label on another patient's sample
- Incomplete information on the label
- Mismatch between label information and test request

56% of blood collection errors occur due



### Test Request Mismatch

This error occurs when:

- A specific test is requested but an inappropriate sample is collected
- Discrepancies exist between information in the test request and that on the sample

Incorrect barcode errors account for

## Sample Quality Errors - Hemolysis and Clotting

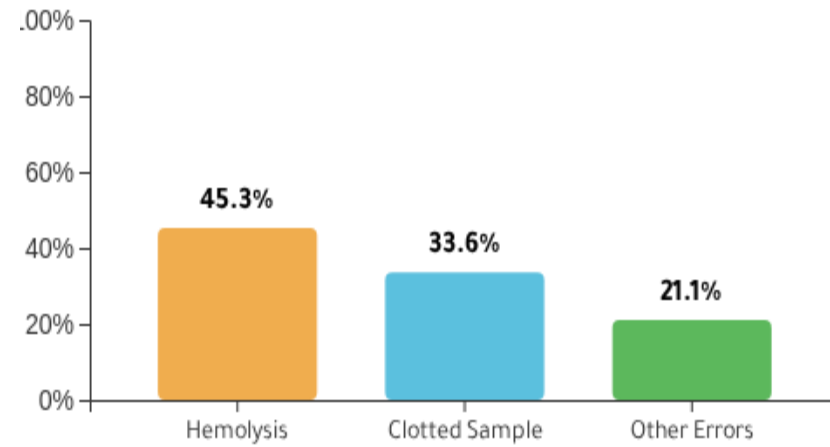


### Hemolysis

Hemolysis occurs when red blood cells rupture, causing their contents to leak into the plasma or serum.

It significantly affects the results of many tests, such as potassium and lactate dehydrogenase (LDH).

Occurrence rate: **45.3%** of total rejected samples in the Jazan



## Clotted Sample

Clotting occurs when the sample coagulates before analysis, especially in blood samples that require anticoagulants.

This leads to inaccurate results, especially in complete blood count (CBC) tests.

Occurrence rate: **33.6%** of total rejected samples in the Jazan study

### Impact of these errors:

- Rejection of samples and need for recollection, delaying diagnosis and treatment
- Increased financial costs for both the hospital and patient
- Possibility of obtaining inaccurate results affecting treatment decisions
- Extended hospital stay for patients

## Insufficient Sample Volume

When the collected sample amount is less than required for testing, the sample is rejected. Especially common in coagulation tests.

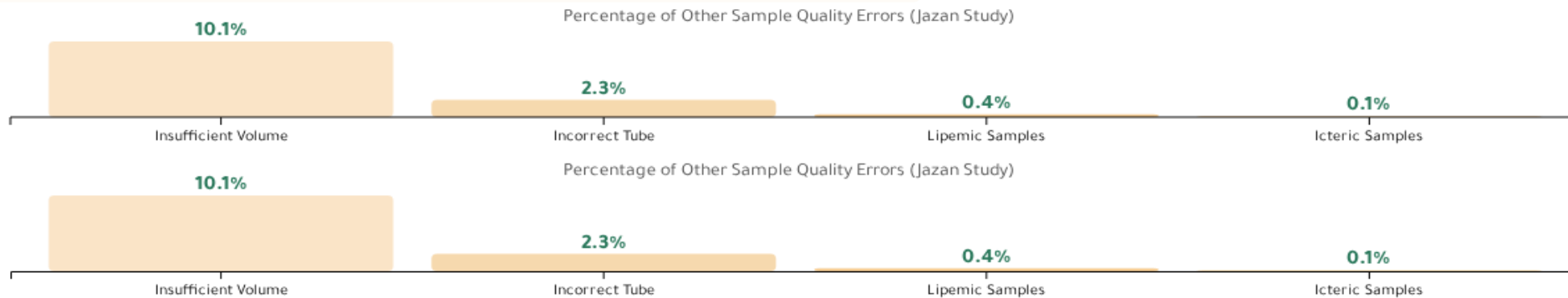
**10.1%** of errors in the Jazan study

## Lipemic Samples

Occurs when the sample contains high levels of lipids, affecting optical measurements of some tests and potentially causing false results.

**0.4%** of errors in the Jazan study

**!** Impact: Interference with optical measurements and inaccurate results





### Icteric Samples

Refers to samples containing high levels of bilirubin, which may interfere with certain chemical and enzymatic tests.

**0.1%** of errors in the Jazan study

**!** Impact: Interference with specific tests and false readings



### Incorrect Tube Use

Using an inappropriate collection tube for the required test can lead to inaccurate results due to interference with additives in the tube.

**2.3%** of errors in the Jazan study



Impact: Unwanted chemical reactions and changes in sample characteristics

## Transportation and Storage Errors

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### Improper Transportation

Incorrect transport of samples, such as exposure to extreme temperatures or excessive vibration, can lead to sample quality deterioration. This may affect the stability of gases in blood samples or cause hemolysis.



## Delayed Delivery

Delays in delivering samples to the laboratory can affect the stability of certain tests, especially those that change over time such as glucose and potassium. Adhering to appropriate timing schedules is essential for maintaining their quality.



## Storage at Incorrect Temperatures

Some samples require specific storage conditions in terms of temperature, humidity, and light. Some samples need to be stored at 2-8 degrees Celsius, while others require freezing. Failure to comply with these conditions can lead to sample deterioration.

### Percentage of Improper Transport Errors of Total Errors

**0.2%**

Prince Mohammed bin Nasser Hospital in Jazan Study

### Percentage of Improper Storage Errors of Total Errors

**0.9%**

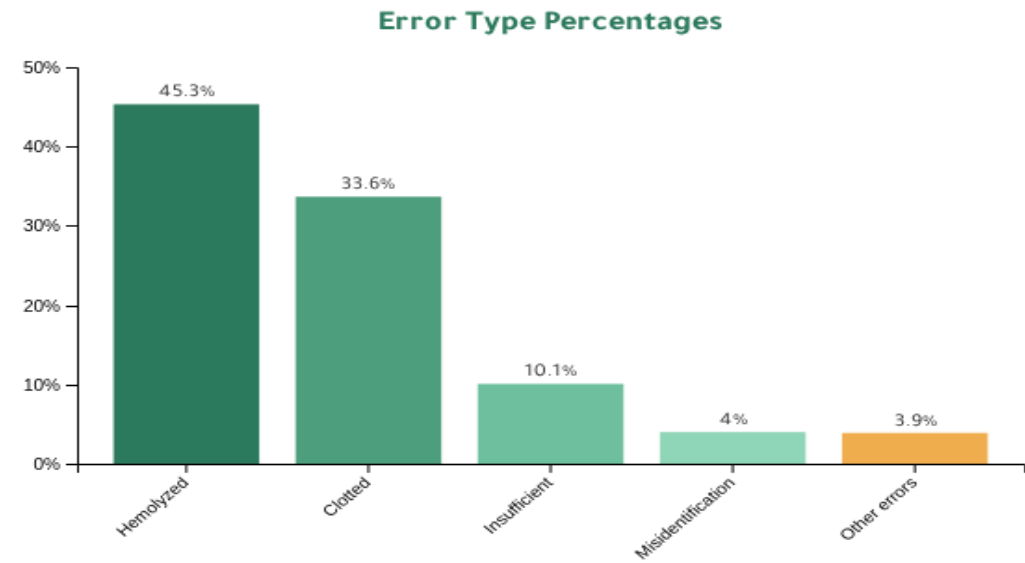
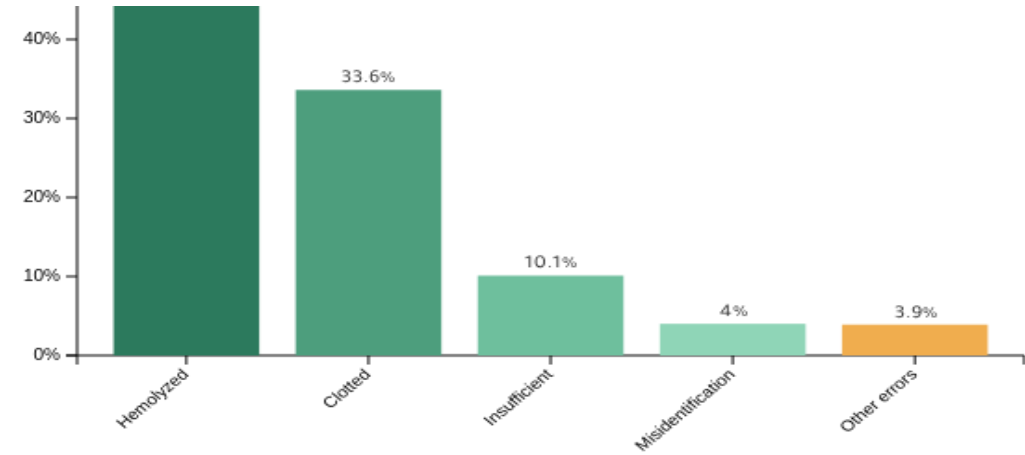
Prince Mohammed bin Nasser Hospital in Jazan Study

**A Comparative Study And Proposed Laboratory Sample Reception Errors In Saudi Hospitals**

Hemolyzed specimen	3272	45.3
Clotted sample	2425	33.6
Insufficient sample	731	10.1
Misidentification/incorrect requests	344	4.7
Inappropriate tube/improper storage	165	2.3
Lipemic/Icteric samples	40	0.5

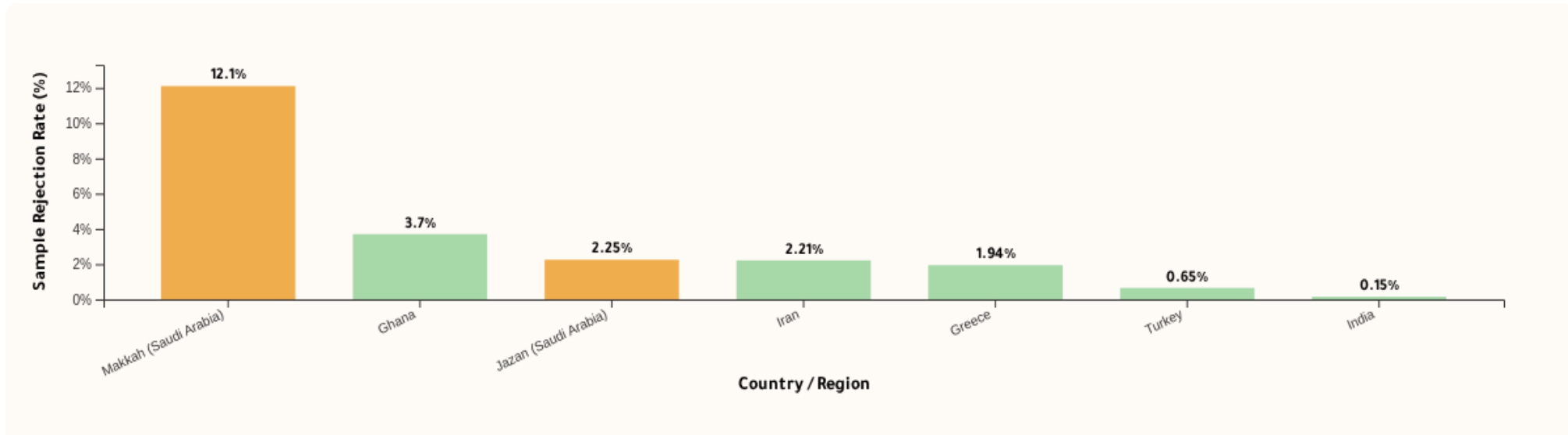
Source: Adapted from Jeraiby, M. A. (2025) study

Note: Hemolyzed and clotted samples account for more than 78% of all errors



## Comparison of Sample Rejection Rates Locally and Internationally

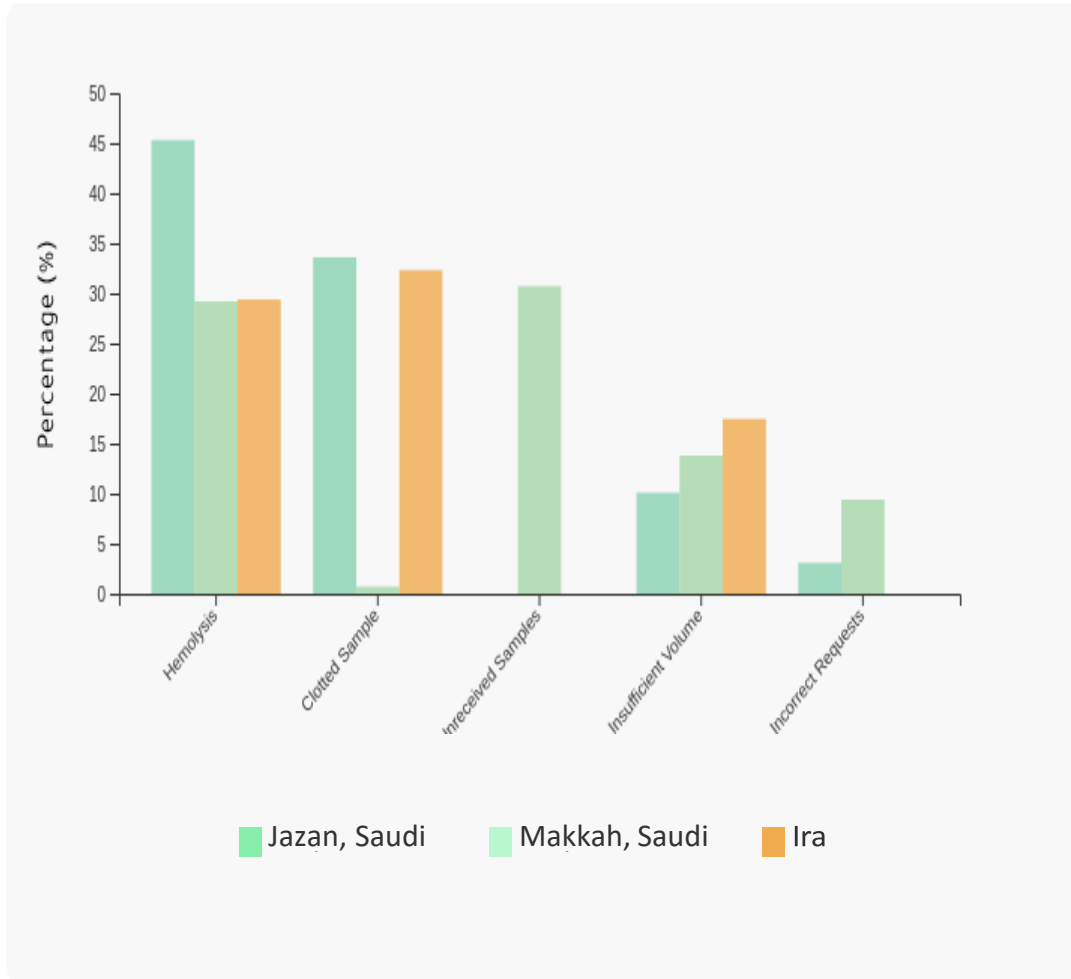
Comparing sample rejection rates in Saudi hospitals with global rates



### Factors Affecting Rejection Rate Differences

- Differences in quality indicators used and criteria for sample acceptance and rejection
- Study duration and reporting/recording system used
- The higher rejection rates in Jazan (2.25%) compared to previous studies may indicate the impact of the COVID-19 pandemic

## Comparison of Common Error Types Internationally



### Hemolysis

Hemolysis represents the highest percentage of errors in Jazan (45.3%) compared to Makkah (29.2%) and Iran (29.38%), indicating a significant challenge in blood collection techniques and sample transportation.

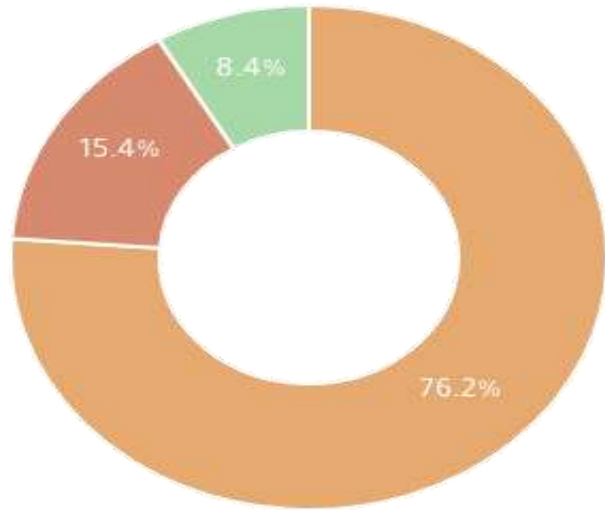
### Clotted Samples

Clotted samples show a significant variation between Jazan (33.6%) and Iran (32.31%) versus Makkah (0.7%), suggesting differences in sample collection methods or reporting practices.

### Overall Rejection Rates

Sample rejection rates range from 2.25% in Jazan to 12.1% in Makkah, compared to 2.21% in Iran and 0.65% in Turkey, reflecting variations in quality standards and practices.

## Impact of Different Hospital Departments on Errors



Studies show that different hospital departments contribute varying percentages to laboratory sample reception errors, which helps direct improvement efforts more effectively.

- Inpatient Departments: 76.2%
- Emergency Department: 15.4%
- Outpatient Clinics: 8.4%



### Inpatient Departments

Contribute the largest percentage of errors (76.2%), requiring concentrated improvement efforts.



### Emergency Department

Contributes a moderate percentage of errors (15.4%), often due to fast-paced work and pressure.



### Outpatient Clinics

Contribute the smallest percentage of errors (8.4%), reflecting more stable procedures.

## Root Cause Analysis of Errors

### Human Errors

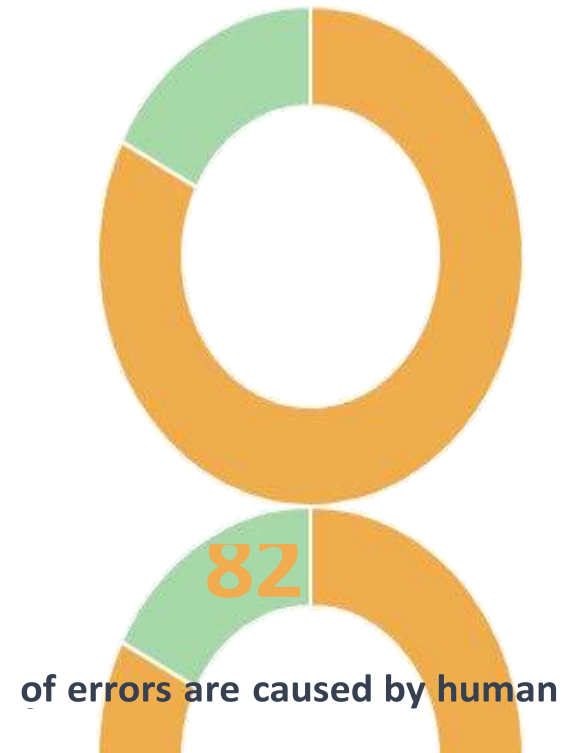
Human errors are considered the main cause of most errors, accounting for up to 82.6% of them. These include patient misidentification, incorrect labeling, and errors in sample collection.

### Lack of Training

Insufficient training for non-laboratory staff, such as nurses and doctors, is a key factor in the high error rate. Inadequate familiarity with sample collection techniques and handling methods leads to errors.

### Weak Procedures and Standards

The absence of standardized procedures and strict criteria for sample collection, transport, and storage contributes to varying practices and increased probability of errors. The lack of clear protocols leads to incorrect individual judgments.



### Other Contributing Factors:

- Work pressure and
- Inadequate monitoring
- Poor communication between
- Deficiencies in quality management

## Proposed Solutions - Training and Continuing Education



### Importance of Training in Error Reduction

Studies indicate that human errors are the main cause of most pre-analytical phase errors, accounting for up to 82.6% of these errors. Therefore, training and continuing education for medical staff is of critical importance.



#### Effective Training Program



**Content** Correct sample collection



techniques Importance of proper



sample handling



Impact of errors on test results and patient care



Procedures for correct patient and sample identification



#### Training Methods and Approaches



Regular workshops for medical staff



Practical training on sample collection and processing



Continuous competency assessment and skill gap identification



Use of simulation tools and virtual training

#### Training Program Effectiveness



Studies have shown that training medical staff significantly reduces the rate of pre-analytical errors. Research indicates that 16% of blood collection errors occur due to patient misidentification, and 56% due to incorrect labeling - errors that can be greatly reduced through appropriate training.

## Technological Solutions and Automation



### Barcode Systems

Reduce identification and classification errors, ensuring correct linkage between the sample and patient. Reduced pre-analytical errors by 70%.



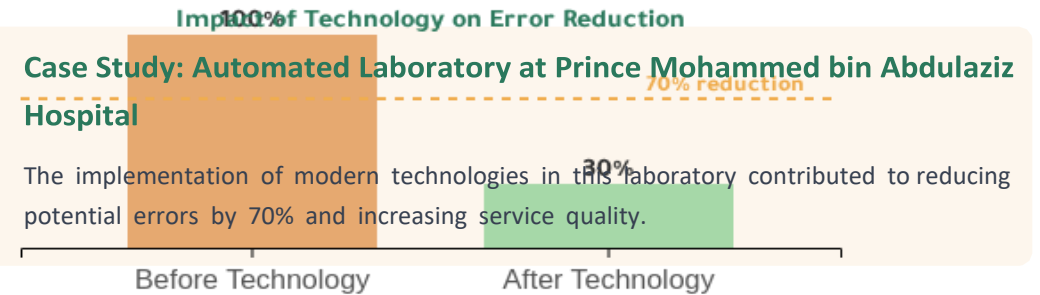
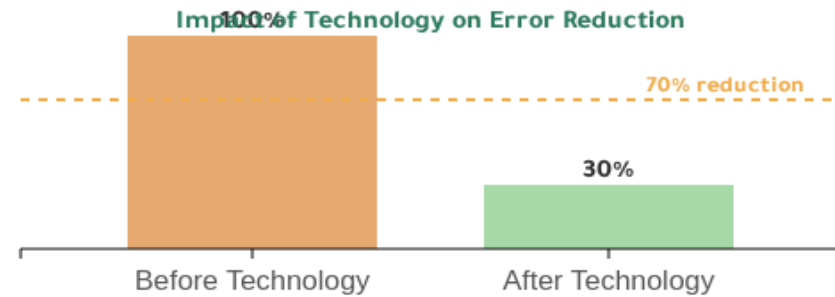
### Laboratory Information Systems (LIS)

Contribute to automating the sample path from test request to delivery tracking, reducing transcription errors and delays.



### Robotic Systems

Used for sample loading and transport, reducing response time and costs while ensuring accurate handling.






#### Key Benefits of Technological Solutions:




- ✓ Reducing sample identification and classification errors
- ✓ Improving sample tracking during the pre-analytical phase
- ✓ Reducing response time and increasing work efficiency

## Standardization of Procedures and Quality Indicators

### Standardized Guidelines and Protocols

-  **CLSI Standards:** The American Clinical Standards Institute provides protocols for the pre-analytical phase
-  **ISO 15189 Standard:** International quality standard for medical laboratories that defines sample management requirements
-  **Local Adaptation:** Adopting international standards and adapting them to the environment to improve outcomes

### Quality Indicators (QIs)

-  **Monitoring Indicators:** Track the percentage of rejected samples, reasons for rejection, and error rates
-  **Specific Indicators:** Rates of hemolysis, sample clotting, identification errors, and sample adequacy
-  **Periodic Analysis:** Data collection and analysis to implement targeted corrective actions

### Quality System Implementation Steps



Adopt Standards and Protocols




Define Quality Indicators



Collect and Analyze Data



Continuous Improvement

 Implementing standardized protocols with quality indicator monitoring can reduce pre-analytical errors by up to 70%, improving result accuracy and patient safety.

### Successful Examples from Saudi Arabia



#### Automated Laboratory at Prince Mohammed bin Abdulaziz Hospital

One of the successful models in the Kingdom for improving laboratory service quality and reducing errors.



Contributed to **reducing errors by 70%** through the automation of sample reception processes



Significant improvement in the quality of service provided to patients

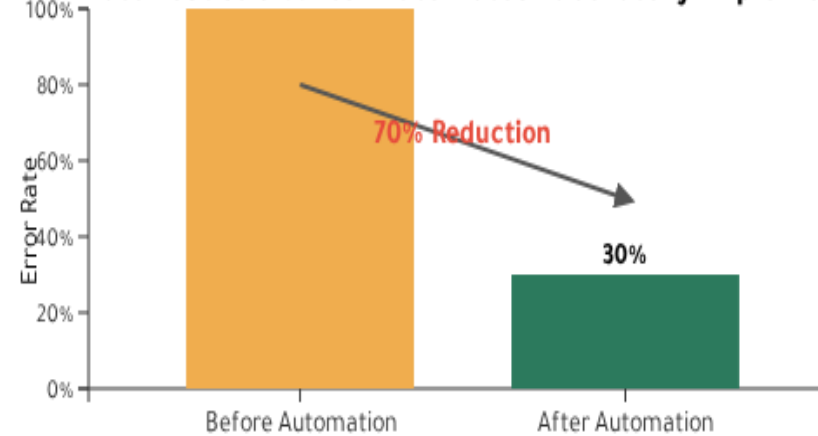


Reduction in response time and faster results delivery

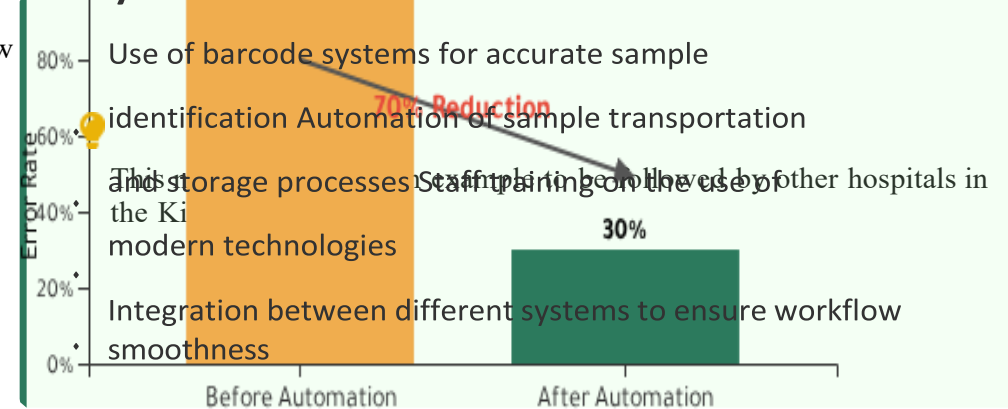


System integration with the Laboratory Information System to ensure workflow smoothness

Error Rate Reduction After Automated Laboratory Implementation



Error Rate Reduction After Automated Laboratory Implementation  
Key Success Elements:



## Cost and Economic Return of Solutions



### Investment Costs



Costs of continuous training for medical staff and laboratory technicians on sample collection techniques



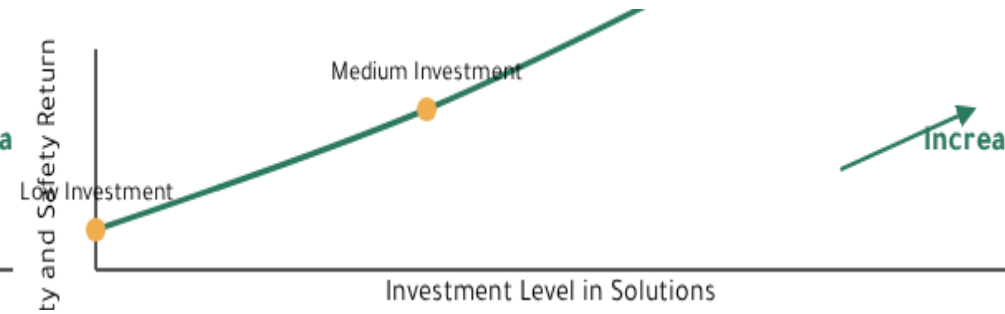
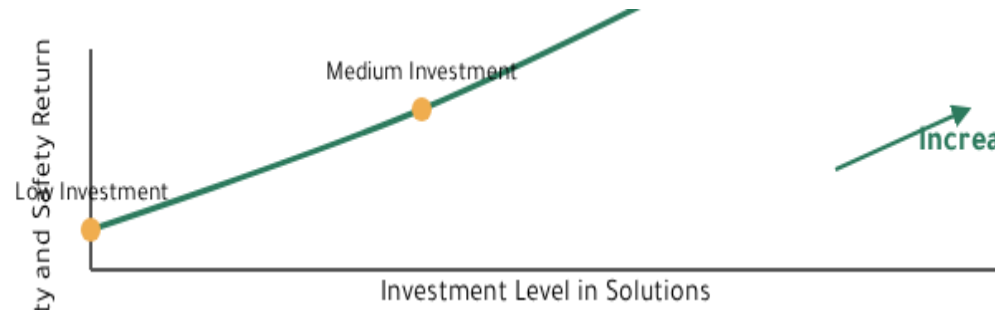
Costs of implementing automation, barcode systems, and sample tracking technologies



### Returns and Benefits

Improving patient care quality by reducing incorrect diagnoses

Cost savings associated with avoiding sample recollection and repeated tests






### Economic Conclusion:

Despite the initial cost, the return is evident through improved laboratory efficiency and error reduction. Investment in reducing errors is an investment in patient safety and quality healthcare delivery.

## Implementation Challenges




### Organizational

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-  Resistance to change from medical and administrative staff
-  Difficulty in coordinating efforts between different hospital departments, especially
-  Absence of unified policies and difficulty in consistently




### Financial

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-  High costs of implementing technological solutions such as Laboratory Information Systems (LIS)
-  Costs of continuous training for medical and technical staff on
-  Difficulty in measuring return on investment in improving

### Technical

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-  Integration of new systems with
-  Data security and patient privacy concerns when
-  Need for continuous maintenance

## Proposed Future Studies

For future research, we suggest focusing on the following areas to improve laboratory sample reception quality:



### Multi-Center Studies

Conducting multi-center studies to provide a more comprehensive picture of the problem's scope and diversity across different regions, helping to identify regional trends and best practices.



### Artificial Intelligence

Exploring the role of artificial intelligence in predicting and preventing errors, and developing systems capable of analyzing data and discovering patterns that precede errors.



### Interventional Studies

Evaluating the effectiveness of proposed solutions after implementation, through interventional studies that track quality indicators before and after improvements are implemented.







### Innovative Training Programs

Developing simulation-based training programs to enhance the skills of personnel working in sample collection and processing.





## Conclusion and Recommendations

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### Key Findings

-  **High Sample Rejection Rates**  
Sample rejection rates in Saudi hospitals range between 2.25% and 12.1%, which are higher than rates in some international locations.
-  **Most Common Errors**  
Hemolyzed samples (45.3%) and clotted samples (33.6%) constitute the largest proportion of errors in the pre-analytical phase.
-  **Impact of Different Departments**  
Inpatient units contribute 76.2% of rejected samples, compared to the emergency department (15.4%) and outpatient clinics (8.4%).
-  **Root Causes**  
Human errors are the main cause of most errors, accounting for a significant percentage of up to 82.6% of these errors.

### Practical Recommendations

-  **Training and Continuing Education**  
Develop intensive training programs for non-laboratory staff on proper sample collection techniques and handling.
-  **Implementing Technological Solutions**  
Use barcode systems and Laboratory Information Systems (LIS) to automate the sample path and reduce human errors.
-  **Standardization of Procedures and Quality Indicators**  
Adopt unified standards and guidelines such as CLSI standards and ISO 15189 with continuous monitoring of quality indicators.
-  **Future Studies**  
Conduct multi-center studies in the Kingdom and explore the role of artificial intelligence in predicting and preventing errors.