ANALYSIS OF THE FREQUENCY AND TYPES OF LABORATORY ERRORS AT DIFFERENT HOSPITALS IN ISLAMABAD

SUBMITTED BY

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CERTIFICATION

D ated: _____

This Is to Certify That the Project Entitled, **"Analysis of the Frequency & Types of Laboratory Errors at Different Hospitals in Islamabad** "Submitted By" **"Tooba Khalil"**. In Partial Fulfillment of The Requirement for The Award Of "BS In Medical Laboratory Technologist" At "Abasyn University Islamabad Campus" Is an Authentic Work Carried Out by Them Under My Supervision and Guidance. To The Best of My Knowledge, The Matter Embodied in the Project Has Not Been Submitted to Any Other University or Institute for The Award of Any Degree or Diploma.

COMMITTEE

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يَرْفَعِ ٱللَّهُ ٱلَّذِينَ ءَامَنُواْ مِنكُمْ وَٱلَّذِينَ أُوتُواْ ٱلْعِلْمَ دَرَجَٰتٍۚ وَٱللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ

God will raise up by several degrees those of you who believe and those who have been given knowledge: God is fully aware of what you do" (Qur'an 58:11, trans. Abdel Haleem).

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Abstract

Clinical laboratory services are essential in the contemporary healthcare system because most medical decisions rely on the outcome of the laboratory tests. Mistakes may compromise patient safety, increase waiting time, and compromise the quality of diagnosis at any stage of the overall test procedure (pre-analytical, analytical, or post-analytical).

Little multi-hospital data is available in Islamabad to comprehensively measure the trends in laboratory errors in all tests carried out despite worldwide efforts on laboratory quality control. This cross-sectional observational study was aimed at determining the nature and rate of laboratory errors in some hospitals in Islamabad. During the investigation, 200 samples of the laboratories identified to have errors were tested. The frequency of the errors in various laboratory investigations was determined by categorizing them into pre-analytical, analytical, and post-analytical stages. The data were analyzed by using SPSS version 25, and the results were presented in percentages and frequencies.

The findings indicated that pre-analytical errors contributed the highest percentage of 47.5, with an analytical error coming second with the percentage of 40.0, and post-analytical error with the third and least percentage of 12.5. Hemolysis was also identified as the most common pre-analytical error succeeded by mislabeling and delays in the transportation of samples. Although post-analytical error mostly accompanied reporting and data entry delays, the analytical error was most closely linked to instrument and processing issues. Many routine tests, particularly those of serum and clotting, contained more errors. Finally, pre-analytical methods are also most vulnerable to laboratory errors, which remain a major challenge in hospital labs in Islamabad. The paper recommends the importance of improving quality control measures, more staff training, compliance to standard operating procedures, and effective utilization of laboratory information systems. By solving such problems, it is possible to significantly decrease errors in laboratories, improve the accuracy of diagnoses, and the indicators of patient safety.

Keywords: Quality management system, diagnostic precision, patient safety, laboratory errors, pre-analytical errors, and clinical laboratories.

ABBREVIATIONS

Abbreviation	Full Form
WHO	World Health Organization
IFCC	International Federation of Clinical Chemistry and Laboratory Medicine
SOP	Standard Operating Procedure
LIS	Laboratory Information System
EMR	Electronic Medical Record
QMS	Quality Management System
CLSI	Clinical and Laboratory Standards Institute
IQC	Internal Quality Control
EQA	External Quality Assurance
IRB	Institutional Review Board
SPSS	Statistical Package for the Social Sciences
CBC	Complete Blood Count
LFTs	Liver Function Tests
RFTs	Renal Function Tests
PT	Prothrombin Time
INR	International Normalized Ratio
APTT	Activated Partial Thromboplastin Time
R/E	Routine Examination

Abbreviation	Full Form
CRP	C-Reactive Protein
HBsAg	Hepatitis B Surface Antigen
HbA1c	Glycated Hemoglobin
PCR	Polymerase Chain Reaction
QC	Quality Control
ED	Emergency Department

CHAPTER 1

INTRODUCTION

1.1Background

Almost 70 percent of medical decisions are related to diagnosis, monitoring and drug planning and a clinical laboratory is required (Lippi G, 2011; Plebani, 2010). The laboratory errors can still affect all stages of testing process such as the pre-analytical, analytical and the post-analytical phase and this may result in delays or faulty clinical judgments (Bonini et al., 2002; Da Rin, 2009). Sixty-seven percent to seventy percent of all laboratory errors are in pre-analytical procedures that involve patient misidentification, wrong sample, hemolysis, inappropriate container, and delayed transportation (Carraro P, 2007; Green, 2013). This is further worsened by the high workload, lack of staff training, and neglect of SOPS (Njoroge SW, 2014; Sharma A, 2020). Automation has minimised the quantity of error in the analysis process, though the issue of contamination, human error, reagent instability, equipment malfunction, and instrument calibration are still part of the issue (Hawkins, 2012).

Examples of post-analytical errors include delays in reporting, errors in transcription, erroneous values, or inappropriate interpretation of the results (Howanitz, 2005; Piva E, 2015). It is clinically important since even the correct test result can lead to harm even when not reported within a short period of time.

To avoid laboratory errors, it is important that organizations such as the WHO and IFCC emphasize a lot on quality-management systems, internal and external quality control, staff competency check, and continuous monitoring (Sciacovelli L, 2008; WHO, 2011).

The same tendencies have been witnessed in Pakistan. Human factors and inconsistent quality methods are the main causes of pre-analytical errors, as the studies conducted in Lahore, Karachi, Rawalpindi, and Islamabad have shown (Afzal M, 2017; Butt S, 2018; Hussain S, 2019). Other problems of government hospitals and high-volume hospitals are the lack of people, excessive workload, and a low level of automation (Ali N, 2020; Sadiq F, 2021).

The diverse nature of the public and private hospitals of Islamabad provides an ideal setting to measure laboratory errors. However, the absence of multi-hospital data in this regard highlights the need to conduct this study.

Laboratory errors also cause significant impacts on healthcare systems by enhancing retesting, prolonging hospitalization, and raising the costs of healthcare (Kalra, 2004; Plebani, 2013).

Patients experience discomfort and lose faith in healthcare when samples are collected again because to hemolysis or incorrect labeling. Hospital labs that handle large amounts of patient samples, particularly in developing nations, are susceptible to the cumulative impact of little mistakes that can lower a lab's effectiveness and quality (Hawkins,

2012). Hospital laboratories that deal with a lot of patient samples, especially in developing countries, are vulnerable to the cumulative effect of small errors that can reduce a lab's efficacy and quality (Hawkins, 2012).

Error reduction is also greatly aided by automation and laboratory information systems (LIS). Research has shown that computerized order entry, barcode-based sample identification, and automated result transfer greatly reduce errors both before and after analysis (Valenstein, 2004).

Unfortunately, Pakistan and many other low- and middle-income nations lack the infrastructure, financial resources, and technical know-how to effectively deploy such systems (Khan, 2020; Riaz, 2021). As a result, manual procedures are still widely used, which raises the possibility of human mistake.

In recent years, risk management and patient safety have become more important aspects of laboratory medicine. The international patient safety programs recognize the laboratory errors as preventable adverse events not necessarily the fault of particular doctors (Reason, 2000). Quality improvement programs should have feedback systems, root cause, and laboratory error audit (Carraro & Plebani, 2007; Sciacovelli & Plebani, 2009). Although these recommendations are made, the hospitals in Islamabad do not always apply structured error-monitoring systems, which demonstrates the importance of generating local evidence.

1.2 ProblemStatement

Despite the importance of laboratory services in the care of the patient, there is no sufficient information with regards to the nature, frequency, and location of errors in the pre-analytical, analytical, and post-analytical stages in Islamabad. Pakistan does not have many such studies,which are multicentric, out-of-date or focused on a specific area of laboratory, which limits their utility.

The inability of healthcare organizations to identify phase-specific defects, compare the performance of laboratories, and make targeted quality improvement efforts is inhibited by the absence of up-to-date and comprehensive regional data. Diagnostic errors can remain unnoticed when the laboratory errors are not systemic recorded and reviewed, and this can be a threat to patient safety and clinical judgment.

Also, there is the likelihood that the occurrence of laboratory errors might depend on the workload, staffing, facilities, and quality practice across the hospitals of Islamabad.

Nonetheless, these facts have not been examined to the full extent because of the lack of integrated data.Thus ,to generate local evidence, facilitate quality assurance programs, and improve the accuracy of diagnosis and patient care outcomes, a structured evaluation of the laboratory error in a few hospitals in Islamabad is needed.

1.3 Study Objectives

- To evaluate the types and frequency of laboratory errors that occur during various stages of the entire testing procedure in particular Islamabad hospitals.
- To ascertain the prevalence and distribution of laboratory errors in the pre-analytical, analytical, and post-analytical stages across a subset of Islamabad hospitals**.**
- To determine the most prevalent kinds of laboratory mistakes that happen at every stage of the testing procedure.
- To examine the relationship between several laboratory test categories, such as hematology, biochemistry, coagulation, urinalysis, and serology, and laboratory mistakes.
- To produce baseline multi-hospital data for clinical laboratory services quality assurance and patient safety programs.

1.4 Significance of the Study

The outcomes of laboratory tests play a vital role in diagnosis, clinical judgment and patient management. In order to ensure patient safety and improve the quality of medical care, it is essential to identify and understand laboratory errors at every level of testing.
This study can be utilized to enhance quality management systems such as standard operating procedures (SOPs), staff training programs, and error tracking systems among others. The research also provides a reference baseline when conducting future audits, interventional studies and formulation of laboratory quality improvement policies. Academically, this research adds to the limited local data on laboratory errors and may prompt future research. In conclusion, the findings are supposed to assist hospitals in the Islamabad region to achieve better patient care outcomes, reduce diagnostic errors, and enhance the efficiency of laboratories.

1.5 Scope and Delimitations of the Study

This study involves the clinical laboratories of most of the major hospitals in Islamabad and is targeted at the busy hematology, biochemistry, microbiology and immunology departments. The research aims to gain an overall view of the diagnostic environment through the analysis of the internal documents and error logs within a specific time frame. The research is restricted to the Islamabad region so as to maintain a narrow focus. We realize there exists a risk of underreporting in the context of documented or self-reported records, and none of the laboratories has a single personality, which is determined by the specific infrastructure and staffing rates and leads to a diverse range of data points. We view these as important context and not merely obstacles. These empirical considerations help the study provide an actual baseline of mistakes, which will eventually be applied as a means to enhance diagnostic accuracy and contribute to higher standards of patient care.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of the Relevant Literature

The center of the modern medicine is the clinical laboratory. It is believed that almost 70% of all medical decisions, including first diagnosis and the refining of life-saving procedures, will be put to rely on the information gathered behind these walls and this has proven to be a revolutionary factor (Lippi G, 2011; Plebani, 2010). One mistake during the testing cycle could not be considered a clerical mistake as the stakes are too high; this may lead to a delay in the treatment or act as a triggering fuel towards a misplaced clinical path.

The three distinct chapters that constituted the total testing process in the past are pre-analytical, analytical and post-analytical phases. All these phases are susceptible as per studies (Bonini et al., 2002). In the recent study, errors are viewed as indicators of structural defects and not individual workers (Reason, 2000). This total realization of the entire testing process drives the labs into a culture of continuous, extensive quality improvement as opposed to the technical accuracy.

2.1.1 Pre-Analytical Errors

All the actions performed before a sample ever gets to the lab bench are referred to as the pre-analytical stage. It involves patient preparation, collection, labeling and transportation and all this is often governed in the chaotic environment of a hospital ward. This is the most vulnerable stage in the process of testing because the majority is prone to mistakes and it is widely recognized as the most vulnerable stage in the laboratory process, as it utilizes a lot of manual work (Da Rin, 2009; Mrazek et al., 2020).

These errors often manifest themselves in the form of practical problems, including a small sample tube, a clotted sample or the so-called hemolysis of red cells caused by difficult phlebotomy. Hemolysis has become the primary cause in all of Europe, North America, Asia, and Africa, particularly in the busy world of emergency rooms (Cornes et al., 2016; Romero et al., 2018). As it was found in the research, we should perceive errors as symptoms of structural pressure instead of individualizing them.

The quality of the work in the laboratory in busy wards of a hospital may be negatively influenced due to high workloads and constant staff deficit. Such risk of a mistake is bound to grow when overworked interns or nurses who may be performing dozens of urgent tasks are to perform blood draws without phlebotomy training (Njoroge SW, 2014). The same tendencies are demonstrated in the sphere of the Pakistani medical system. The statistics always show the problems of hand labelling and time struggle in the transportation of the samples between Karachi and Peshawar (Hussain S, 2019; Sadiq F, 2021). These findings are a valuable lesson to keep in mind that a reliable diagnosis starts well before a vial is taken to the laboratory. It starts with a commitment to the human element of medicine, ensuring that our staff are supported and trained to ensure that the first mile of a diagnosis on a patient is safe immediately it is collected.

2.1.2 Analytical Errors

The “analytical stage" that is considered the technical center of the diagnostic process starts as soon as a sample is received by the lab. This step remains in error despite increased accuracy in the past decades in case of automation and digital tools (Boone, 2014; Goldschmidt, 2002). The unseen technological pressures are now often the reason behind the errors of analysis than the lack of effort in the modern practice. They include faulty equipment, slow calibration variations, or even interference of the equipment by a physiological state of the patient, e.g., hemolysis or lipemia.

This is a range of errors that constitute 10-20 percent of all lab errors in the world (Plebani, 2012). Nonetheless, it is apparent in the literature that there exists a human factor gap: it is more likely to fail in a laboratory that has an uneven maintenance timetable, unstable power supply, or lacks strict quality control (Gounden, 2012). Even the most sophisticated computers still need a watchful human eye to respond to quality-control alarms and uphold internal standards, as Westgard (2018) notes.

This problem is especially evident in Pakistan, where a large number of committed professionals have to deal with antiquated, partially automated analyzers or deal with the annoyance of erratic reagent supply (Afzal M, 2017). The duty of guaranteeing correctness frequently rests squarely on the shoulders of the individual technologist since many smaller and public-sector labs still find it difficult to participate in external quality-assurance programs. In the end, the analytical stage shows us that although technology is a strong ally, it still needs a stable environment and a strong quality culture to genuinely protect patient health.

2.1.3 Post-Analytical Errors

The last crucial connection between the laboratory and the patient's care is the post-analytical stage. This is the time to turn data into communication that is understandable and useful. However, mistakes might still occur during data entry, transcription, or even just sending out a report, even in the case of a flawless test. These mistakes, which make up 15–25% of all laboratory errors worldwide (Howanitz, 2005; Piva E, 2015), serve as a reminder that a medically "correct" result is useless if it is not received by the physician in a timely manner (Goswami et al., 2010).

Miscommunication of significant values to clinicians that would change their life and require an immediate response is another common weakness found in the world literature (Lillo, 2016). It is uncommon that it is the infrastructure that causes such malfunctions and not lack of attention. Communication gap The hospitals which do not operate on integrated Electronic Medical Records (EMRs) and, instead, use manual reporting, often encounter a gap in communication, when important information is misinterpreted or delayed (Han, 2017).

(This is also aggravated by the fact that post-analytical errors are often silent in Pakistan. The errors are not usually recorded and reported due to the absence of standard laboratory information systems in many facilities (Butt S, 2018; Hussain S, 2019). Ultimately, this part of the literature points out that laboratory medicine does not end at the analyzer but continues to end when the relevant information is in the right hands and this ensures that the patient receives the care he or she needs immediately.

2.1.4 Global Guidelines and Best Practices

To enhance laboratory medicine, the need to rectify errors should be replaced by the need to avoid failures. The major international organizations (WHO, IFCC, and CLSI) say that this is done by a good Quality Management System, which has a framework designed to assist the laboratory team with competencies-based training, detailed documentation, and an error reporting culture (Sciacovelli L, 2008).

It has been shown that these systems do not just check boxes; they can reduce the number of errors dramatically; thus, preparing the groundwork to safer patient care (Westgard, 2018). International literature strongly advocates for the use of contemporary methods to help protect this process:

- To get rid of transcribing errors, use barcodes and digital reporting.
- Lessening the burden that manual processing places on the body and mind (Salinas, 2018).
- Ensuring that the laboratory crew remains at the forefront of medical science through ongoing training.

By adhering to these international guidelines, labs may develop a robust system where human knowledge and technology coexist harmoniously, going beyond mere analytical precision.

2.1.5 Regional Studies and Relevance to Islamabad

Despite the significant studies performed throughout Pakistan, much of what we have today is the snapshots of one or two hospitals in such locations as Rawalpindi, Karachi, or Lahore. Nevertheless, Islamabad provides a unique and differentiated healthcare setting that has not been well covered in the literature. As a government, semi-government, and privately owned organization center, capital territory constitutes a wide spectrum of laboratory facilities and challenges (Ali N, 2020; Sadiq F, 2021).

Local studies have already begun to enlighten us on the troubles our medical departments face on an everyday basis. These encompass the logistical challenges of transportation of samples, the tension posed by heavy workload in the state hospitals and the risks associated with manual data entry. Cases of understaffed shifts and lack of adequate formal training of phlebotomy often lead to inadvertent patient care gaps despite the well-meaning intentions. Nevertheless, these revelations do not mean that Islamabad does not require a comprehensive multi-hospital study which will analyze the overall path of a sample of the total journeys by analyzing all the three laboratories errors in totality. This study aims to close that gap by going beyond disparate reporting to provide the capital's laboratory community a distinct, cohesive voice.

2.2 Study Gap

We still don't fully comprehend the diagnostic environment in Islamabad. We don't have a "big picture" of how errors spread throughout the city's testing cycle, even though we have snapshots of specific institutions. The pre-analytical phase of the procedure is the focus of a big portion of our present local research, with the following stages of testing being mostly ignored.

Additionally, we frequently fail to consider the human context of the data, including the effects of high workloads, understaffing, and the existence (or lack thereof) of automation on the workers. Most significantly, the data we do have is frequently constrained by a "culture of blame," in which sincere errors go unreported out of fear of consequences. A single-center research is insufficient to provide a complete picture because Islamabad is home to such a wide mix of state and commercial laboratories. This study fills that void by offering a thorough, multi-hospital investigation that shifts the focus from assigning blame to enhancing the safety and standard of treatment for each patient in the capital.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Study Design

Because we intended to depict laboratory life as it actually occurred without the artificiality of a controlled experiment, we used a retrospective design.

3.2 Study Setting

The research was done within the clinical laboratories of some hospitals in Islamabad. The selection of these places was due to the fact that they are the front line of the community healthcare and offer a plethora of services such as clinical chemistry and hematology.

3.3 Study Duration

Three months in September through November were spent on data collection. During this period, we had an opportunity to visit the labs during their usual working hours.

3.4 Study Population

This study was conducted on the basis of a wide-ranging, detailed analysis of all the activities of the laboratory. By sorting through the entire set of tests we were able to make our conclusions based on the real everyday experiences of the diagnostic teams.

- Total tests reviewed: 15,611
- Breakdown by month: 5,670 in September, 4,591 in October, and 5,350 in November

3.5 Sample Size

In our last study we considered 200 reported error cases of 15611 tests. These 200 samples provided the much-needed insight as to the areas in the testing cycle that are the most vulnerable.

3.6 Sampling Technique

Our strategy was based on purposive sampling, whereby all the samples we meticulously hand-selected had to meet our criteria of laboratory errors. To make sure that all errors recorded would have a voice in our final analysis, we could afford to leave out the thousands of normal tests and focus all our efforts on the specific cases where the testing process was disrupted.

3.7 Inclusion and Exclusion Criteria.

To record the "Total Testing Process," we analyzed the samples of all the areas of the lab, such as chemistry, hematology, serology, and the urinalysis.

3.7.1 Inclusion Criteria

All samples which had problems in the pre-analytical, analytical or post-analytical phase were recorded carefully.

3.7.2 Exclusion Criteria

We filtered out error-free samples and tests which had been repeated simply because the use of those tests was clinical. Since our research was to have the basis of verifiable facts, we also excluded rejected samples that could not be well documented.

3.8 Data Collection Procedure

The process of re-tracing the path of each sample was a tedious one in the collection of this data. To identify the root cause of what had gone wrong, we took the time to cross-examine error logs, lab documents and internal quality notes. The type of test, the time of the error, and its specifics of each case we studied.

The first thing that we considered in this procedure was patient confidentiality. All records were treated with utmost care; names were removed immediately and coded numbers put in their place. Consequently, we were in a position to make inferences based on the information and at the same time protect the privacy of the individuals who gave the samples fully. The laboratory errors are to be classified as follows: To make sense of the data we categorized each mistake as per its position during the Total Testing Process. With our own approach of life cycle, we could isolate the specific point
at which the diagnostic process was terminated:

3.9 Error Phases

3.9.1 The Pre-Analytical Phase (Pre-Lab)

We were looking at errors that occur at an early stage such as the physical integrity of the sample (hemolysis), the logistics of transporting the sample to the bench (transportation delays), or the most significant element of the procedure, which is ensuring the name on the appropriate tube is correct (mislabeling).

3.9.2 Analytical Phase (During Testing)

We encountered technical problems with the laboratory, such as the reliability of the reagents to produce the results, malfunction with the equipment or the silent drift of the instrument calibration.

3.9.3 The Post-Analytical Phase (After Analysis)

Finally, we kept track of how information was handled after the test was completed with special attention to report delays, accuracy of data entry, and the most important task of ensuring that the medical team was told about the results.

3.10 Data Analysis

After the records were collected, we used SPSS to turn these unprocessed data into an understandable story. Through the use of descriptive statistics, particularly with regard to frequencies and percentages, we were able to see the "big picture." Our analysis was concentrated on:

- Identifying which phase of testing is the most vulnerable.
- Seeing which types of tests (like hematology or chemistry) are most prone to errors.
- Comparing monthly workloads against the frequency of errors to see if busier periods impacted accuracy.

3.11 Ethical Considerations

A high level of commitment to moral principles was made during this investigation. We were given an official ethical authorization by the right authorities prior to starting. With the same attention as we would have in a face-to-face interview, we treated each of the records with the same care provided that the character of this retrospective study did not allow us to have any direct contact with the patients.

We have used an effective anonymization process to honor patient privacy. No names or personal identifiers were provided in our analysis and the final report. We ensured that our quest to achieve laboratory excellence did not compromise on the personal privacy since we eliminated the identities and focused on the patterns.

CHAPTER 4

RESULTS & DISCUSSION

4.1 Results

Our investigation focuses on 200 laboratory samples that had mistakes found during the diagnosis process. We classified these results using SPSS version 25 to have a better understanding of the system's advantages and disadvantages.

4.1.1 Distribution of Laboratory Errors by Phase

To determine where the most common disruptions were place, we divided the errors into three main phases. Pre-analytical, analytical, and post-analytical are the three stages. The outcomes are as follows:

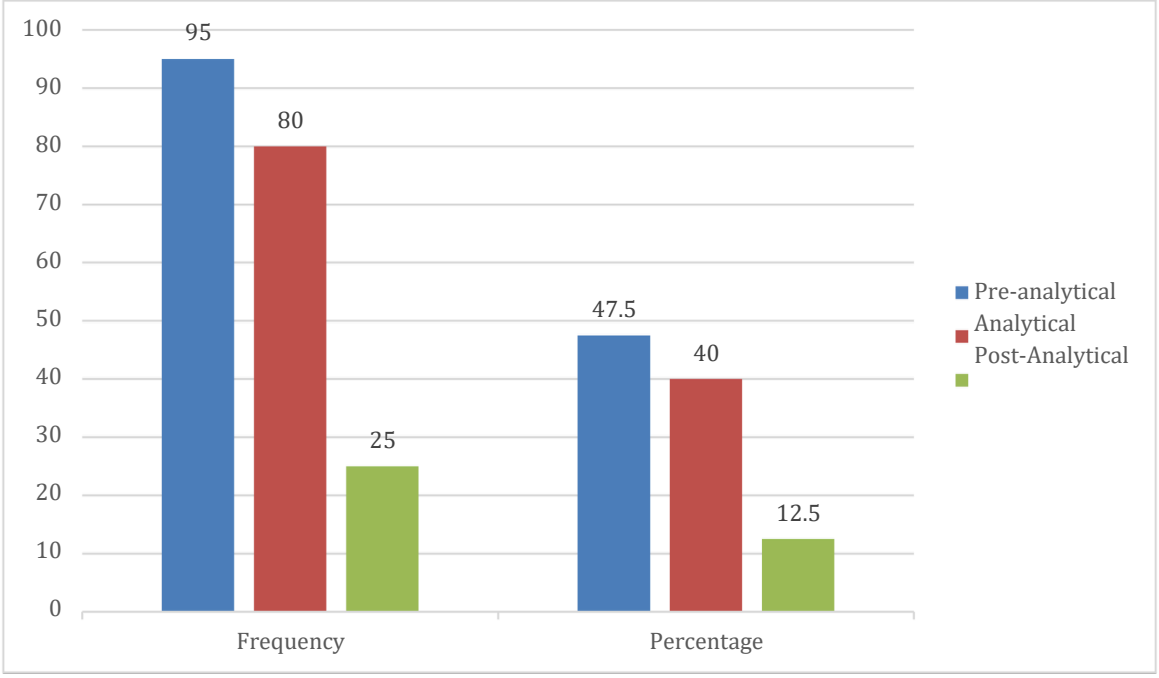
TABLE 4.1

Error Phase	**Frequency (n)**	**Percentage (%)**
Pre-analytical	95	47.5
Analytical	80	40.0
Post-analytical	25	12.5
Total	**200**	**100.0**

(Table 4.1: Distribution of laboratory errors by phase)

These results show that the main cause of laboratory errors in this study is the pre-analytical stage. This demonstrates that the most common interruptions occur in the initial phases, with difficulties during patient preparation and sample handling closely followed by difficulties during the actual analytical testing.

FIGURE 1:



(Figure 1: Distribution of laboratory errors by phase)

4.1.2 Types of Pre-Analytical Errors

The "first mile" of the diagnostic process is the pre-analytical phase, which included 95 cases. According to our research, the most frequent disruptions take place here:

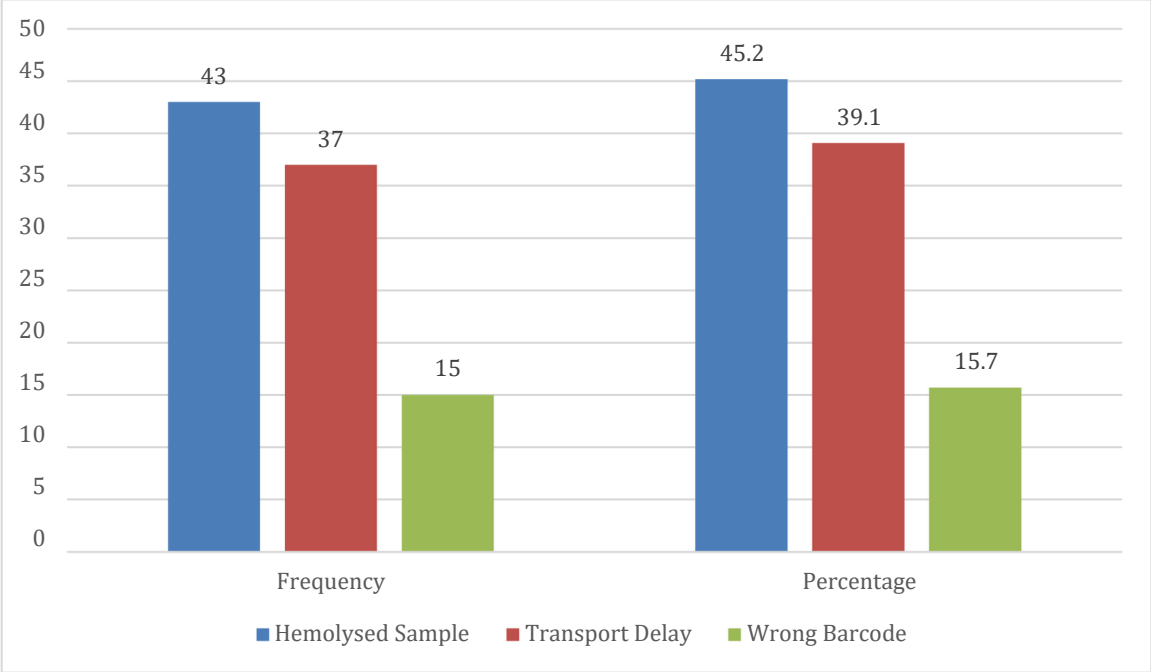
- Nearly half of these errors (45.2%, 43 cases) were due to hemolysis. Draws attention to the physical fragility of red blood cells during the phlebotomy procedure and the delicate nature of sample collection.
- Sample transport delays were the second most frequent hurdle (39.1%, 37 cases), reflecting the logistical difficulties of moving samples through a busy hospital environment.
- Mislabeling or barcode errors accounted for the remaining 15.7% (15 cases). While smaller in number, these represent critical moments where the connection between the patient and their data was at risk

TABLE 4.2

Type of Pre-Analytical Error	Frequency (n)	Percentage (%)
Hemolysed sample	43	45.2
Sampletransport delay	37	39.1
Wrongbarcode / mislabeling	15	15.7
Total	**95**	**100.0**

(Table 4.2: Types of pre-analytical errors)

FIGURE 2:



(Figure 2: Types of pre-analytical errors)

4.1.3 Analytical Errors

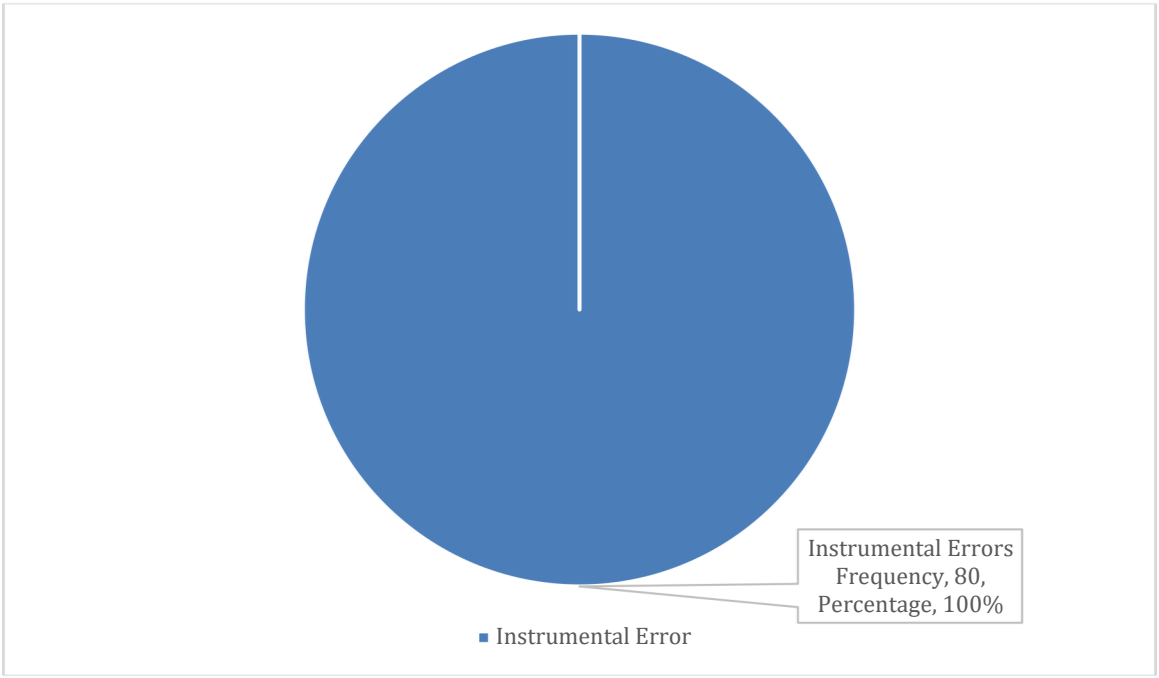
The number of analytical errors (40.0) in the lab itself was 80. These findings are the wake-up call that technology and technique are always being put to the test even in regulated settings. The cause of these mishaps was mostly caused by instrument failures and processing issues. Such high number of errors in analysis points to one significant fact: the quality of a result depends on the quality of maintenance of machines and strict adherence to the rules according to which they operate on a regular basis.

TABLE 4.3

Type of Error	Frequency (n)	Percentage (%)
Instrument / processing error	80	40.0
Total	**80**	**40.0**

(Table 4.3: Frequency of analytical errors)

FIGURE 3:



(Figure 3: Frequency of analytical errors)

4.1.4 Post-Analytical Errors

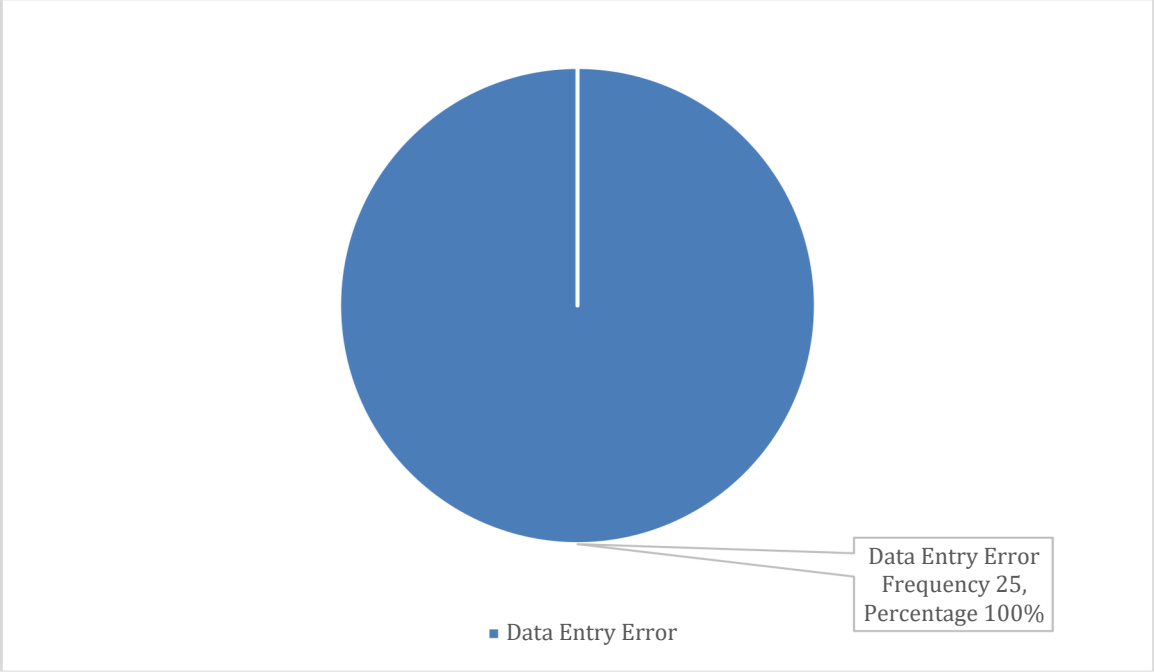
Post-analytical errors were the least frequent, but, as they form the last relay in the information flow, they were 25 (12.3%) in number. These flaws normally entailed the mistakes in transcription when inputting the data or lag in reporting. Although these numbers are lower than the figures in the other stages, they remain very significant as a correct outcome can only be of value when well documented and provided to the doctor on time to assist the patient.

TABLE 4.4

Type of Error	Frequency (n)	Percentage (%)
Reporting / data entry error	25	100.0
Total	**25**	**100.0**

(Table 4.4: Frequency of post-analytical errors)

FIGURE 4:



(Figure 4: Frequency of post-analytical errors)

4.1.5 Distribution of Errors by Test Type

The full range of diagnostic services was affected by laboratory errors, which were not limited to a single department. We monitored these difficulties in each of the lab's main areas, such as:

- Core Blood Work: Complete Blood Counts (CBC) and Coagulation profiles (PT/INR, APTT).
- Metabolic & Chemistry Panels: Liver Function Tests (LFTs), Renal Function Tests (RFTs), and Lipid Profiles.
- Specialized & Routine Checks: Serology (CRP, HBsAg, HbA1c) and Urine Routine Examinations.

We identify a definite trend in our results: CBC, and coagulation profile tests which had the greatest number of errors were the workhorse tests of the hospital. They are most exposed to the fast-paced reality of the frontline because these are routine, high-volume investigations. The high frequency of errors in a CBC, for instance, is a direct result of the pre-analytical pressures we previously noted, such as hemolysis and the precise time needed for coagulation samples. This is because a CBC is extremely sensitive to the way a sample is drawn and handled. According to this research, it is precisely because these tests are "routine" that we must pay close attention to them to make sure that the hospital's pace never jeopardizes patient safety.

TABLE 4.5

Laboratory Test	**Frequency (n)**	**Percentage (%)**
Complete Blood Count (CBC)	16	8
Liver Function Tests (LFTs)	21	10.5
Renal Function Tests (RFTs)	15	7.5
Lipid Profile	22	11
PT / INR / APTT	47	23.5
Urine Routine Examination (R/E)	19	9.5
Serology (CRP, HBsAg, HbA1c)	60	30
Total	**200**	**100.0**

(Table 4.5: Distribution of errors according to laboratory test type)

FIGURE 5:

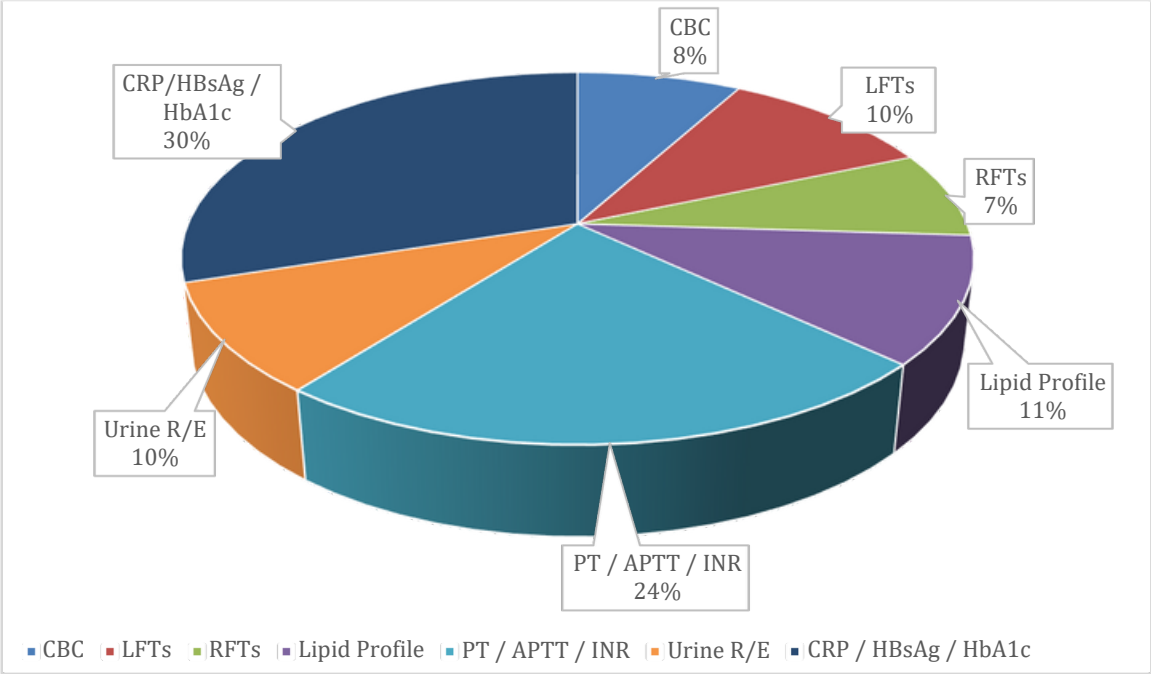
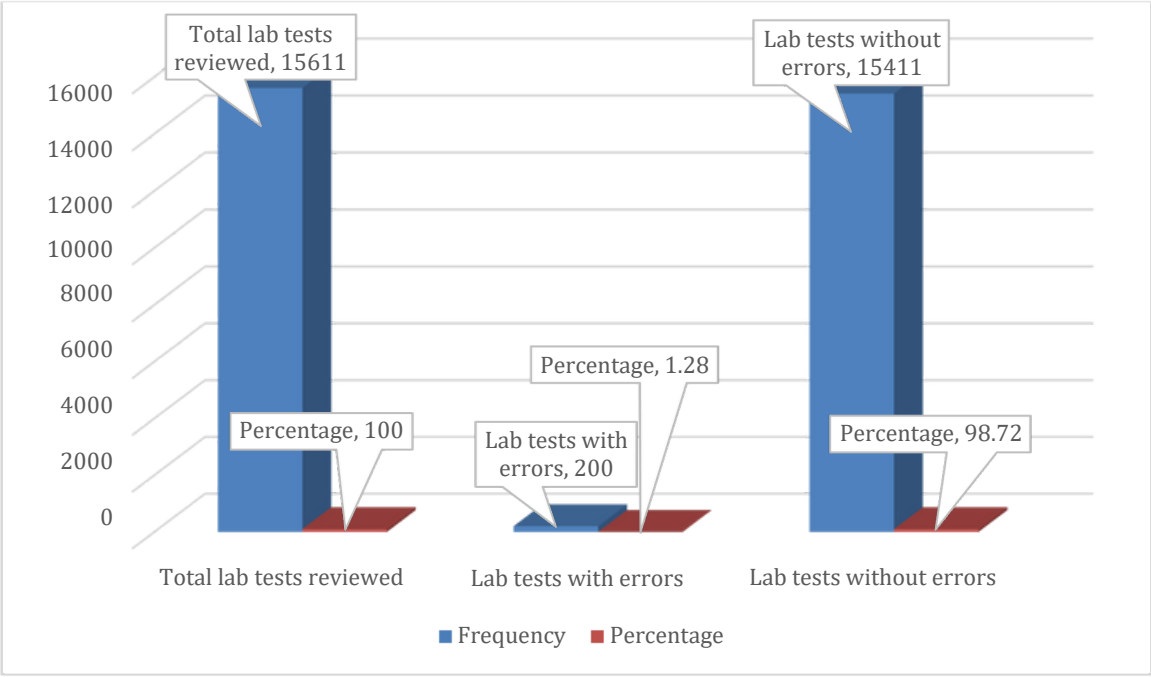


TABLE 4.6:

Parameter	Frequency (n)	Percentage (%)
Total laboratory tests reviewed	15611	100.0
Laboratory tests with errors	200	1.28
Laboratory tests without errors	15411	98.72

(Table 4.6: Total Laboratory Tests Reviewed and Tests with Errors)

FIGURE 6:



(Figure 6: Total Laboratory Tests Reviewed and Tests with Errors)

Breakdown of Total Tests Reviewed by Month

Month	Total Tests Reviewed (n)
September	5670
October	4591
November	5350
Total	15611

Table 4.7: Breakdown of Total Tests Reviewed by Month

Figure 7:

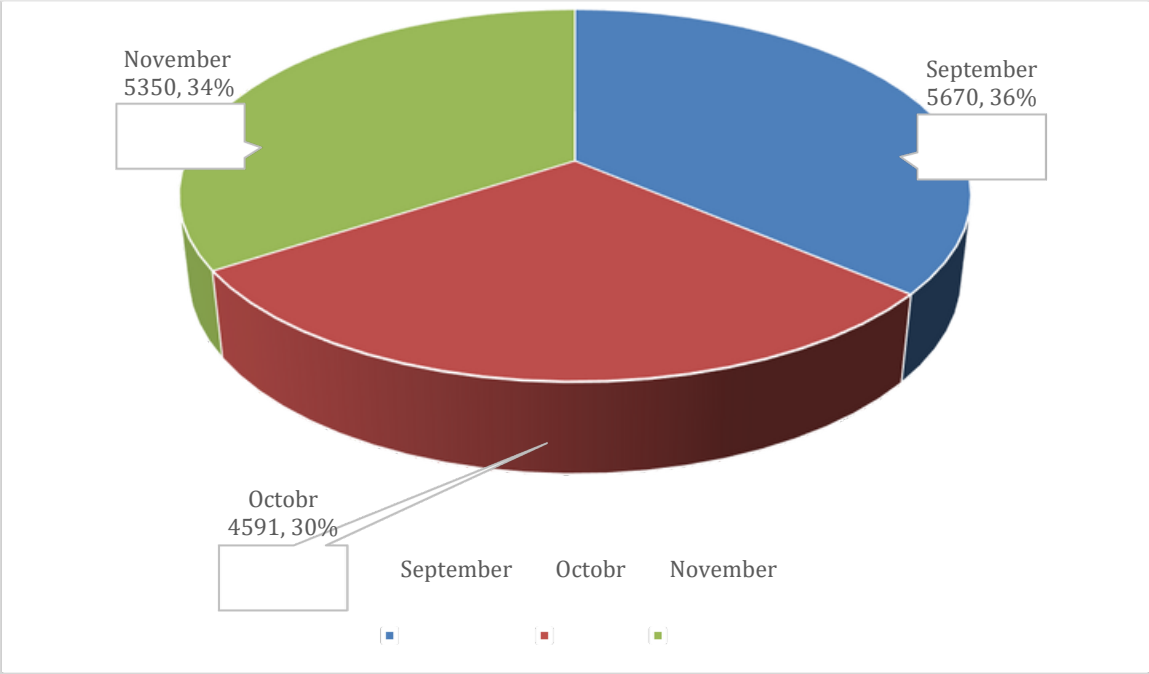


Figure 7: Breakdown of Total Tests Reviewed by Month

200 samples (1.28%) of the 15,611 laboratory tests examined throughout the study period had laboratory errors, whilst the majority (98.72%) had no recorded errors.

4.2 Discussion

The aim of the research was to access the daily routine of the laboratories of Islamabad and determine the spheres where the diagnosis process faces the greatest challenges. The depressing picture of our results is pretty clear: the quality of laboratories is a continuous process which begins much earlier than a sample is placed into a machine and is not a fixed achievement.

With our analysis, we have found that the testing cycle is most vulnerable in the pre-analytical stage as it is correlated with regional and international studies. These are the most likely barriers in the initial-mile between the patient and the healthcare professional.

The major concern was hemolysis. This is not just a technical term, but it refers to the physical frailty of a sample of a patient that is often put at risk due to the extreme pressure of overcrowded wards, unsuitable needle usage, or due to the simple exertion of a difficult blood draw. Similarly, the observed transfer delays indicate a strain in the logistics, a failure of the harmonious interaction between the laboratory and the overcrowded clinical wards.

Although technology has automated much of the analytical process, the 40 percent error rate that we experienced is a warning that robots are not set-and-forget tools. They require the continuous and close supervision of certified experts when it comes to calibration and maintenance. The last relay of information are post-analytical errors which were less frequent although.

A test, however accurate, however, is as good as the communication that transmits it to the doctor; a lost decimal, a laggard report is a fatal influence that is silent.

4.3. Comparison of Existing Literature

We have identified these trends in Islamabad, which are common, rather than isolated, to a familiar story in tertiary medical centers all over the developing world. In making a comparison with the world literature we substantiate a general medical fact that the human-dependent phases of testing are the most sensitive, regardless of the nation or the sophistication of the technology. The results of our investigation prove that Islamabad is facing the same problems its foreign counterparts do, and this fact proves that the establishment of the diagnostic excellence is a universal undertaking that requires a unified focus on serving the individuals that are involved in the process.

4.4 Implications and Significance of Findings

They are more than mere numbers on a piece of paper; these results are a road map on how to protect the lives of patients in our city. We need to initiate investments into those people who contribute to making mistakes so that to establish a stronger healthcare system in Islamabad.

The idea of strengthening the pre-analytical stage is not only to enforce stricter rules but also to provide our nurses and phlebotomist with the constant learning and the latest expertise they need to be confident they can perform their tasks successfully at the bedside of a patient.

- To the workers, a good quality control system is their closest friend as opposed to their enemy. We create culture of quality which is the silent guardian of every technician working the bench by ensuring that our equipment is reliable and our processes are clear.
- The walls between the laboratory and the clinical wards should be done away with. We ensure that a sample is not considered as a vial, but as a priority, that will result in a person having better chances of being diagnosed, by improving communication between the physicians, nurses, and the lab personnel.

Ultimately, we have more than just minimized error rates by bringing about systemic and human gaps to be filled in. Whenever the people of Islamabad await the outcome of a test, we are thankful that they have such a strong faith in us.

CHAPTER 5

CONCLUSION & FUTURE WORK

5.1 Key Findings

This study sought to understand the heartbeat of the diagnostic services in the city of Islamabad by carefully analyzing the periods when there was a breakdown in the process. By simulating 200 different mistakes scenarios we were in a position to observe a coherent and clear image of the functioning of our laboratories under strain.

Our findings can be summed up as follows:

- Nearly half of all hurdles (47.5%) occur during the pre-analytical phase. This confirms what most medical practitioners face on a day-to-day basis; the most sensitive situations are the first time the patient sees the needle. These are the most usceptible procedures to the hectic environment of the hospital as they are solely left at the mercy of the sample collector and coordination.
- 40 percent of our cases contained errors in analysis. This is to remind us that, though our labs may be equipped with the most advanced technology, such machinery still requires human attention at all times. The critical space between human and technical perfection in the testing process remains a vital field such as the precision in calibration to the careful approach in the handling of the reagents.
- Post-analytical errors have a high load even though they are the least prevalent (12.5%). Each of them is the final seconds when the file of a patient is diagnosed. The final mile is of paramount importance as a single mistake in reporting or interpretation can change the treatment of a patient.

The physical degradation of a sample or hemolysis became the primary challenge when we penetrated deeper into the pre-analytical phase. These outcomes demonstrate the huge load on our phlebotomists as well as our logistics team, especially in our city with busy workload hospitals, not to mention the delay in transportation and labeling issues.

Finally, we discovered that serological and coagulation tests were our most error-prone tests. It is simply an expression of the voluminous and complicated nature of these departments on day-to-day basis and not necessarily a sign of low competency. It shows that the need of a good safety net to provide our laboratory professionals with the required support is increasing with the workload.

5.2 Conclusion

Overall, our analysis demonstrates that laboratory errors are not isolated cases, but they can be regarded as a mirror of the challenges experienced in the clinical environments of Islamabad on a daily basis. The results of our study clearly prove that the pre-analytical stage or the first mile where we interact with the patient is the most vulnerable. This highlights the value of investing in our front-line employees so that they are supported by accurate instructions and time needed to properly carry out sample collection, identify and transportation.

In spite of the fact that technology has enhanced the security of the analytical and post-analytical stages, their frequent challenges remind that human focus to details is unreplaceable. Even a calibration drift or reporting error can cause a tremendous effect on the life of a patient. Consequently, the presence of a good quality control system will not only be technical but also ethical assurance of safety to every single patient walking into a hospital. Conclusively, we should abandon the culture of blame and adopt the culture of constant improvement. These challenges can be utilized as opportunities to improve ourselves through the implementation of comprehensive quality practices and open communication of errors. Besides modifying the efficiency of our laboratories, these holes, which we systematically fill in, would significantly enhance the security line we provide to our patients.

5.3 Future Research Direction

This paper is by no means as extensive as the analysis of laboratory excellence in Islamabad. Although we may have learnt a lot, the journey is a long way. To develop a future in which our diagnostic systems are as strong as the individuals that drive them, we propose the following directions of our future actions.

The city should be seen as one and not as a set of buildings. To create a health map of the Islamabad laboratory performance, we can implement a larger, multi-center study, which will ensure that the excellent standards are satisfied regardless of the patient visiting a private hospital or a state clinic.

There is lack of information per se, there is need of interventional research. This will involve designing and reviewing practical training programs and workshops to identify the ones that do improve the confidence and performance of our nurses and phlebotomists in the hectic environment of a busy ward.

The relationship between the workload, staffing and error rates must be looked into in greater detail. Awareness of the human limits of our laboratory staff can be used to prevent burnout and ensure patient safety by promoting reasonable schedules and better support mechanisms.

We should explore how smart reporting tools and Laboratory Information Systems (LIS) can become a silent partner of our employees. Technology should then be a safety net that will help identify small mistakes before it can even reach a patient in the bed. Here we can focus our future attention and help our city to further manage its quality management systems. We can also ensure that each diagnostic decision that is made in Islamabad is backed by a system that values patient safety, respects the expertise of people who work there, and values accuracy.

APPENDICES

Appendix A: Data Collection Form

Laboratory Error Data Collection Form

Information on laboratory samples that were found to have errors during the study period was recorded using this form.

SECTION A: GENERAL INFORMATION

- **Hospital Name: _____**
- **Laboratory Section:**
    - Hematology
    - Biochemistry
    - Coagulation
    - Urinalysis
    - Serology
- **Date of Sample Collection: _____**
- **Sample Identification Number: _____**

SECTION B: PATIENT & TEST INFORMATION

- **Patient Name / Code: _____**
- **Test Requested:**
    - CBC
    - LFTs
    - RFTs
    - Lipid Profile
    - PT / INR / APTT
    - Urine R/E
    - Serology (Specify): _____

SECTION C: ERROR CLASSIFICATION

- **Error Phase:**
    - Pre-analytical
    - Analytical
    - Post-analytical

SECTION D: SPECIFIC TYPE OF ERROR

- Hemolysed sample
- Insufficient sample volume
- Wrong barcode / mislabeling
- Sample transport delay
- Instrument malfunction
- Calibration / reagent issue
- Data entry error
- Delay in reporting
- Failure to notify critical value
- Other (Specify): _____

SECTION E: REMARKS (IF ANY)

Appendix B: Error Classification Framework

Classification of Laboratory Errors Based on Testing Phase

Pre-Analytical Errors

- Patient misidentification
- Incorrect sample labeling
- Wrong collection tube
- Hemolysis due to improper phlebotomy
- Insufficient sample volume
- Sample clotting
- Delayed transportation
- Improper storage conditions

Analytical Errors

- Instrument malfunction
- Calibration errors
- Reagent instability or expiry
- Contamination
- Analytical interference (lipemia, icterus, hemolysis)
- Operator-related procedural errors

Post-Analytical Errors

- Transcription errors
- Incorrect data entry
- Delay in result reporting
- Failure to communicate critical values
- Missing or incomplete reports
- Incorrect interpretation of results

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