Open Access Original Article

# Improving Hematology Lab Results: Detecting Preanalytical Errors through Quality Metrics

***Noorulain Fareed[1]***
***Maliha Sumbul[2]***
***Aiman Ishtiaq[3]***
***Saira Bano[4]***
***Muhammad Nadeem[5]***

*Hematology department, Pathology Laboratory at National Institute of Cardiovascular Diseases, Karachi*

## Abstract

Objective: To evaluate pre-analytical quality indicators in hematology laboratory to improve and strengthen healthcare outcome.
Methodology: This retrospective study was conducted in the hematology section of Pathology lab, at National Institute of Cardiovascular Diseases (NICVD) from 01-06-2024 to 30-11-2024. A total of 188,682 consecutive samples received for investigations in the hematology department were included in the study. The pre-analytical issues were reviewed and evaluated using a set of quality indicators (QIs), including Quantity not sufficient (QNS), Hemolysed, Clotted, Wrong labeling, Wrong Vacutainer, Sample redo, and insufficient blood volume
Results: The hematology department analyzed a total of 188,682 blood samples over the study period from 01 June to 30 Nov 2024. Overall, 689 (0.35%) samples was found to have quality indicators issues. The most frequent error was "Clotted specimen" 392(56.8%), "Quantity not sufficient (QNS)" 277(40.2%), Wrong labeling in 12 (1.74%), Hemolysed sample 07(1.0%), and sample redo was 01(0.14%) out of all 689 rejected samples.
Conclusion: The study shows that hematology department maintained a low percentage of errors across key quality indicators due to the strict implementation of SOPs and the recording of sample rejection data. Future studies could focus on assessing the impact of specific interventions or exploring new indicators to further refine continuous quality monitoring in hematology labs as an important tool for self-assessment
Keywords: Hematology, Laboratory errors, Quality indicator, Preanalytical, Sample rejection

**Address for Correspondence**
*Dr. Noorulain Fareed*
*Senior Registrar*
*Hematology department, Pathology Laboratory at National Institute of Cardiovascular Diseases, Karachi*
*drnoorulain1@gmail.com*

## Introduction

A quality indicator (QI) is a measurable parameter used to assess the essential component of health care system, enabling the standardized application and comparison across various setting and time frames.[1] Reliable and accurate laboratory test results are essential for diagnosis and management of patients; therefore we need precise and reliable test results.[2] Quality indicators have been widely utilized to identify the laboratory errors in health care facility, and form the basis of implementing corrective strategies to improve performance of laboratory.

We use quality indicators to assess the laboratory test results because we need them to be accurate and precise. If the results are inaccurate and imprecise it can lead to bad impact on the diagnosis and management of patients. Pre analytical errors have been recognized as a important source of inaccuracy and imprecision in the diagnostic test results.[3-6] Laboratory testing are broadly classified into three phases: Pre analytical, analytical and postanalytical. The concept of pre analytical phase was described by Statland and Winkle in 1977.[7] While advances in automated analyzers have substantially reduced errors in analytical and post analytical phases but pre analytical phases remain on manual handling by staff. [8] Consequently this preanalytical phase consider most critical, accounting for around 40-70% of total laboratory test results.[9] Furthermore, the financial impact due to preanalytical errors, with associated cost estimated to represent 0.2 to 1.2% of the total hospital expenditure.[10]

Quality indicators are important because they help us to figure out how well the laboratory is doing according to SOPs. Based on objective metrics, quality indicators (QI) serve as essential tools for evaluating the key dimensions of health care delivery and enable the objective assessment of laboratory assessment.[11] Quality in laboratory services plays a pivotal role in accurate diagnosis and effective patient treatment, because approximately 80% of clinical decision which made on laboratory test results.[12] The quality of the work in the laboratory is very important for doctors to diagnose

Authorship Contribution: [1,2,] Conceived and planned the idea of the study, Collecting the data drafting the work or revising it critically for important intellectual content, [5]final approval of the version to be published, [3,4]data entry, literature review

Funding Source: none
Conflict of Interest: none
Received: Aug 26, 2025
Accepted: Jan 12, 2026

patients and decide what treatment they need. This is because doctors make about 80 percent of their diagnoses based on the results of laboratory tests.

The pre-analytical phase is really complicated. It has a big impact on the testing process. It affects the quality of the result. How we understand the information we get. The pre-analytical phase is the complex part of the testing process, and it affects both the quality of the analytical result and the interpretation of the information provided.

The pre-analytical phase plays a pivotal role in laboratory testing, significantly influencing the analytical phase and result interpretation.[13-15] Various studies indicate that pre-analytical errors account up to 70% of laboratory errors, while analytical errors contribute around 7 to 13%, and post analytical errors account around 20 to 50%.[16, 17]

Quality in medical diagnostics is fundamental to ensuring patients' safety and effective health care delivery.[18] Errors in laboratory process scan results in delayed diagnosis, reduced patient satisfaction and wastage of resources in health care system.[19] The pre analytical phase susceptible to errors, including inappropriate test request, patient misidentification, inadequate patient preparation, improper sample collection, poor specimen quality such as clotted, hemolysis, diluted and insufficient samples and errors in sample transportation and storage conditions. In addition, activities after sample collection including centrifugation and separation are also in preanalytical phase.[20]This study aims to identify pre analytical errors leading to sample rejection in a laboratory setting and propose corrective strategies to reduce their occurrence.

## Methodology

A retrospective observational study was conducted over the six months from 01-06-2024 to 30-11-2024 in the hematology department at the National Institute of Cardiovascular Diseases (NICVD).

This study was approved by the Institutional Review Board (IRB #36/2025/NICVD) and was performed with the principles of the Declaration of Helsinki.

This study includes blood samples received from different departments including the inpatient department (intensive care unit (ICU), Cardiac care unit (CCU) and adult and pediatric wards.

Hematology investigations included complete blood count (CBC) parameters (hemoglobin, white blood cell count, platelet count), malarial parasite examination, and coagulation tests comprising prothrombin time (PT), international normalized ratio (INR), and activated partial thromboplastin time (APTT).

Relevant data were retrieved from laboratory records, which documented details related to sample collection, processing, and reasons for sample rejection.

Pre-analytical variables evaluated in this study included incorrect vacutainer use, clotted samples, insufficient sample volume, hemolyzed or diluted samples, empty or damaged tubes, incorrect or missing labeling and Delays in sample transportation to the laboratory

For coagulation testing, only samples with the correct blood-to-anticoagulant ratio were accepted. Samples with inappropriate volume were rejected and categorized as pre-analytical errors.

Data were entered into Microsoft Excel and analyzed descriptively. Results are presented as frequencies and percentages.

## Results

A total of 188,682 blood samples received for investigations were included in the study. Of these, 689 samples were rejected, resulting in an overall rejection rate of 0.36%. Clotted samples were the most common cause of rejection, accounting for 56.5% of rejected specimens, followed by quantity not sufficient (QNS) samples (39.9%). Sample redo requests constituted the least frequent pre-analytical error (0.14%) (Table I).

Table I: Frequency distribution of rejected samples (689) across preanalytical variables.

| Pre-analytical errors | Number of samples | CBC vacutainer (%) | Coagulation vacutainer (%) |
|---|---|---|---|
| Clotted sample | 392 | 73.9% | 26.0% |
| Insufficient sample | 277 | 41.8% | 58.1% |
| Labeling error | 12 | 1.0% | 0.36% |
| Hemolysed sample | 08 | 0.48% | 0.08% |
| Empty/damaged tubes | 00 | 00 | 00 |
| Wrong Vacutainer | 00 | 00 | 00 |

We analyzed the data according to department, showed that the majority of rejected samples originated from inpatient services, accounting for 0.3% of total samples, whereas outpatient department samples contributed 0.05% of rejected specimens. Among the inpatient

rejection rate of samples, the emergency department contributed the highest proportion (38.2%), followed by the pediatric department (24.8%), adult wards (20%), cardiac care unit (4%), and intensive care unit (2%) (Figure 1).

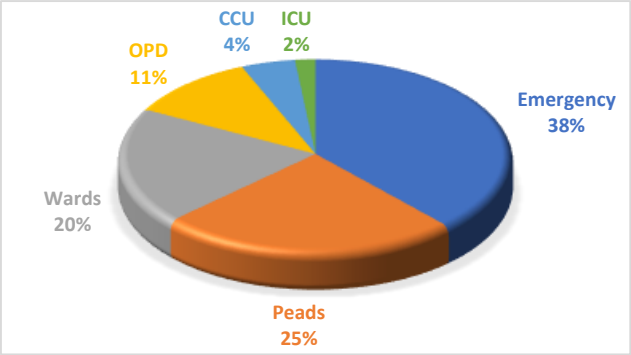


Figure 1. Showing department-wise error distribution.

On the further analysis of emergency department rejected samples demonstrated that predominant cause of sample rejection was clotted samples, followed by quantity not sufficient (QNS) samples. Surprisingly no samples from the emergency department were rejected due to delayed transport to the laboratory. In contrast, the pediatric department contributed a substantial proportion of both clotted and insufficient quantity samples.

Assessment of pre-analytical quality indicators against established quality specifications demonstrated an overall moderate level of performance across the evaluated indicators.

## Discussion

Pre-analytical errors happen before the laboratory even looks at the sample. These mistakes are a problem for clinical laboratories. The study found that most pre-analytical errors happen when collecting specimens. Pre-analytical errors, which occur prior to sample processing, continue to pose a major challenge for clinical laboratories.[21] Findings from the present study indicate that most of the pre-analytical errors were associated with errors in the specimen collection procedures, resulting in poor sample quality. A laboratory error is defined as any mistake occurring throughout the total testing process—from test request to reporting of result—that adversely affects the quality of laboratory test results.[22] Previous studies have reported that up to 75% of laboratory errors originate during the pre-analytical phase, underscoring its critical role in ensuring reliable laboratory results.[23]

Classification of laboratory errors based on the identification of errors requiring urgent corrective action and enables the implementation of preventive strategies with the help of SOPs. It has been reported that extensive hemolysis can lead to inaccurate complete blood count results[24], further emphasizing the clinical impact of pre-analytical variables. The high frequency of pre-analytical errors observed in pediatric hospital care highlights the complexity and vulnerability of blood sampling procedures in this patient population. The fact that mistakes happen often when taking blood samples from pediatric population in the hospital shows that the blood sampling method is complicated and prone, to errors.[25]

In this retrospective analysis, we evaluated the prevalence and types of pre-analytical variables leading to sample rejection across multiple departments of the hospital. These findings are consistent with reports from other centers, as summarized in Table 2. The disproportionately higher rate of pre-analytical errors in pediatric patients reinforces the technical challenges associated with blood collection in this group.[26] We have to make sure that everything is done correctly from the start of sample collection, not just at the time of test analysis. This is important, for pediatric care -analytical variables and pre-analytical errors. The stage before the samples get to the laboratory and after the sample has been tested are really important. In the present study, the most common causes of sample rejection were quantity not sufficient (QNS) and clotted samples, with clotting predominantly observed in complete blood count specimens.

Ensuring clinical laboratory reliability cannot be achieved solely by focusing on analytical accuracy. Both the pre-analytical phase—before samples reach the laboratory—and the post-analytical phase—after result generation—play equally critical roles in maintaining overall test quality.[27, 28]

A study conducted in Pakistan in 2023 reported lower pre-analytical error rates, attributing this improvement to the implementation of a laboratory information system that minimized manual handling. However, clotted and hemolyzed samples persisted as significant issues,

highlighting the continued need for staff training and education.[29] In the current study, pre-analytical errors constituted 0.35% of total samples, which is substantially much lower than the 21.6% reported in a hematology laboratory study conducted in Ethiopia[30], indicating comparatively better pre-analytical performance at our center.

## Conclusion

This study demonstrated a low pre-analytical error rate of approximately 0.35% in hematology samples. The most common causes of sample rejection were clotted specimens and quantity-not-sufficient. Effective control of pre-analytical errors is essential to ensure accurate laboratory results, which directly impact patient diagnosis and clinical management.

Improved awareness of factors influencing laboratory results, strengthened communication and coordination between laboratory personnel and clinical wards, and the implementation of structured training and continuing medical education programs through lectures and CME for laboratory and paramedical staff are key strategies for minimizing pre-analytical errors due to wrong blood collection and handling procedures and enhancing overall laboratory quality.

## References


1. Shahangian S, Snyder SR. Laboratory medicine quality indicators: a review of the literature. Am J Clin Pathol. 2009;131(3):418-31. doi: 10.1309/AJCPJF8JI4ZLDQUE
2. Iqbal MS, Tabassum A, Arbaeen AF, Qasem AH, Elshemi AG, Almasmoum H. Preanalytical errors in a hematology laboratory: an experience from a tertiary care center. Diagnostics (Basel). 2023;13:591. doi: 10.3390/diagnostics13040591
3. Lippi G, Blanckaert N, Bonini P, Green S, Kitchen S, Palicka V, et al. Causes, consequences, detection, and prevention of identification errors in laboratory diagnostics. Clin Chem Lab Med. 2009;47:143-53. doi: 10.1515/CCLM.2009.045
4. Bonini P, Plebani M, Ceriotti F, Rubboli F. Errors in laboratory medicine. Clin Chem. 2002;48:691-8. doi: 10.1093/clinchem/48.5.691
5. Lippi G. Governance of preanalytical variability: travelling the right path to the bright side of the moon? Clin Chim Acta. 2009;404:32-6. doi: 10.1016/j.cca.2009.03.026
6. Cornes M. The preanalytical phase - past, present, and future. Ann Clin Biochem. 2020;57:4-7. doi: 10.1177/0004563219867989
7. Sonmez C, Yıldız U, Akkaya N, Taneli F. Preanalytical phase errors: experience of a central laboratory. Cureus. 2020;12:e7335. doi: 10.7759/cureus.7335
8. Mehndiratta M, Pasha EH, Chandra N, Almeida EA. Quality indicators for evaluating errors in the preanalytical phase. J Lab Physicians. 2021;13:169-74. doi: 10.1055/s-0041-1729473
9. Noordin SS, Isa S. Evaluation of blood sample rejection in a clinical laboratory of an oncology institute. Malays J Med Health Sci. 2021;17:49-54.
10. Plebani M. Quality indicators to detect pre-analytical errors in laboratory testing. Clin Biochem Rev. 2012;33:85-8.
11. Grecu DS, Vlad DC, Dumitrascu V. Quality indicators in the pre-analytical phase of testing in a stat laboratory. Lab Med. 2014;45(1):74-81. doi: 10.1309/LM9ZY92YBZRFPFQY
12. Agarwal R, Chaturvedi S, Chhillar N, Goyal R, Pant I, Tripathi CB. Role of intervention on laboratory performance: evaluation of quality indicators in a tertiary care hospital. Indian J Clin Biochem. 2012;27(1):61-8. doi: 10.1007/s12291-011-0182-7
13. Plebani M. Towards a new paradigm in laboratory medicine: the five rights. Clin Chem Lab Med. 2016;54(12):1881-91. doi: 10.1515/cclm-2016-0848
14. Grasas A, Ramalhinho H, Pessoa LS, Resende MGC, Caballe I, Barba N. On the improvement of blood sample collection at clinical laboratories. BMC Health Serv Res. 2014;14(1):12. doi: 10.1186/1472-6963-14-12
15. Llopis M, Alvarez V, Martínez-Bru C, et al. Quality assurance in the preanalytical phase. In: Application and Experience of Quality Control. Published 2011.
16. Tapper MA, Pethick JC, Dilworth LL, McGrowder DA. Preanalytical errors at the chemical pathology laboratory of a teaching hospital. J Clin Diagn Res. 2017;11(8):BC16-BC18. doi: 10.7860/JCDR/2017/30159.10378
17. Bates DW, Gawande AA. Improving safety with information technology. N Engl J Med. 2003;348(25):2526-34. doi: 10.1056/NEJMsa020847
18. Alavi N, Khan SH, Saadia A, Naeem T. Challenges in preanalytical phase of laboratory medicine: rate of blood sample nonconformity in a tertiary care hospital. EJIFCC. 2020;31:21-27.
19. Venkat Raghavan ATM, Sweta K, Shanmugasamy K, Sowmya S. Risk assessment of pre-analytical errors and their impact on patient safety in a tertiary care center in South India. IP J Diagn Pathol Oncol. 2020;5:415-8. doi: 10.18231/j.jdpo.2020.080

20. Mehndiratta M, Pasha EH, Chandra N, Almeida EA. Quality indicators for evaluating errors in the preanalytical phase. J Lab Physicians. 2021;13:169-74. doi: 10.1055/s-0041-1729473
21. Green SF. The cost of poor blood specimen quality and errors in preanalytical processes. Clin Biochem. 2013;46:1175-9. doi: 10.1016/j.clinbiochem.2013.06.001
22. Puri V, Gaur K, Shukla S, Sharma S, Suman S, Singh R. Finish before the start: analyzing preanalytical sample errors in a tertiary care hematology laboratory. Indian J Pathol Microbiol. 2020;63:435-40. doi: 10.4103/IJPM.IJPM_191_19
23. Aggarwal K, Jhajharia S, Pradhan T, Acharya V, Patra S, Mahapatra SK. Analysis of errors in a clinical laboratory of a tertiary care hospital, Odisha, India. J Clin Diagn Res. 2021;15:27-30. doi: 10.7860/JCDR/2021/51206.15531
24. Ercan M, Akbulut ED, Bayraktar N, Ercan Ş. Effects of specimen hemolysis on complete blood count results by Abbott Alinity hq system. Biochem Med (Zagreb). 2021;31:030706. doi: 10.11613/BM.2021.030706
25. Hjelmgren H, Nilsson A, Myrberg IH, Andersson N, Ygge B, Nordlund B. Capillary blood sampling increases the risk of preanalytical errors in pediatric hospital care: observational clinical study. J Spec Pediatr Nurs. 2021;26:e12337. doi: 10.1111/jspn.12337
26. Hjelmgren H, Nilsson A, Myrberg IH, Andersson N, Ygge BM, Nordlund B. Capillary blood sampling increases the risk of preanalytical errors in pediatric hospital care: observational clinical study. J Spec Pediatr Nurs. 2021;26:e12337. doi: 10.1111/jspn.12337
27. Zaidi SSH, Sana M, Ghafoor MT. Assessment of total laboratory errors in clinical chemistry laboratory: experience at a tertiary care hospital. Liaquat Natl J Prim Care. 2022;4(1):6-10. doi: 10.37184/lnjpc.2707-3521.4.7
28. Gaur K, Puri V, Shukla S, Sharma S, Suman S, Singh R. Finish before the start: analyzing pre-analytical sample errors in a tertiary care hematology laboratory. Indian J Pathol Microbiol. 2020;63(3):435-40. doi: 10.4103/IJPM.IJPM_191_19
29. Kouser S, Abbas FF, Huda NU, et al. Review of key performance indicator in a hematology laboratory: a preventable source of error. J Liaquat Univ Med Health Sci. 2023. doi: 10.22442/jlumhs.2023.00985
30. Tadesse H, Desta K, Kinde S, Hassen F, Gize A. Errors in the hematology laboratory at St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia. BMC Res Notes. 2018;11(1):420. doi: 10.1186/s13104-018-3551-y