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Pre-Analytical Errors in Blood Sample Collection: A Narrative Review Focus on Hematology Testing

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Abstract

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Almost all clinical decisions are based on analytical results. There are three critical phases in the analysis of laboratory tests which take place before, during, and after the laboratory analysis. This thesis is dedicated to the detection of errors that occur at the pre analytical stage and its following effect on the test outcomes in the hematology laboratories. Most of the pre-analytical errors are made prior to the actual test, which may result in wrong diagnosis and slow treatment. Among the most widespread ones are ineffective management and incorrect labeling.

The current research is based on the literature review that involves both qualitative and quantitative studies. A total of twenty-seven articles published in 2010-2025 were chosen, mostly in the PubMed database and the site of the International Journal of Biomedical Laboratory Science (IJBLS). The review focuses on the main questions: What are the most frequent mistakes that happen in blood sample collection? How do pre-analytical errors affect the results of hematology? What can be done to minimize pre-analytical errors?

The review shows that clinical errors may be significantly reduced with the help of proper training of the staff and ensuring the clarity of communication. This is especially important in hematology laboratories where the integrity of samples is of paramount importance. Even small mistakes can cause great complications. All the personnel should be aware of the importance of every step in the workflow. The present review focuses on pre-analytical errors and following the set protocols, the errors can be minimized significantly.

Keywords: Pre- analytical error, Laboratory error, Hematology error, Sample quality, Clotted samples, Hemolyzed sample, Blood collection errors

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Contents

1. Introduction

The outcome of laboratory tests is crucial in the diagnosis of diseases and identifying the medical condition of a patient. Various researches indicate that laboratory findings are critical in determining whether the patient can be admitted, discharged or given medication. The blood sampling procedure consists of three major stages; the pre-analytical, analytical, and post-analytical stages. Of these, the analytical phase in which real testing is actually performed has been the most studied whilst the pre-analytical phase is usually disregarded. Mishandling of the samples or mistakes made in this stage mean that the whole process will be repeated again. This increases the costs incurred, delays treatment and there is a possibility of making wrong medical decisions. The most frequent mistakes can be found in the pre-analytical stage and it can relate to mistakes in the handling, collection, and labelling of samples (Mäkitalo and Liikanen, 2013).

In most of the developing nations like Pakistan, the international standards of collecting blood samples are not strictly adhered to in most hospitals. This is mostly because samples are frequently gathered by untrained personnel. Moreover, laboratories might also use varied sample screening regulations, which will result in discrepancies in the testing procedure (Alavi et al., 2020). Over 60 per cent of all lab errors happen at the beginning of the sample collection. The above failures include the misuse of containers, wrong labeling of specimen tubes, and collection of samples of wrong patients. These errors have a strong impact on patient safety and the quality of healthcare in general. Despite the facilitation provided by automation and technology, particularly in the hematology laboratory, the issue of human error persistence is one of the major challenges (Arul et al., 2018). Mislabeling, sample clotting, and inadequate amounts of blood have also been cited as the most common problems in the major hospitals in India. Complications are common in inpatient units that have a high workload and turnover (Upreti et al., 2013).

2. Background

In modern healthcare, the laboratory is placed in a central but more complicated position. In this review, the authors outline the effect of pre-analytical errors on the diagnosis of hematological diseases such as red blood cell deficiency and leukemia. In the past few years, laboratory testing has been a part of clinical decision-making, and in most medical diagnoses, the correct and timely results are crucial. The slightest error in taking the first actions of samples manipulation can have devastating consequences, such as misdiagnosis or untimely treatment. It has been demonstrated, such as in Abdollahi et al. (2014) that the majority of laboratory errors do happen before the process of analysis begins, yet this stage of the process is often not adequately addressed as opposed to the analytical one.

Consequently, pre-analytical quality control will be one of the most significant spheres of patient safety and efficiency in healthcare. These mistakes may greatly affect clinical hematology whereby the quantification of blood cells is highly accurate and is required to detect diseases like anemia and leukemia. Pre-analytical errors can be involved at any stage before the receipt of a sample

in the laboratory. The most frequent mistakes involve the usage of incompatible collection tubes, late blood collection, improper technique utilization, insufficient mixing of the sample and communication deficiency between the patient and the medical staff. These are human mistakes that pose a significant problem in the hematology laboratories. In an example, inappropriate anticoagulant tube may lead to the sample being coagulated hence producing a false positive outcome during a complete blood count analysis.

2.1 Importance of Hematology Laboratory Test

Hematology tests are significant in the diagnosis of many health disorders including; anemia, infections, and blood cancers. Complete Blood Count (CBC), hemoglobin, platelet count and white blood cell count are the most common tests performed in the hematology field. According to Gulatti et al. (2022), the hematology tests are founded on measuring cellular elements properly. This means that pre analytical errors such as hemolysis, clotting, slow processing can provide false results. As an example, red or white blood cells count can be altered due to inadequate mixing of anticoagulant tubes or storing them in an inappropriate temperature, which results in misdiagnosis. This is the reason hematology is one of the most prone fields of laboratory medicine to errors and that there is a necessity of the standardization of collection and handling procedures. It is also claimed that 70 percent of medical purposes are founded on laboratory tests. The test outcomes play a crucial role in the medical decision to admit a patient, prescribe a medication, or discharge him or her. There is a possibility that the treatment might be delayed, the healthcare costs might be elevated, and the burden on the staff might be expanded due to improper test outcomes. Consequently, it is essential to have quality and accurate outcomes in the process of hematology laboratory testing (Kani, Kannan, Arumugam, and Sonti 2024).

2.2 Laboratory Workflow

There are three main steps that constitute the laboratory workflow, including the sample collection, testing, and result reporting stages. Research has revealed that majority of the errors occur in the pre-analytical stage, which is the initial stages of the blood specimen. The analytic or assessment stage is much cheaper compared to the sample collection stage. The whole testing process starts with the patient and ends with the patient. The pre-analytical stages include patient preparation, sample collection, labeling, transportation, and storage. The analytical stage is the one where the real examination is performed with the help of machines and other methods. The last reporting to the physician, quality check and other activities are included in the result reporting phase (Sonmez, Yıldız, Akkaya, and Taneli 2020).

3. Purpose, Aims, and Research Questions

3.1 Purpose

To assess the most common errors that occur prior to analysis when collecting blood samples, with a focus on hematology laboratory testing, and to recommend remedial actions to improve test precision and lower pre-analytical errors

3.2 Aims

To provide a comprehensive account of pre-analytical errors that occur during blood collection, with a particular emphasis on hematology tests, and to propose potential measures to mitigate these mistakes.

3.3 Research Questions

- What are the most common pre- analytical errors during blood sample collection?
- How does pre-analytical effect on hematology test results?
- What methods can help to reduce pre-analytical errors?

4. Methodology

4.1 Collection of Data and Search Method

The selected papers were chosen from the PubMed database and journals such as the International Journal of Biomedical Laboratory Science. To guarantee that the data was pertinent, only articles published between 2010 to 2025 were considered. The database was searched using the following pertinent keywords: pre-analytical errors, laboratory errors, hematology laboratory errors, faults while collecting blood, clotted samples and hemolyzed samples.

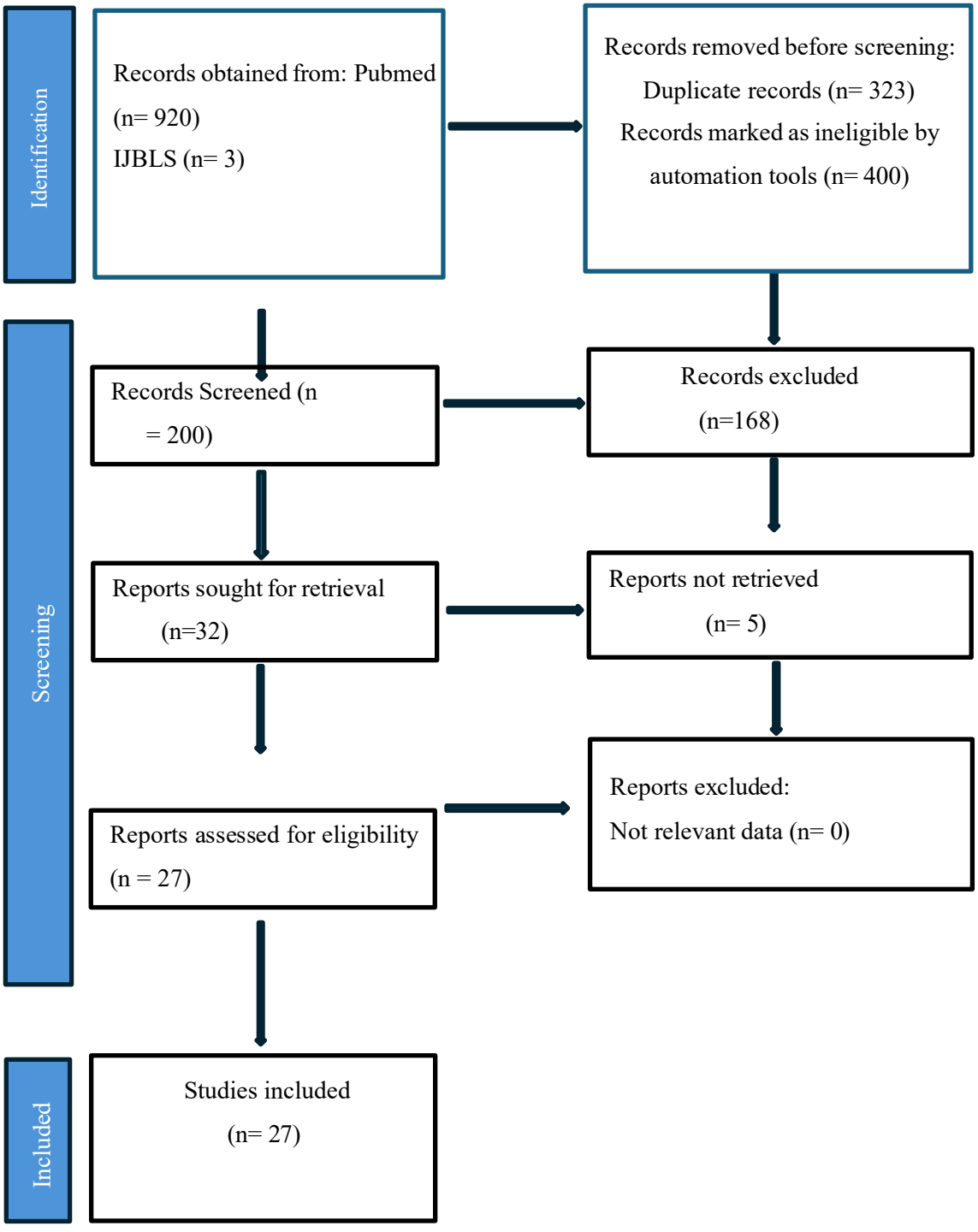
Articles that did not fit these criteria were excluded. The articles that were selected were explicitly associated with specimen collection errors. Qualitative and quantitative research are both incorporated. Most of the studies were sourced from hospitals and laboratories. The review is not relevant to microbiology or other laboratory disciplines. The investigations that were not conducted in English are omitted.

The literature review comprised 27 articles that were identified as being of value. In this review, the cause and varieties of pre-analytic errors, the reasons behind them, and the methods to reduce such inaccuracy are examined after a thorough reading of all these articles. This review method is a valuable tool for identifying critical information regarding pre-analytical errors, the potential impact of these discrepancies on patient health, and the methods to mitigate such unforeseen errors.

4.2 Prisma Diagram for Study Selection

The article selection was conducted in accordance with the PRISMA 2020 guidelines to demonstrate the literature review process. (Page et al.2021: 89.)

Figure 1. PRISMA Flow Diagram Process



Adapted from PRISMA 2020 guidelines (Page et al. 2021: 89)

4.3 Narrative Literature Review

A Narrative Literature Review is one of the two widely used review methods for summarizing previously published articles without duplication. It also seeks the new study area as well as synthesize existing findings. Unlike Systematic Narrative method, that does not follow the strict rules. A narrative review is more flexible and allows the researcher to explore from different angles. (Ferrari 2015.)

However, to keep the review clear a structured format is needed. While writing Narrative review Preferred method in is IMRAD (introduction, Methods, Results, and Discussion).
One of the crucial parts of the process is to find the related article from the ocean of information. Searching term or keywords helps to find related literature as well as helps to eliminate the irrelevant subject. It is also important to critically assess the selected articles by looking at the methods used, the quality of the results, and the relevance of the findings to the review objectives. This critical approach ensures that the narrative review is informative, reliable, and useful for readers interested in the topic. Narrative Review helps to synthesize the information and initiate meaningful discussion. (Ferrari 2015.)

4.4 Data Analysis

The review will use thematic analysis method to recognize, categorize, and analyze recurrent patterns of the literature gathered. Thematic analysis helps the researcher to transcend the summarization process of the content to unravel the depth of meaning, relationships and common view-points among studies (Braun and Clarke, 2006). This approach is also most applicable to the synthesis of research results in laboratory and biomedical research where various studies tend to discuss similar issues in a diverse range of methodological or geographical perspectives.

The thematic approach is flexible and will enable both qualitative and quantitative results to be incorporated without losing sight of the research goals. It is not based on a particular theoretical framework, so it can be used in interdisciplinary reviews in case of overlapping scientific and clinical information. This methodology will be used to determine the trends that reflect the impact of pre-analytical errors on the accuracy of diagnosis in hematology through systematic reading, coding, and comparison.

In this research, peer-reviewed articles (17) were reviewed in detail and appropriate information was gathered and was coded. The articles were read repeatedly to gain a fair understanding of the situation and findings of the research. The key concepts of the material being reviewed were noted, extracted and later organized into broader themes. This was done iteratively and in such a way to involve constant reflection and improvement to ensure coherence and richness of interpretation. In the analysis, three main themes emerged. Appendix 1 gives a fuller description

of data coded with the thematic framework. This thematic approach facilitated coherence and clarity of the review through the location of recurrent problems and best practices that were mentioned in more than one source.

5. Findings

According to the thematic analysis approach, this section presents the key findings and information from the selected articles in three themes.

5.1 Common Errors and causes found in Blood Collection

According to the research, the frequent mistakes made in hematology laboratory are collection of insufficient sample volume and clotted samples. Other mistakes that can happen include misidentification, wrong use of hemolyzed samples and vials. The study conducted in tertiary care hospital in South India indicated that on average 0.73 percent of pre-analytical error was observed in Inpatient as well as Outpatient department. (Arul et al. 2018.) Similarly, research revealed that out of 56,604 collected samples, 1.3 percent of samples were not accepted due to pre-analytical errors. (Kani et al.2024.) One of the mistakes that were found common in the two articles was the submission of inadequate or diluted samples. Writers indicated that poor training and awareness contributed significantly towards human factors. These errors may have a great impact on the sample quality and hematology test, particularly on the IMRAD Blood Count results.

Likewise, according to research conducted in Shalamar Hospital 1.4 percent of 113,817 samples were defective. (Alavi et al. 2020.) The defective specimens had 35.8 per cent and 14.9 per cent sample error because of clotted and unlabeled samples. Regarding causes, according to Englezopoulou et.al. (2016), human factor and sample integrity are 2 of the causes of pre-analytical errors during sample taking. Overall, all 4 articles identified the most prevalent sources of error as sample integrity (mislabeling and inadequate sampling), human factors like inefficient training and reduced responsiveness of standard protocols.

Phlebotomy is an important but overlooked aspect of laboratory services within most healthcare facilities, especially within Africa. It is noted that blood collection in hospitals is often performed by personnel with limited training and in a workplace that lacks specific areas and clear protocols, which is more likely to cause errors (Mbah, 2014:132). This may result in poor quality of specimens, mislabeling, and delays or problems in transport that all impact on the accuracy of laboratory results. The absence of consistent training and appropriate instructions, as well as shortages of resources, implies that employees are overworked very often, and this also leads to errors during the pre-analytical stage of testing. On the same note, Gimenez-Marin et al. (2014), analyzed more than 750,000 test requests in a five-year period and revealed that serious errors occurred infrequently (0.047 percent), but that more common, everyday problems during sample collection occurred frequently, with an overall error rate of 13.54 percent. Hemolyzed samples were the most common issue with 8.76 percent of cases, followed by missing urine and clotted blood samples. These findings demonstrated that daily collection

errors, in particular hemolysis, are an area to be addressed with the intent of continuously improving laboratory quality and patient safety, even though critical errors are under control in some situations.

Pre-analytical errors are still a major problem in the process of blood collection in the Neonatal intensive care unit environment. According to Nencini et al. (2025), about 10 percent of all the blood samples collected on neonates for the purpose of carrying out complete blood counts had complications prior to the actual testing process, clotting being the major problem that caused a sample to be rejected, or the analyses fail. This is occasioned by a number of factors including the small volumes of blood collected, challenges in neonatal vein access, and thicker neonatal blood, which may predispose it to risk clotting and hemolysis. These are issues that are most relevant in preterm infants, who are quite susceptible to difficulties in the sampling process. The study further iterates that despite the use of point-of-care testing analyzers, clot samples need to be manually reviewed with quality assessment to ensure the delivery of accurate and reliable NICU laboratory results.

Moreover, Auvet et al. (2016) revealed that preanalytical conditions notably influenced the reliability of POCT results in the ICU. Whereas hemoglobin levels markedly differed between the time of sample collection and its arrival and processing before analysis, electrolyte levels remained consistent; suboptimal preanalytical procedures resulted in significant differences between local and central laboratory results. Significantly, quality improvement initiatives, namely the reduction of delays and the use of checklists, resulted in a significant increase in the accuracy of hemoglobin measurements. Taking together, these reports highlight that poor pre-analytical practices, including insufficient phlebotomy procedures, labelling, delays, and improper handling, are the usual reasons for errors in blood collection, and that systematic training, procedure clarity, and quality control are important to increase laboratory accuracy and protect patients.

Two authors dealt with the ongoing issue of preanalytical errors in hematology laboratories and the importance of quality indicators to control and minimize preanalytical errors (Alshaghdali 2021:176; Tadesse 2018:420). Both papers emphasize that preanalytical phase is the most erroneous section of the testing process primarily because of the problems associated with the assortment, management, and transportation of specimens, which is directly related to the patient care. The results of Alshaghdali et al. (2021), research revealed that the most frequent errors were clotted specimens and samples that were not received, whereas Tadesse et al. (2018a), published that clotted samples and hemolysis were the most frequent preanalytical errors in their laboratory, and the findings of both studies follow the same pattern in different laboratory contexts. Both articles highlight the need to monitor continuously through quality indicators as a means of enhancing the performance of laboratories, minimizing errors, and increasing patient safety. They also emphasize that the detection of these errors and the action based on the information can allow laboratories to move toward improved quality standards in the hematology testing.

Blood collection is a very important preanalytical step in clinical chemistry, and it has been reported in many studies in Europe that most laboratory errors happen at this stage. The most common mistakes are often associated with patient identification and preparation as the wrong identification and varying pre-

test conditions (fasting/posture/recent activity) may change results (Sylte 2013). Technique of collection also contributes a lot; long tourniquet application of more than one minute or more than 40 mmHg, repeated fist clenching have been demonstrated to cause hemoconcentration and increase analytes like potassium and lactate dehydrogenase. Misuse of butterfly needles, especially in the case of incorrect needle choice, may also lead to bias and hemolysis. Errors related to tubes are also of importance, because the use of inappropriate tube type (e.g., SST vs RST) or unvalidated tubes may affect analyte stability. Incorrect mixing (not enough mixing to prevent clotting, or an overmixing resulting in hemolysis) and variations in clotting time may result in inaccurate results, which may be particularly problematic with glucose and potassium. The error of centrifugation and separation, including wrong speed and time or slow separation, enables continuing cellular metabolism to alter the serum composition. Transport and storage can also be a source of variation; pneumatic tube systems are efficient but have been linked with hemolysis and failure to store at recommended temperatures (2-8 o C) or delays in analysis may result in degradation of glucose. In European laboratories, hemolysis is the most frequent cause of inappropriate samples and is usually caused by an inadequate phlebotomy technique, weak veins, collection at a hematoma site, or mechanical pressure during manipulation and transport. These results emphasize the fact that preanalytical variability in blood collection is mostly avoidable by following standardized protocols, including those provided by CLSI and ISO 15189, which is why proper training and quality control in European clinical laboratories are so crucial. (Sylte 2013.)

5.2 Impacts on Hematology Results

Two authors highlighted that errors such as clotted or insufficient blood samples may influence the accuracy of blood test. (Iqbal 2023: 591; Narang 2016:151.) Likewise, errors which occur prior to or during blood testing can alter the outcome and can contribute to inaccurate treatment. In Narang et.al. (2016), study the most frequent issues reported were clotted blood samples, the insufficient quantity of blood in the tube, or incorrect or absent labeling. There were approximately 1,800 of over 470,000 blood samples with such problems. These mistakes relate to critical tests, such as the count of white blood cells or that of platelets. It is hazardous especially when physicians require accurate results to make urgent decisions.

Conversely, Iqbal et al. (2023), paid attention to errors in the microscopic checking section of the test, which is known as peripheral blood smear examination. The author emphasized that without doing this part with care and in stages, one can overlook indicators of diseases like leukemia, anemia, or infections. Iqbal proposed an orderly approach to the examination of the blood smear, i.e., examining the red cells, the white cells, the platelets and any abnormalities in the correct sequence. This approach can minimize misunderstanding among various lab personnel and increase the accuracy of the results. Both articles demonstrate that errors prior to testing or when checking under a microscope can cause severe issues in patient care, and thus, one should use good procedures and train the personnel. (Iqbal 2023: 591; Narang 2016:151.)

Among the effects on patient care, there is preanalytical errors that results in unnecessary redrawing of samples, false treatment, which may jeopardize patient health, resulting in a negative impact on patient

outcome of 24.4%. (Alavi et al. 2020.) Two authors emphasized that preanalytical errors may have an adverse impact on the hematology results and patient care, in general. (Alavi 2020; Alshaghdali 2021: 176.) According to Alavi et al. (2020), wrong labelling, hemolysis, or incorrectly filled tubes are the most common errors that result in false results or rejection of tests, particularly in an emergency. The issues may result in delayed diagnosis and even repeated blood draws, which are not very comfortable for the patients. On the same note, in a study by Alshaghdali et al. (2021), the prevalence of preanalytical quality defects in hematology samples in their study was approximately 9.3 percent and was primarily caused by clotted samples and incomplete specimens. These mistakes were associated with ineffective collection and handling processes, and they influenced the accuracy of lab results. Both researchers admit that preanalytical errors decrease the accuracy of results and even endanger patients due to the time lag in getting the correct treatment. (Alavi 2020; Alshaghdali 2021: 176.)

5.3 Comparison Across Regions

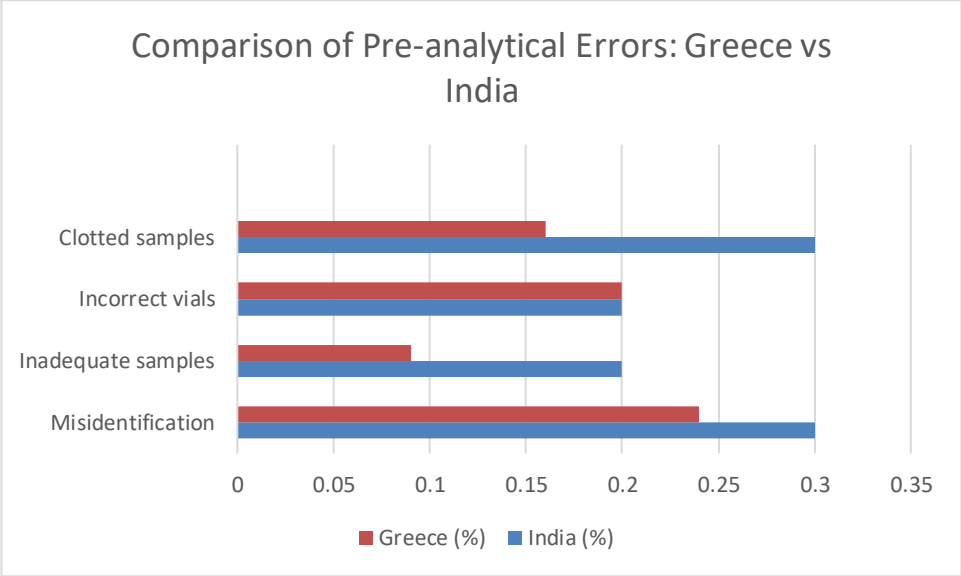


Figure 2. Comparison of Pre-analytical Errors: Greece vs India (Englezopoulou 2016; Arul 2018).

Two studies compared the prevalence of preanalytical errors between South India and Greece. The pre-analytical error comparison between India and Greece indicates that India reports higher rates across all four categories with misidentification at 0.3 compared to 0.24 in Greece, inadequate samples at 0.2 compared to 0.09, incorrect vials at 0.2 compared to 0.20 almost equal, and clotted samples at 0.3 compared to 0.16. (Arul 2018; Englezopoulou 2016). The greatest disparities lie in poor and clotted samples with the rates in India being over two times higher than in Greece implying that there may be problems with the sample collection and handling processes. Such differences can be explained by the differences in staff training, compliance with standard operating protocols, and the level of quality control measures provided in the laboratory. The relatively lower error rates in Greece may be due to greater enforcement of pre-analytical quality indicators, frequent checkups and greater compliance with

standardized processes which enhance accuracy and minimize errors in the laboratory process.

Likewise, in a Sylte study conducted in Norway points out systematic problems in the collection of blood, the overuse of tourniquets, the wrong choice of tubes, inadequate mixing, inadequate centrifugation, and transport parameters (including pneumatic tube systems) all of which may result in hemolysis or the degradation of the analyte. (Sylte 2013.) A study conducted in Iraqi Kurdistan revealed that there was a lot of improper sample handling happening during the pre-analytical phase. (Najat et.al. 2017: e0170211.) The percentage error in some samples was as high as 39%. The main reasons for rejection included incorrect sample identification at 8%, clotted samples at 6% and hemolyzed samples at 9%. To recapitulate, although regional discrepancies in data and infrastructure exist, all these studies emphasize the need of introducing systematic quality control, ongoing education, and standardization of processes, to minimize pre-analytical errors and improve patient care.

5.4 Way to Reduce Pre analytical Errors

Regular training in sample collection procedures must be followed to reduce errors in pre-analytical phase conformance with standard laboratory practice. It is the responsibility of the staff to work diligently and deliver high quality output to the patients. (Chhillar, Khurana, Agarwal and Singh 2010: 46). Most of the studies identified that training staff is one of the most significant steps to minimize pre-analytical errors (Mohammedsaleh and Mohammedsaleh, 2014:46). The healthcare workers should be trained regularly on appropriate sample collection and handling procedures, including filling the tubes correctly, labelling, and preventing hemolysis. (Alavi 2020; Alshaghdali 2021: 176.) They also emphasize the necessity to apply checklists and standard procedures to make sure that all the procedures are performed properly. Similarly, Alshaghdali et al. (2021), focused on the importance of using quality indicators (QIs) to track the performance in the lab and identify errors in their initial stages. In his study, they demonstrated that monitoring QIs and analyzing the prevalent problems (such as clotted or missing samples) lowered the error rate to 6.5% in 2019 as opposed to 11.6% in 2017. This study also pointed out that evaluating lab procedures with sigma metrics is essential and assures high-level performance. This paper also supports the view that constant oversight, worker training, and proper laboratory procedures will minimize or lessen mistakes and provide quality care to the patients. Similarly, two authors inferred that pre-analytical errors can be reduced by better training of the staff and making sure that efficient protocols are followed. (Iqbal 2023: 591; Ye 2018: 030704) Narang et al. (2016) asserted that most of the mistakes are made because of improper sample collection technique which either uses the wrong container or fails to label the tubes. Such mistakes can be minimized once proper staff training is provided. In short, these articles suggest that regular training of the staff, close supervision, and the use of standardized processes will help avoid such mistakes.
They also emphasized the importance of cooperation and communication between laboratory personnel and nurses. Their work indicates that through quality checks and responsibilities, it is possible to mitigate such errors as clotted or hemolyzed samples. These studies also concur that awareness creation among the healthcare personnel and appropriate training are the most effective methods of reducing the rate of errors and enhancing accuracy of hematology results.

6. Discussion

The primary conclusions of the literature review are covered in this part, along with an explanation of how these mistakes affect the results of hematology tests.

6.1 Summary of Key Findings

Upon examining the twenty-three studies, the key issues that were found included collection, handling, labelling, and transporting of blood samples. According to study by Chhillar et al. (2010), the major cause of sample rejection was poor communication between staff and incomplete test forms.

Likewise, Iqbal et al. (2023), study discovered that the specimen rejection can be minimized with adequate training and standard procedure. The number of flaws could increase because most developing countries such as India and Pakistan, nurses and junior doctors who are not adequately skilled in the subject are taking blood samples in a place of qualified phlebotomist.
Alshaghdali et al. (2021), introduced the features of new technologies like barcode reading, electronic test ordering and automated labelling system to not only minimize the number of errors but also increase the accuracy and good results. Likewise, the samples that were gathered and transported by individuals other than laboratory staff members were associated with more rejection in samples than the specimen handled by trained laboratory staff and thus contribute to less rejection. (Ye et al. 2018: 030704.)

Clotted samples, hemolyzed samples, incorrect sample identification, and insufficient volume were the most frequent ones. (Alavi 2020; Alshaghdali 2021: 176; Narang 2016:151.) These mistakes tended to happen at the stage of blood collection and were associated with the ineffective methods, the absence of training, and the inappropriate storing and usage.

Regarding the effect on hematology outcomes, the studies demonstrated that preanalytical errors may result in delays of diagnosis, inaccurate test results and in some cases, repeat sampling, which is stressful to patients particularly neonates and children. (Iqbal 2023:591; Alavi 2020.) Such mistakes also contribute to additional workload of personnel and cost in the laboratory.

6.2 Suggestions for Future Research

Future studies need to examine the occurrence of preanalytical errors in different hospitals and countries to determine how these errors occur in other settings. (Alavi 2020; Auvet 2016:57.) Follow-up after the introduction of training programs or new systems such as checklists or

barcodes on how they decrease errors with time would be useful. (Narang 2016:151; Iqbal 2023:591.) Additional studies are also required to learn how certain mistakes such as clotted or hemolyzed samples influence patient care and diagnosis. (Alshaghdali et.al. 2021:176.)

Automatic machines or tracking tools could be researched as a means of preventing human errors. (Auvet et al. 2016:57.) As non- lab personnel (i.e. nurses or students) take many blood samples, it is worth studying their training and its impact on the quality of samples. (Tadesse et al. 2018:420.) Developing and testing common quality rules or indicators in labs, particularly in blood tests, would allow all labs to check and enhance their performance in a similar manner. (Alshaghdali et.al. 2021:176.)

Lastly, it would also be beneficial to learn how such mistakes impact the patients emotionally such as frustration due to the need to provide another sample so we can know the extent of how it impacts their experience.

6.3 Ethical Condition

According to Rebers et al., (2016), research that does not require consent generally falls into two categories: emergency research where consent is impossible to obtain in the moment, and studies using anonymized data or public information. The current study is a literature review study and there is no direct or indirect involvement of human subjects, animals, or collection of personal data. Hence, this piece of work did not need formal ethical consent. Data and information were collected only through publicly available and reputable scholarly websites, such as peer-reviewed open access journals, institutional repositories, and databases. These sources were chosen to ensure the reliability and academic integrity of the review.

All the sources of information have been cited based on the correct procedure for referencing to ensure that academic integrity is achieved and plagiarism is avoided. Further, the review only included those studies and articles that were published on reputable platforms and accessible in full. All those behind paywalls or those that required a subscription to access were not considered for analysis, due to the implication for transparency and reproducibility. This literature review has been completed in conformance with the scholarly requirements and ethical standards of Metropolia University of Applied Sciences.

6.4 Reliability and Validity

Reliability and validity are two of the most important and crucial aspects of assessing any measuring procedure to data-collection in a quality study. Validity basically refers to how something is measured and how accurately it is done. Reliability encompasses the accuracy of data collected and the extent to which any measuring device controls for random error (Ahmed and Ishtiaq, 2021). To ensure validity and reliability in this literature review, only reliable data from peer-reviewed publications, written between 2010 and 2025, were used to collect information. Sources were identified from the following databases: the International Journal of Biomedical Laboratory Science, PubMed, ScienceDirect, and other reputable academic databases that maintain tight editorial and peer-review processes to assure scientific validity and authenticity. All these sources have been selected to reduce the likelihood of biased or non-scholarly inclusions, which is critical to synthesizing research in biomedical sciences.

The review applied the inclusion and exclusion criteria in selecting the articles to be included in the review to enhance consistency and reliability. Only the studies that have clear methodology, reproducible results, and quantifiable results in connection to hematology and pre-analytical errors were put into consideration. Research on the accuracy of diagnosis, sample processing, and assurance of quality in laboratory testing was given priority as it can help directly to gain insight into the minimization of errors in clinical practice. Despite the inaccessibility of some original full-text materials because of paywalls, only high-quality open-access papers were included in the review, which is why it was transparent, traceable, and academically sound.

The works reviewed contained both studies specifically focused on hematological disorders which included anemia, thrombocytopenia, and leukemia as well as general studies on pre-analytical variables, including the transport, labelling and storage of samples. These two kinds of research combined provided a comprehensive picture and allowed for comparisons in various lab environments. This heterogeneity enhanced the external validity of the results in that it demonstrated the effects of pre-analytical errors on diagnostic results within various healthcare settings.

In addition, the methodological consistency was ensured through the use of critical appraisal techniques that included source credibility checks, cross-referencing, and research design and statistical validity checks. Intellectual honesty and plagiarism were avoided by proper citation and referencing of all the studies. All of these steps contributed to the credibility of the review and were able to guarantee that its findings reflect the existing body of knowledge in the field of hematology laboratory research.

7. Conclusion

As exhibited in this literature review, the probability of error is very high between sample collection and storage. General errors like the inadequate blood volume, the invalid test tube, incorrect matching of the sample or the patient identification. This deviation in precision may have severe consequences. As a result of this, the costs will be high in the hospital and make it extremely difficult for both the patient and the staff. When laboratory person or nurse learns the right course of action, and receives adequate training on the error, its causes, and prevention, then it can assist in making the results better and keeping the patient safe.

Despite this, the pre-analytical aspect requires greater focus even though the analytical stage has been enhanced by advanced technology. Staff awareness and training should be conducted that assists in minimizing these types of errors. Hematology labs will be able to have better results by minimizing these errors. In this study, it is indicated that preanalytical errors (i.e., errors occurring prior to testing) continue to present a significant issue in hematology labs. The most frequent errors were the blood samples that were clotted and samples that were not received at the lab. It is highly necessary to continue monitoring these errors and educate the staff that takes blood samples on how to do it properly. It can contribute to the fewer mistakes and the more accurate results in labs. Once lab outcomes are trustworthy, physicians can arrive at more appropriate choices on behalf of their patients. In general, the enhancement of the quality of the preanalytical phase will contribute to patient care and safety. One should continue to make clear rules and train sample collection personnel better in the future, and additional studies are necessary to discover new methods of preventing these errors occurrence.

8. References

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9. Appendix

9.1 Summary Table of Selected Articles

No.	Author(s)	Year	Title	Study Design	Key Findings	Relevance to Current Study	Country
1	Chhillar et al.	2010	Impact of pre-analytical Errors on Lab Quality (North India)	Prospective Screening Study	The absence of critical information results in a pre-analytical error.	Illustrates the impact of incomplete information on patient safety.	India
2	Kani et al	2024	Preanalytical Errors in Hematology: Insights From a Tertiary Care Hospital	Retrospective analytical study	Preanalystical errors are often due to submitting an insufficient sample, use of an empty or defective tube, insufficient and clotted samples, and inadequate or diluted samples.	Illustrates the causes of pre analytical errors	India

3	Englezopoulou et al.	2016	Pre Analytical Errors as Quality Indicators in Clinical Laboratory	prospective observational study	Continuous monitoring and control of the total testing process allow the decrease of pre analytical errors	State of pre analytical errors in Greece	Greece
4	(Mohammedsaleh & Mohammedsaleh, 2014)	2014	A Review of Reducing Errors in Medical Laboratories	Review Article	Despite advanced technology, errors persist due to pre-analytical issues and in-sufficient staff training. Improved equipment and education are key to reducing lab errors.	Highlights the impacts of staff training on errors and sup- ports focus on improving skills.	U S Canada U K Australia

5	Najat	2017	Prevalence of Pre-Analytical Errors in Clinical Chemistry Diagnostic Labs in Sulaimani City of Iraqi Kurdistan	Retrospective study	Transport delays, expired reagents, hemolysis, and coagulation were the primary causes of 39% of pre-analytical errors, which were accompanied by low rejection rates. Highlights the necessity of staff training and quality control to mitigate these types of errors.	Demonstrates that POCT, quality control, and training mitigate errors, thereby fostering collaboration and technical proficiency in laboratories.	Iraq
6	Narang et al.	2016	Preanalytical Errors in Hematology Laboratory- an Avoidable In-competence	Retrospective Analysis	The primary cause of pre-analytical errors (0.38%) was the insufficient quantity and congested samples, which were frequently the result of poor technique and insufficient training.	Underlines the necessity of enhanced staff training to mitigate pre-analytical laboratory errors.	India

7	(Arul et al., 2018)	2018	Preanalytical Error Patterns in a Hematology Lab	Cross Sectional	The most prevalent of the 513 pre-analytical errors (0.43%) was inadequate samples (0.20%) and clotted samples (0.12%).	Emphasizes the prevalence of insufficient and congested samples, with an emphasis on the staff technique and sample collection mistakes.	Saudi Arabia
8	Tadesse et al.	2018	Errors in the Hematology Laboratory	Cross sectional studies	The majority (75.5%) of the 28.5% lab errors were pre-analytical, primarily from emergency and inpatient departments.	Emphasizes the pre-analytical phase as a critical source of laboratory errors, which supports the current focus of the study.	Ethiopia

9	Ye et al.	2018	Survey of Hematology Sample Acceptability in Laboratories Throughout China	Cross Sectional Survey	Most of the phlebotomy is performed by nurses, while specimen transport is primarily performed by full-time employees. The rejection rate of specimens is low (0.11%), and most laboratories are of high quality (4σ–5σ).	Supports the emphasis on staff training and quality control, emphasizing the importance of efficient specimen handling and trained personnel in the reduction of pre-analytical errors.	China
10	**Nencini et al.**	**2025**	Complete blood count in neonatal Intensive care Unit (NICU): Performance comparison between POCT Sight OLO® and Sysmex XN-9100™ hematology analyzers.	Regression analysis and Bland-Altman plot study	Clotting is the major problem that caused a sample to be rejected or the analysis to fail.	Use of a POCT (Point Of Care Test) could help in reducing the impact of pre-analytical errors	Italy

11	Iqbal et al.	2023	Preanalytical Errors in a Hematology Laboratory: An Experience from a Tertiary Care Center	Retrospective analysis	Inadequate samples and clotted samples account for the vast majority of preanalytical factors	Highlights causes of pre analytical errors	Saudi Arabia
12	Auvet et al.	2016	Preanalytical conditions of point-of-care testing in the intensive care unit are decisive for analysis reliability	Bland–Altman plots study	Preanalytical conditions influence the reliability of POCT results in the ICU	Quality management focused on the preanalytical process and performed by the partners involved in the POCT can overcome pre analytical errors.	France

13	Alavi et al.	2020	Preanalytical Phase Challenges: Frequency of Blood Sample Noncompliance in a Tertiary Hospital	Retrospective Study	Pre-analytical errors occurred in 1.48% of samples; most common error was unlabeled samples (36%). peak errors recorded in October.	Highlights importance of sample labelling and monitoring error trends to improve lab accuracy and reduce mistakes.	Pakistan
14	Mbah	2014	Phlebotomy and quality in the African laboratory	Literature Review	Improvement of phlebotomy in Africa	Lack of trained personnel in laboratories cause errors	Cameroon, Chad, Côte d'Ivoire, Kenya and Nigeria

15	Gimenez-Marin	2014	Pre-analytical errors management in the clinical laboratory: a five-year study.	Descriptive study	Haemolysed samples are major causes of laboratory test errors	Daily collection errors, in particular hemolysis, are an area to be addressed	Spain
16	Sylte	2013	Estimation of Preanalytical Uncertainty in Clinical Chemistry	Three-part study: Paper I Modeled preanalytical uncertainty using paired observations (bottom-up). Paper II – Estimated minimal uncertainty for 15 analytes under optimal conditions (top-down). Paper	Measurable bias is primarily caused by preanalytical errors from tubes, coagulation time, centrifugation, storage, and transport, particularly for glucose. Despite optimal handling, certain analytes (specifically, potassium and LD) exhibit a higher preanalytical variation	Provides strategies for quantifying and mitigating preanalytical variation. Encourages the standardization of collection, handling, and conveyance to enhance the accuracy of the	Norway

				III – Evaluated effects of suboptimal handling (pneumatic vs manual delivery, butterfly vs straight needles, suboptimal vs optimal.	than analytical variation.	results.	
17	Alshaghdali et al.	2021	Detecting Preanalytical Errors Using Quality Indicators in a Hematology Laboratory	Retrospective Review	The majority of the preanalytical errors (9.3%) were clotted samples (3.6%) and absent samples (3.5%), out of a total of 95,002 samples. The error rate decreased from 11.6% to 6.5% as time progressed.	The study supports the present research by demonstrating how the use of quality indicators and the monitoring of preanalytical errors can reduce error rates and enhance laboratory performance, in accordance with	Saudi Arabia

						the ongoing endeavors.	

This table was generated using ChatGPT (OpenAI, GPT-5) based on the prompt: Create a table summarizing studies on pre-analytical laboratory errors with columns for author, year, title, study design, key findings, and relevance to current study.’" All information was checked and confirmed by the authors.