ORIGINAL ARTICLE

Frequency of Pre-Analytical Errors and Its Causes in Glucose Specimen Collection: A Cross-Sectional Analysis in Bahawal Victoria Hospital, Pakistan

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ABSTRACT

Background: The laboratory testing process comprises the pre-analytical, analytical, and post-analytical phases. The pre-analytical phase has the highest frequency of error among these three stages. The purpose of the study was to determine the prevalence of pre-analytical errors and the reasons behind them in the collection of glucose specimens.

Methods: This descriptive cross-sectional study (039-DME-QAMC) was carried out on 225 samples collected at the Pathology Department of Bahawal Victoria Hospital in Bahawalpur between July and December of 2024. The method of non-probability sequential sampling was applied. Samples from indoor departments, patients who did not give their informed consent, and any stored specimens were not included. All information on pre-analytical problems, including hemolyzed samples, quantity insufficient, improper centrifugation, delayed processing, and labeling errors, has been meticulously documented by the lead researcher in the proforma. During the data collection process, quality control procedures were in place to ensure accuracy and consistency. SPSS Ver. 25 was used to enter and analyze all of the data. The data's normality was examined using the Shapiro-Wilk test.

Results: In this study, frequency of preanalytical errors in glucose specimen collection process is 20% with delayed specimens (9.3%, n=21) is the most common, while other errors like inappropriate centrifugation (3.1%, n=7), hemolyzed samples (2.7%, n=6) and sample quantity insufficient (QNS) were 1.8% (n=4).

Conclusion: This study highlighted the need for sodium fluoride tubes for the delayed processing specimens to prevent in vitro glycolysis, proper blood collection techniques, and timely specimen handling in proper ways to minimize errors.

Keywords: Glucose, Specimen Collection, Blood Collection, Quality Control.

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INTRODUCTION

The pre-analytical, analytical, and post-analytical phases comprise the laboratory testing process. The pre-analytical phase is the one with the highest frequency of error among these three stages. Up to 70% of all errors that occur in the clinical laboratory are pre-analytical, and issues with patient preparation, sample collection, transportation, analysis, and storage preparation cause the majority of them[1]. The pre-analytical phase encompasses all clinical laboratory procedures and activities that take place before the analytical phase [2]. The pre-analytical phase poses the biggest obstacles for laboratory staff and is the most vulnerable step of the entire laboratory testing procedure. The caliber of the pre-analytical stages affects the caliber of the test results [3,4].

On the other hand, pre-analytical procedures, specimen handling, and reporting guidelines are not widely standardized or harmonized. The conventional and pre-pre-analytical phases make up the pre-analytical phase. The "conventional" pre-analytical phase is managed by the laboratory and consists of a number of associated procedures, starting with patient identification, choosing the best tubes, ensuring safe transportation and storage, and concluding with sample preparation. Centrifugation, aliquoting, diluting, and batching the specimens for entry into an automated analyzer are among the steps involved in creating an appropriate sample for analysis [5]. The pre-pre-analytical phase takes place outside of the lab and includes ordering, gathering, handling, transporting, and receiving materials before testing, as well as choosing the right tests based on the clinical question [6]. About 70% of all laboratory errors are caused by pre-analytical errors, which constitute a significant fraction of all laboratory errors [7]. Improper form (28.24%), improper sample (3.52%), inappropriate transport (22.16%), and inappropriate centrifugation (7.29%) were the pre-analytical mistakes categorized one [8].

The percentage error reached 39% in another study. Hemolyzed samples (9%), improper sample identification (8%), and clotted samples (6%) were the main causes of rejection [9]. Of the rejected specimens in local research, 41.6% showed signs of hemolysis, 22.5% showed clotting, 12.6% had an inadequate volume, and the remaining specimens fell into other unspecified categories, such as unlabeled samples or insufficient quantity [10,11]. These mistakes can cause patients to receive the wrong diagnosis, be mistreated, and have a bad effect on their memory of the specimen [12]. Despite pre-analytical errors, which are critical for diabetes management are being prevalent in glucose testing, yet lack of standardized protocols necessitates localized evidence to improve practices and patient outcomes. The purpose of the study was to determine the prevalence of pre-analytical errors and the reasons behind them in the collection of glucose specimens.

METHODS

This descriptive cross-sectional study (039-DME-QAMC) was carried out at the Pathology Department of Bahawal Victoria Hospital in Bahawalpur between July and December of 2024. The institutional ethical review committee gave its approval. With a 95% confidence interval, a sample size of 225 has been determined via OpenEpi version 3.0.1. The WHO sample size calculator was used to determine the sample size. The method of non-probability sequential sampling was applied. Samples from indoor departments, patients who did not give their informed consent, and any stored specimens were not included. The inclusion criteria focused on samples collected from ODP patients, patients who signed the written consent, freshly collected specimens, and samples collected within the time constraint. Exclusion criteria were applied to samples obtained from patients of indoor departments, participants who did not provide informed consent, and any stored or archived specimens.

Name, age, gender, and the time and date of sample collection are among the demographic details recorded on the structured proforma that was designed for this study. Additionally, the proforma had pre-established categories for recording particular pre-analytical failures, such as hemolyzed samples, problems with blood coagulation, improper centrifugation, unlabeled samples, delayed specimen processing, and inadequate sample volume. Every sample was examined for mistakes using the study's operational definitions.

When drawing blood, standardized tools and equipment, such as vacutainers, were used. The Cobas c 303 analyzer was utilized, and glucose was measured by the enzymatic method, Hexokinase. A plain red-top tube, also called a clot activator non-gel tube, without any additives, was used to collect the specimen. Since samples went through the centrifuge (in this lab centrifuge Hettich Rotofix 32 A, swinging bucket is used), it must be scaled at the correct RPM to keep serum or plasma separated from constituents. However, the manufacturer's recommendations were followed for the specimen type. Furthermore, to reduce inter-observer variability and guarantee consistency, the lead investigator logged all data. By ensuring that every sample was methodically checked for mistakes by operational criteria, the proforma made it possible to gather thorough and precise data for analysis.

SPSS Ver. 25 was used to enter and analyze all of the data. The data's normality was examined using the Shapiro-Wilk test. The frequency and percentages of the categorical variables—gender, ward, pre-analytical error (yes/no), and its causes—inadequate sample, hemolyzed sample, blood clotting, improper centrifugation, and unlabeled samples—were displayed. The mean and standard deviation of the numerical variables, such as age, were displayed. The p-value threshold of <0.05 is considered statistically significant.

RESULTS

Table 1: Statistical Analysis of the 'Age' Variable

Statistic	Value
N	225
Mean	40.70
Std. Deviation	10.866
Gender	**Number (%age)**
Male	90 (40%)
Female	135 (60%)

The study included 225 participants, whose mean age was 40.70 ± 10.866 years with a standard deviation of 10.866 years, meaning that the average participant was about 41 years old, and whose ages varied by about ±11 years from the mean. Participants were 90 (40%) males and 135 (60%) females. The inclusion of participants from a wide age range reflects the study's goal of assessing pre-analytical errors in glucose specimen collection across a diverse adult population, as shown in **Table 1**. These demographics provide a balanced overview of the study population for further subgroup analysis.

Error Type	Frequency	Percent	Valid Percent	Cumulative Percent
Hemolyzed Sample	6	2.7%	2.7%	2.7
Quantity Insufficient	4	1.8%	1.8%	4.5
Inappropriate centrifugation	7	3.1%	3.1%	7.6
Unlabeled Samples	7	3.1%	3.1%	10.7
Delayed Specimen	21	9.3%	9.3%	20.0
Nill	180	80%	80%	100.0
Total	225	100%	100%	-

The study revealed 21 examples of delayed specimens (collected more than 1 hour after the specified period) out of the total 225 samples, accounting for 9.3% of the samples, as shown in **Table 2**. This percentage is consistent with the valid percent, as there was no missing data for this fault type. These errors arise due to delays in testing the specimens. It is routine practice to delay 2 to 3 hours or more when specimens are collected from wards. However, the OPD patient sample collection area is close to the laboratory analysis room, so 1 hour is taken for the sample processing.

There were 190 cases in the study where no pre-analytical mistakes were found, or 80% of the 225 samples in total. This finding shows that even though there were several pre-analytical problems, more than two-thirds of the study's samples were error-free, demonstrating that sample handling was generally done correctly. The study analyzed that overall finding were 20% (n=45) had at least one form of pre-analytical error. Statistically significant (p <0.05).

DISCUSSION

This study highlighted the frequency of preanalytical errors in glucose specimen collection process was 20% (n=45) with delayed specimens (9.3 %, n=21) was the most common, while other errors like inappropriate centrifugation (3.1%, n=7), hemolyzed samples (2.7%, n=6) and sample quantity insufficient (QNS) were 1.8% (n=4). These results are aligned with a recent study conducted in 2024 suggests that errors in phlebotomy procedures, specimen handling, and patient preparation, along with delayed centrifugation and delayed analysis, are common factors or error [13]. Improper form (28.24%), improper sample (3.52%), inappropriate transport (22.16%), and inappropriate centrifugation (7.29%) were the pre-analytical mistakes categorized by one study [14]. The percentage error reached 39% in another study. Hemolyzed samples (9%), improper sample identification (8%), and clotted samples (6%) were the main causes of rejection.9 Of the rejected specimens in a local research, 41.6% (94) showed signs of hemolysis, 22.5% (51) showed clotting, 12.6% (28) had an inadequate volume, and the remaining specimens fell into other unspecified categories, such as unlabeled samples or insufficient quantity. One study discovered that the primary cause of pre-analytical mistakes was poor phlebotomist technique [15].

This study also showed that improper phlebotomy techniques (like narrow bore needle use, wrong tourniquet application, squeezing blood vessel to forcefully draw blood, plunger pushing during putting the specimen into the tube) were the primary cause of hemolysis, but it was not the main Preanalytical error in this study. In modern day, advanced analyzers utilize only a few microliters of sample (serum, plasma) for analysis [16]. Hence, QNS was not the issue. However, it arises when the sample is dropped, spilled, or the patient is advised to undergo many baseline tests to be done including Fasting glucose. The sample Quantity is insufficient problem arises. Another significant culprit that we discovered was the wrong order of draw that contaminates the specimens with additives and alters results. Research has discovered clotting to be the most common mistake in the pre-analytical phase, which is different from the findings of this study [17,18].

It's crucial to identify the many approaches and fixes for avoiding mistakes during the pre-analytical stage. According to one study, complete lab automation may increase productivity and lower pre-analytical mistakes [19]. Targeted educational interventions can be one way to increase knowledge, encourage better practices, and stop mistakes in the future while also improving laboratory testing accuracy [20,21].

It has been established that quality improvement initiatives are a successful way to lower pre-analytical errors. A study conducted in a Hospital in Korea showed how quality improvement initiatives might reduce pre-analytical errors in clinical labs [22].

According to the explanation above, poor phlebotomy practices, which can be caused by things like a heavy workload or a lack of awareness, are the main cause of pre-analytical errors. Promoting the best phlebotomy techniques among medical workers requires immediate action. Non-specialized staff and unclear guidelines about standardized procedures and transit times for different tests can also lead to mistakes [23]. It is essential to give the healthcare workers involved the right training on how to collect and handle blood samples to address this problem. Errors can be reduced and patient care enhanced by using specialized vessels and making sure samples are transported promptly by qualified personnel [24,25].

To improve patient safety, cost-effectiveness, workflow efficiency, standardization, informed decision-making, ongoing advancement, educational activities, and favorable clinical results in the future, this study will assist in detecting flaws, enhancing quality, and improving workflow efficiency.

CONCLUSION

The findings of the study provide an evidence-based foundation for optimizing glucose testing in a localized setting. Preanalytical processes like following recommended phlebotomy techniques (like proper sample collection and sample handling methodologies), careful transportation, timely processing (less time delay), and strong Quality control measures to ensure reliability in diagnostic practices for better management of metabolic disorders within diverse healthcare settings. Competency checks, training, standardization, teamwork, and methodical error analysis are all components of successful solutions. Errors can be decreased, and accuracy and efficiency increased, by putting strategies like computerization, staff training, and coordination into practice.

LIST OF ABBREVIATIONS

QNS: Quantity Not Sufficient
OPD: Outpatient Department
RPM: Revolutions Per Minute
SPSS: Statistical Package for the Social Sciences
ICMJE: International Committee of Medical Journal Editors
WHO: World Health Organization

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CONFLICT OF INTEREST
None

ETHICAL APPROVAL
The ethical approval for the descriptive cross-sectional study was approved from the Bahawal Victoria Hospital ERC #(039-DME-QAMC).

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AUTHORS' CONTRIBUTIONS
HAH contributed significantly by conceiving the idea, designing the research work, and performing data analysis. All other Authors contributed equally as per **IMCJE**. All authors agreed to be accountable for all aspects of the research.

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