Spectrum of Preanalytical Laboratory Errors in Clinical Biochemistry Laboratory in a Tertiary Care Center in Nepal

Niraula A,[1] Das BKL,[2] Sherchand O,[2] Mishra B,[2] Choudhary RM,[3] Tamang S,[3] Lamsal M[2]

[1]Department of Clinical Biochemistry,
Institute of Medicine,
Tribhuvan University Teaching Hospital,
Maharajgunj, Kathmandu, Nepal.

[2]Department of Biochemistry,
[3]Routine Biochemistry Laboratory,
B.P. Koirala Institute of Health Sciences,
Dharan, Nepal.

Corresponding Author

Apeksha Niraula
Department of Clinical Biochemistry,
Institute of Medicine,
Tribhuvan University Teaching Hospital,
Maharajgunj, Kathmandu, Nepal.
E-mail: apeksha.niraula@iom.edu.np

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ABSTRACT

Background

The laboratory contributes substantially to proper management and quality laboratory reports contribute approximately 70% to medical diagnosis and treatment. Laboratory Science has been considerably facilitated by automation specifically in the field of clinical chemistry. In spite of the major contribution of laboratory automation, errors in the whole laboratory cycle are existent.

Objective

To evaluate the common pre-analytical errors occurring in routine biochemistry laboratories and subsequently imply strategies applicable in our laboratory setting to minimize their occurrence.

Method

This is a hospital-based descriptive cross-sectional study conducted in a routine biochemistry laboratory, BPKIHS. All the samples in the routine biochemistry laboratory were screened for a period of 1 year from April 2019 to March 2020 respectively. All the types of preanalytical errors were assessed and recorded. Data were entered in Microsoft Excel and analyzed using SPSS version 11.5. Descriptive statistics were used to depict the frequency of the errors.

Result

A total of 34,540 samples were screened during the study period. Out of the total samples, 1015 samples were subjected to rejection which accounted for a total of 2.94%. Among the rejected samples, the maximum was due to hemolyzed samples (1.5%), wrong identification (0.6%), samples misplaced (0.4%), improper sample collection (0.2%), inappropriate sample collection time (0.12%), missing samples (0.1%) and lipemic samples (0.02%) respectively.

Conclusion

The study revealed a significant number of pre-analytical errors existed in our laboratory which has a direct impact on the quality of laboratory results and patient service.

KEY WORDS

Clinical chemistry tests, Clinical laboratory techniques, Diagnostic errors

INTRODUCTION

Clinical laboratories have always been watchful in maintaining the quality in their analytical process.[1,2] Quality laboratory service practice by efficient and skilled human resources stands to be the keystone of the health care systems in the modern era. Quality laboratory reports contribute about 70% to medical diagnosis and treatment.[3] In addition, the development of automation in the field of clinical chemistry has aided in significant improvements in medicine and laboratory science.[4] Though there has been substantial growth in the field of laboratory medicine, some laboratory errors still exist. The errors in the clinical chemistry laboratory are classified as pre-analytical, analytical, and post-analytical.[4] The focus of the clinical laboratory has been on quality control (QC) materials and quality assessment programs.[5] Various approaches have been implemented to reduce laboratory errors, such as certification/accreditation by professional organizations, internal and external quality control assessment, and certification of education programs.[5] Studies have depicted that the majority of the laboratory errors, comprising approximately 93% arises from the pre- and post-analytical phases.[5-9] Abundant heterogeneity in laboratory errors has been demonstrated by various studies, with the major factor being errors in the data collection method, which influences the prevalence and types of errors.[6,8-11]

Recent studies have highlighted that pre-analytical variability remains one of the major challenges in laboratory medicine despite advances in automation and quality systems.[8,10,11] Common causes include hemolysis, improper labeling, inadequate specimen volume, and delays in transportation and processing.[12-14] Therefore, continual monitoring of quality indicators and harmonization of laboratory practices are essential to improve patient safety and diagnostic accuracy.[16-18]

This study aims to evaluate the errors occurring in a clinical biochemistry laboratory during routine laboratory testing at the largest tertiary care center in eastern Nepal, identify the most common errors, and propose strategies applicable in our laboratory setting to minimize their occurrence.

METHODS

This was a hospital-based descriptive cross-sectional study conducted for a period of 1 year from April 2019 to March 2020. All samples in the routine Biochemistry Laboratory were included in the study for screening and analysis for any errors. A consecutive sampling technique was used to include all samples requested for routine biochemical tests in the biochemistry laboratory. Samples requested for emergency and special biochemistry tests in the immunoassay laboratory were excluded. Ethical approval was received for this study from the Institutional Review Committee (IRC, BPKIHS) with Code No: IRC/ 1401/018.

Taking the reference from a similar study done in India, the preanalytical error (i.e., hemolytic samples) with the highest frequency of 1.10%.[2] The sample size is calculated as mentioned below:

p= 1.10%

q= 98.9%

Permissible error, L= 10% of p= 0.11

α = 5%

$Z\alpha$= 1.96

Total Sample Size (n) = $Z\alpha^2pq/L^2$

N= $(1.96)^2$ X 0.011X 0.989/ $(0.0011)^2$

= 0.041793/ 0.00000121

= 34,540

We assessed the samples sent for biochemical tests under 4 different major headings, i.e.

A. Inappropriate Form: Incomplete or wrong name of patient, Age/ Gender not mentioned, Registration number not written, Time of collection not mentioned, Ward/ OPD not mentioned, Incomplete or no clinical history, no medicinal history, Test mentioned incorrectly (In short forms/ Test not mentioned), Type of specimen not defined (Fluid/Venous/ Capillary blood, Sample without request/ Request without sample, Wrong Billing, Physician Information [Name, Signature, Provisional Diagnosis].

B. Inappropriate Sample: Insufficient volume, improperly labeled, wrong container, Hemolyzed sample, Lipemic specimens, Insufficient sample volume, Clotted plasma specimen, Wrong vial used, Delay in specimen handling & transport

C. Inappropriate Transport: Date & Time of receipt, Faulty transport medium & method, Sample spillage, Incorrect sorting

D. Inappropriate Centrifugation

Outcome measures:

-Frequency/proportion/number of Pre-analytical error in Routine Biochemical samples.

-Distribution of different types of Pre-analytical errors.

Data was entered in MS Excel 2007, and analyzed with Statistical Package for Social Sciences (SPSS 11.5 Inc., Chicago, USA). Master charts were prepared and the sum of errors will be calculated. Their relative frequencies were calculated and presented as percentages when compared with the total specimens.

RESULTS

This was a hospital-based cross-sectional study conducted for the period of one year in the Routine Biochemistry

Laboratory, B.P. Koirala Institute of Health Sciences, Dharan, Nepal. During the period of one year of study, we screened 34,540 samples in a routine biochemistry laboratory.

Out of 34,540 samples, 1015 samples were subjected to rejection comprising a total of 2.93% of the total sample included.

The most common cause for rejection was hemolysis (2.93%), followed by insufficient volume (0.72%) and improperly labeled or wrong container (0.69%), as depicted in tables 1 and 2, respectively. Comparison of in-patient versus out-patient samples revealed that the maximum samples that were subjected to rejection were from the inpatient services [38.32% (wards); 36.74% (ICU)] and 24.9% from the OPD services, as shown in table 3 and figure 1. The screening of the requisition form revealed that the maximum error that was prevalent was the time of collection not mentioned (66.45%), followed by the type of specimen not mentioned (62.97%), no medical history (58%), and incomplete or no clinical history (45.78%) as illustrated in table 4 respectively. The evaluation of pre-analytical errors associated with inappropriate transport and centrifugation depicted that the maximum errors that occurred during this phase were missing date and time in the form and sample (50%), and inappropriately centrifuged samples were seen in 0.87% of the total study samples as depicted in table 5 respectively.

Table 1. **Proportion of rejected sample during one year period**

Month	Total samples Screened	Total Samples rejected	Proportion (%) of rejected samples
April	3600	100	2.77
May	3900	175	4.48
June	3850	140	3.63
July	3915	200	5.10
August	3100	115	3.70
September	3080	71	2.30
October	2625	65	2.47
November	2016	25	1.24
December	1914	15	0.78
January	1860	13	0.69
February	1980	18	0.90
March	2700	78	2.88
Total	34,540	1015	2.93

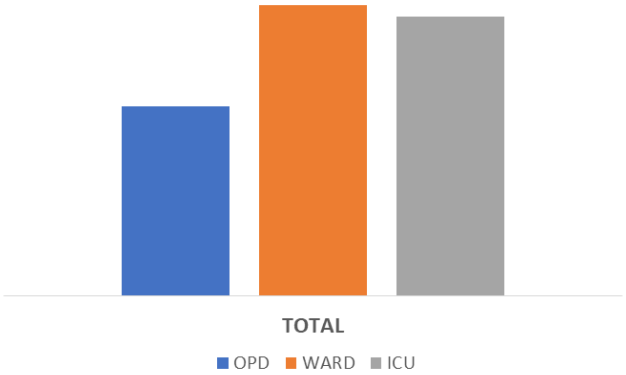

Figure 1. **Comparison of proportion of rejected samples from OPD, Ward and ICU sources**

Table 2. **Frequencies of pre-analytical errors associated with inappropriate sample**

Month	Insufficient volume	Improperly labeled, Wrong container	Hemolyzed sample	Lipemic Specimens	Clotted plasma specimen	Wrong vial used	Delay in specimen handling & transport
April	21	15	100	4	2	5	4
May	24	23	175	2	4	3	2
June	25	18	140	4	2	2	3
July	17	24	200	5	2	4	4
August	22	20	115	4	1	5	2
September	28	21	71	4	3	2	4
October	31	22	65	3	2	4	2
November	13	24	25	2	2	4	11
December	16	18	15	1	2	3	10
January	15	17	13	2	-	2	8
February	18	22	18	-	-	4	7
March	20	16	78	1	3	6	6
Total	250 (0.72%)	240 (0.69%)	1015(2.93%)	32 (0.09%)	23 (0.06%)	44 (0.12%)	63 (0.18%)

Table 3. Comparison of rejected samples from out-patient and in-patient sources during one year period

	Out-Patient Services		In-Patient Services	
Month	Total	OPD	Ward	ICU
April	100	22	37	41
May	175	44	72	59
June	140	32	53	55
July	200	54	76	70
August	115	28	45	42
September	71	19	28	24
October	65	6	31	28
November	25	8	8	9
December	15	5	4	6
January	13	4	4	5
February	18	6	5	7
March	78	25	26	27
Total	1015	253 (24.9%)	389 (38.32%)	373(36.74%)

Table 5. Pre-analytical errors associated with inappropriate transport and centrifugation

Month	Date and Time not mentioned	Faulty Transport	Inappropriate Centrifugation
April	1650	28	30
May	1425	29	31
June	1710	24	32
July	1520	22	15
August	1210	26	18
September	1615	22	22
October	1210	31	20
November	1800	25	27
December	1115	35	26
January	1210	17	24
February	1350	15	27
March	1550	25	28
Total	17,365(50.27%)	299 (0.86%)	300 (0.87%)

Table 4. Proportion of pre-analytical errors associated with inappropriate requisition form

Month	In-complete or wrong name of patient	Age/ Gender not mentioned	Registration number not written	Time of colection not mentioned	Ward/OPD not mentioned	In-complete or no clinical history	No medicinal history	Test mentioned incorrectly (In short forms/ Test not mentioned)	Type of specimen not de-fined (Fluid/Venous/ Capilary blood)	Sample with-out request/ Request without sample	Wrong Billing	Physician Information [Name, Signature)
Apr.	540	97	68	2200	515	1665	1970	87	1807	18	18	678
May	310	125	54	2600	630	1718	2080	52	2070	22	34	690
Jun.	120	110	68	2100	625	1348	2175	42	2100	34	14	950
Jul.	410	92	57	2000	780	1670	1765	46	1800	37	13	875
Aug.	340	88	62	2200	612	1340	1855	76	1765	38	7	645
Sep.	288	76	61	2100	515	1197	1650	41	1890	34	11	564
Oct.	388	65	56	2015	413	987	1312	31	1600	40	10	575
Nov.	570	68	75	1850	325	1564	1910	48	1950	25	22	678
Dec.	460	188	73	1567	530	1156	1310	54	1650	21	31	750
Jan.	345	150	32	1620	429	1210	1019	38	1623	22	24	312
Feb.	220	110	34	1500	412	975	1100	51	1765	25	21	410
Mar.	320	95	67	1200	514	985	1890	75	1732	20	10	445
Total	4311 (12.64%)	1264 (3.65%)	707 (2.04%)	22,952 (66.45%)	6300 (18.23%)	15,815 (45.78%)	20,036 (58%)	641 (1.85%)	21,752 (62.97%)	336 (0.97%)	215 (0.62%)	7572 (21.92%)

DISCUSSIONS

Laboratory Diagnostics has undergone a significant transformation from a manual, labor-intensive process to a fully automated system. Despite this advancement, clinical biochemistry has shown a significant error in the pre-analytical phase.[7,13,18] This consequently has led to unexpected diagnosis and treatment of the patient. A laboratory is not an independent system, and laboratory professionals cannot work in isolation. There must be a good collaboration between the clinical departments (Consultants, Residents), Nurses, and the laboratory, with the major contribution from the clinical departments by sending the properly filled requisition slips and samples for analysis.[7,14,19] There is growing evidence that reliability cannot be achieved in a clinical laboratory through the mere promotion of accuracy in the analytical phase of the testing process. The phases before the sample reaches the

laboratory (preanalytical) and the phase after the sample is analyzed (post-analytical) are equally important.[18-20] The preanalytical phase is peppered with many shortcomings, ranging from a lax attitude about filling the requisition slips to the staff's lack of education about ideal phlebotomy procedures. The healthcare system must be more diligent in applying scientific knowledge to reduce errors in this phase. This is imperative to curtail the dent in laboratory services that arise due to human errors. There has been varied information on the error rate within the whole lab testing procedure (0.1% to 9.3%).[19] Plebani and Carraro reported that the great majority of errors result from problems in the preanalytical or post-analytical phases.[19]

The present study reports that the most common cause for the sample rejection was hemolysis (2.93%), which is in accordance with the study done by Chawla et al., Goswami et al. and Zaini et al.[2,12,13] In our institute, specifically at the collection counter in the central laboratory, the introduction of vacuum tubes along with the closed system of blood collection has made blood collection efficient and easy. Despite this, the lack of staff training in phlebotomy impedes expediting sample collection and transport. Hemolysis of samples occurs when blood is forced through a fine needle, shaking the tubes vigorously, and centrifuging the sample specimens before clotting is complete.[14,20-22] Red top vacutainers without any anticoagulant should not be shaken after the sample has been collected, and vacutainers for plasma should be gently inverted a few times so the anticoagulant mixes with the blood. Freezing and thawing of blood specimens may cause massive hemolysis. In a study by Jay and colleagues, the majority of hemolyzed samples (> 95%) could be attributed to in vitro processes resulting from incorrect sampling procedures or transportation.[22] Hemolysis leads to the extravasation of intracellular contents into the plasma, leading to falsely high values of potassium and intracellular enzymes such as SGOT and LDH.[13] It also leads to a prolonged turnaround time (TAT) due to the need for fresh samples for processing the request.[13] Also, our study found that the frequency of the samples subjected to rejection were more from in-patient services [38.32% (wards) and 36.74% (ICU)] and 24.9% from the out-patient services, respectively. Similar trends have been observed in previous international studies where heavy workload, emergency sample collection, and staff shortages contributed significantly to pre-analytical errors.[23-25] Quality improvement strategies, including proper phlebotomy training, adherence to CLSI guidelines, implementation of laboratory quality indicators, and standardized transport systems, are critical to reducing such errors.[26,27]

The inappropriate sample collection in the inpatient services might be due to workload and the pressurized environment in the wards and critical care units. In contrast, we also found a strikingly high proportion of sample being subjected to rejection from the OPD services which could be because at our institute, we have a centralized collection center for clinical biochemistry, hematology and microbiology where sample is collected simultaneously, paucity of manpower (Ratio of patients to phlebotomists is disproportionate), making sample collection difficult, collection is carried out during fixed hours (shortage of time may adversely affect proper sample collection in the OPD setting), difficult sampling and patient non-compliance further aggravates. Nevertheless, the laboratory staff must practice a certain basic level of workmanship and skillful phlebotomy techniques to reduce such errors to a minimum level. Prevention of pre-analytical errors, including problems in specimen preparation, centrifugation, aliquot preparation, pipetting, and sorting, is required to improve patient safety and the performance of the clinical laboratory.

The implementation of laboratory quality management systems and ISO 15189 standards has been shown to reduce laboratory-associated diagnostic errors and improve patient safety outcomes.[27,28] Continuous education of healthcare personnel and harmonization of laboratory practices remain key interventions in minimizing pre-analytical variability and ensuring high-quality laboratory services.[10,28]

CONCLUSION

Total quality management comprises all the steps involved in sample processing, beginning from the test order to the final interpretation of results by the clinicians, to reduce or eliminate the errors that may arise during the various steps. The promotion of ideal phlebotomy practices and sample transport procedures is a prerequisite for the efficacy of laboratory functioning. The dependence on accurate laboratory results for diagnostics makes it mandatory for labs to ensure accountability and accuracy of results to negate incorrect diagnoses as a consequence of faulty reporting. It is essential to adopt a holistic approach toward laboratory diagnosis and function in concert with the clinicians to provide effective services to the patients.

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REFERENCES

1. Sakyi AS, Laing EF, Ephraim RK, Asibey OF, Sadique SK. Evaluation of analytical errors in a clinical chemistry laboratory experience: A 3-year experience. *Ann Med Health Sci Res*. 2015 Jan-Feb;5(1):8-12.
2. Goswami B, Singh B, Chawla R, Mallika V. Evaluation of errors in a clinical laboratory: A one-year experience. *Clin Chem Lab Med.* 2010;48: 63-6.
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.
4. Hawkins R. Managing the pre- and post-analytical phases of the total testing process. *Ann Lab Med.* 2012;32:5-16.
5. Bonini P, Plebani M, Ceriotti F, Rubboli F. Errors in laboratory medicine. *Clin Chem*. 2002;48:691-8.
6. Howanitz PJ. Errors in laboratory medicine: Practical lessons to improve patient safety. *Arch Pathol Lab Med.* 2005;129:1252–61.
7. Plebani M. Exploring the iceberg of errors in laboratory medicine. *Clin Chim Acta*. 2009;404(1):16–23.
8. Lippi G, Guidi GC, Mattiuzzi C, Plebani M. Preanalytical variability: The dark side of the moon in laboratory testing. *Clin Chem Lab Med*. 2006;44(4):358–65.
9. Narayanan S. The preanalytic phase: An important component of laboratory medicine. *Am J Clin Pathol.* 2000;113(3):429–452.
10. Lippi G, Chance JJ, Church S, Dazzi P, Fontana R, Giavarina D, et al. Preanalytical quality improvement: from dream to reality. *Clin Chem Lab Med*. 2011 Jul;49(7):1113-26.
11. Lima-Oliveira G, Lippi G, Salvagno GL. Quality management in preanalytical phase. *Clin Biochem*. 2011;44(16):1303-6.
12. Zaini GR, Dahlawi HA, Siddiqui A. Identification of the types and frequencies of pre-analytical errors in the clinical biochemistry laboratory. *Arch Med.* 2016;8(4):1-4.
13. Chawla R, Goswami B, Tayal D, Mallika V. Identification of the types of preanalytical errors in the clinical chemistry laboratory. *Lab Med.* 2010;41(2):89-92.
14. Lippi G, Salvagno GL, Montagnana M, Brocco G, Guidi GC. Influence of hemolysis on routine clinical chemistry testing. *Clin Chem Lab Med*. 2006;44(3):311-6.
15. Plebani Mario. The quality indicator paradox in laboratory medicine. *Clin Chem Lab Med.* 2016;54(7):1119–22.
16. Sciacovelli Laura, O'Kane M, Skaik YA, Caciagli P, Pellegrini C, Da Rin G, et al. Quality indicators in laboratory medicine: From theory to practice. Preliminary data from the IFCC Working Group Project Laboratory Errors and Patient Safety. *Clin Chem Lab Med.* 2011;49(5):835–44.
17. Mario P, Sciacovelli L, Aita A, Chiozza ML. Harmonization of pre-analytical quality indicators. *Biochem Med (Zagreb)*. 2014;24(1):105–13.
18. Plebani M. Laboratory errors: How to improve pre- and post-analytical phases? Biochem Med. 2007;17(1):5–9.
19. Plebani M, Carraro P. Mistakes in a stat laboratory: Types and frequency. *Clin Chem.* 1997;43(8):1348-51.
20. Carraro P, Plebani M. Errors in a stat laboratory: Types and frequencies 10 years later. *Clin Chem*. 2007;53:1338–42.
21. Carraro P. Hemolyzed specimens: A reason for rejection or a clinical challenge? Clin Chem. 2000;46:306–7.
22. Jay DW, Provasek D. Characterization and mathematical correction of hemolysis interference in selected Hitachi 717 assays. *Clin Chem.* 1993;39:1804–10.
23. Wiwanitkit V. Types and frequency of preanalytical mistakes in a certified clinical laboratory. *BMC Clin Pathol.* 2001;1:5.
24. Ola W, Söderberg J, Van Guelpen B, Grankvist K, Brulin C. Preanalytical venous blood sampling practices demand improvement a survey of test-request management, test-tube labelling and information search procedures. *Clin Chim Acta.* 2008;391(1-2):91–97.
25. Lippi G, Guidi GC. Risk management in the preanalytical phase of laboratory testing. *Clin Chem Lab Med.* 2007;45(6):720–727.
26. Clinical and Laboratory Standards Institute. Procedures for the Collection of Diagnostic Blood Specimens by Venipuncture; Approved Standard. CLSI document GP41. 7th ed. Wayne, PA: CLSI; 2017.
27. World Health Organization. Laboratory Quality Management System: Handbook. Geneva: WHO Press; 2011.
28. International Organization for Standardization. ISO 15189: Medical laboratories Requirements for quality and competence. Geneva: ISO; 2012.