

Research Article

Awareness of Pre-Analytical Errors Amongst Nurses – The Phlebotomists in Our Local Set Up

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Abstract

Objective: To assess the awareness of these errors amongst nurses, the primary phlebotomists in our system, in the light of their relative qualifications and phlebotomy experience.

Methodology: A cross-sectional study was conducted at Mayo Hospital, Lahore. Ninety- three registered nurses were included in the study through purposive sampling, excluding student & head nurses. Data were collected through a structured pre-tested questionnaire with supplementary Urdu translation.

Results: Of the 93 nurses, 70% were diploma holders, 59% had less than 5 years of phlebotomy experience and 83% were trained at public sector hospitals. Total correct responses were more amongst diploma holders (mean=7.42) as compared to graduate nurses (mean=7.14). Awareness of ideal sampling practices was inadequate amongst majority. In questions related to appropriate vacutainer selection, maximum correct responses were recorded for calcium estimation (95%) but extremely low for biochemistry, serology (4.3%) and glucose estimation (1.1%). When compared on the basis of phlebotomy experience, correct responses were more among nurses with less than 5 years' work experience (2/3rd of questions & mean=7.6) when compared to nurses with 5 or more years of experience (1/3rd of questions & mean=6.9).

Conclusion: Diploma qualified nurses showed greater overall awareness compared to their graduate counterparts. However, awareness of recommended sampling practices was low amongst most participants. With the exception of calcium estimation, for other tests the correct vacutainer was identified by below 50 % of participants.

Received | 15-08-2018: **Accepted** | 21-05-2019

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Keywords | Nurses, pre-analytical phase, errors, awareness.

Introduction

Quality assurance of diagnostic testing in biochemical laboratories plays an important role in creating an optimal healthcare experience while also decreasing financial costs due to medical errors.¹ The main aim for the diagnostic service is to get the correct lab result of the correct patient to the requesting doctor without unnecessary delays.² This process

is divided into pre-analytical, analytical and post analytical phases.³ Bonini et al found pre-analytical errors to be the predominant error of laboratory diagnostic procedure, ranging from 31.6% to 75%.⁴ Furthermore, a local study suggests 77% laboratory errors occur in the pre-analytical phase, 8% in analytical, 15% in post-analytical phase of laboratory diagnostic process. These studies suggest that the pre-analytical phase should be a major target for quality

improvement.⁵

Gauging the awareness of pre-analytical errors amongst nurses, the primary phlebotomists in our set up, may provide useful insight for guiding future policy to ensure more reliable diagnostic testing. A study done by Milutinović and colleagues has shown that despite being confident in their sampling techniques, nurses had insufficient knowledge about possible factors affecting hemolysis due to materials used in venipuncture.⁶ Lack of knowledge about tourniquet application, plasma tubes and various other factors among nurses also indicate the need for further investigation in this area.⁷ Moreover, nurses in our hospitals belong to either of two qualifications; diploma in nursing (3 years) or the newer BSc Nursing (Generic; 4 years).⁸ This study was designed with three objectives in mind: Firstly, to assess the awareness of nurses of Mayo Hospital Lahore, a tertiary care hospital, regarding pre-analytical errors during collection, storage and transportation of samples; secondly, to compare the two streams of education of nurses for awareness regarding pre-analytical errors; thirdly, to explore any potential relationship of awareness of these errors with years of phlebotomy experience.

Methods

The study was a descriptive, cross-sectional study set in clinical departments of Mayo Hospital, Lahore. We included registered nurses of Mayo Hospital Lahore who had been working in the hospital for at least three months whereas student and head nurses were excluded from the study. The sampling technique used was purposive (non-probability) and a required sample size of 93 nurses was estimated using 95% confidence level, 8% absolute precision with expected percentage of awareness about pre-analytical errors as 10%⁹ and non-response rate of 15%, using

the formula, $n = \frac{Z^2 1 - \frac{\alpha}{2} \bar{p} \bar{q}}{d^2}$ where $Z^2 1 - \frac{\alpha}{2}$, \bar{p}

= Prevalence 10%, $\bar{q} = 1 - \bar{p}$ & $d =$ absolute precision 8%.

Our study was approved by Institutional Review Board of KEMU vide letter no.310/RC/KEMU. Data were collected, employing a WHO¹⁰ & CLSI¹¹ guidelines-based, pretested, structured, expert validated questionnaire by the co-principal investigators with

written consent of study participants. Data regarding the qualification, phlebotomy experience, place of training, and various variables in the form of correct responses of the questions asked with respect to pre-analytical errors, were recorded. Pre-analytical errors related to phlebotomists included in this study were as follows: improper patient preparation, wrong patient & sample identification, selection of inappropriate vacutainers, blood sample collection errors due to incorrect phlebotomy practice, inadequate volume, errors in specimen processing such as lipemic samples, hemolysis¹², precautions required for transport of blood sample for certain analytes. The finalized close ended questionnaire included questions regarding background characteristics (5 questions) and qualitative variables (23 questions). Data were analyzed by SPSS²¹. Descriptive statistics were applied determining frequency & percentages of qualitative variables consisting of correct and incorrect responses against the questions asked. Chi-square test was applied to find out the association between correct responses of individual questions and qualification of study subjects along with their phlebotomy experience. Descriptive statistics for quantitative variables were done determining the mean \pm SD. p -value < 0.05 was considered significant.

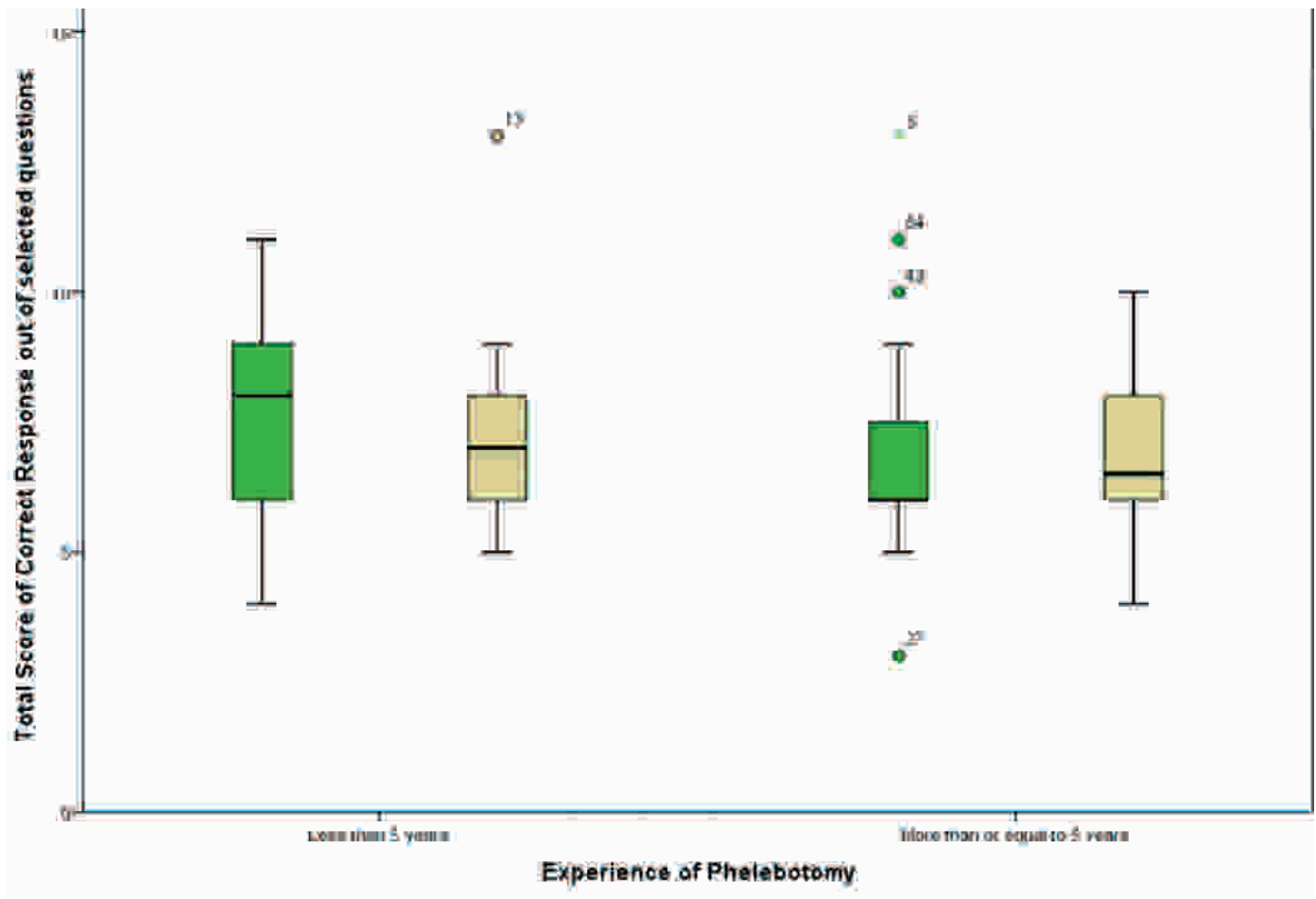
Results

Of a total of 93 respondents, 70% (n=65) nurses were diploma holder. Majority (83%) were trained at public sector hospitals (Table 1). Out of them 33 were trained at Mayo, 32 at other teaching & 12 at different District Headquarter Hospitals (DHQ). 82% had phlebotomy experience of 1-10 years out of which 48% (n=45) had phlebotomy experience of 1 to 4 years, 33.33 % (n=31) of 5-10 years. Only 10.7% (n=10) nurses had less than 1 year of experience and 7.5% (n=7) had more than 10 years of phlebotomy experience. Mean (\pm SD) & median phlebotomy experience were 4.53(\pm 4.7) & 3 years respectively. Total correct response range was 10 with minimum score of 3 & maximum of 13 out of 20 questions. Majority respondents (71%) obtained correct response score of 6-9 out of 20 questions asked. Total correct responses were slightly more among diploma holders with mean (\pm SD) of 7.42(\pm 2.06) as compared to 7.14 (\pm 1.84) among graduate nurses. Highest number of correct response in 6 of 20 questions, were also recorded higher in diploma holder nurses as compared to B.Sc. holders. However, highest correct response in 13 of 20 questions was recorded equal in both groups of nurses.

Table 1: Distribution of Subjects According to Place of Training, Experience of Phlebotomy, and Qualification (N=93)

Place of training	Phlebotomy experience (Years)	Diploma holder (n)	Phlebotomy experience (Years)	B.Sc. (Hons) holder (n)	Total (%)	
Mayo Hospital Lahore	<5	11	22	<5	6	33 (35.5)
	≥ 5	11		≥ 5	5	
Other Teaching Hospitals of Public Sector	<5	16	22	<5	4	32 (34.4)
	≥ 5	6		≥ 5	6	
Nursing Schools at DHQs	<5	5	10	<5	1	12 (12.9)
	≥ 5	5		≥ 5	1	
Teaching Hospitals of Private Sector	<5	0	2	<5	2	4 (4.3)
	≥ 5	2		≥ 5	0	
Unclassified Nursing Schools or Colleges	<5	9	9	<5	1	12 (12.9)
	≥ 5	0		≥ 5	2	
Total			65		28	93

*trained only while course of studies completed elsewhere

**Figure 1:** Comparison of Total Score of Correct Responses among Subjects based on their Qualification and Phlebotomy Experience (N=93)

When compared on the basis of years of phlebotomy experience, correct responses were more among nurses with less than 5 years with mean (\pm sd) of 7.6 (\pm 1.97) whereas, 6.9 (\pm 1.97) among nurses with 5 or more than 5 years of experience. Moreover, higher median, Q1 and Q3 values were recorded among those having less than 5 years of phlebotomy experience

as compared to those having 5 or more years of phlebotomy experience consistent among both qualifications (Figure 1).

In questions related to appropriate vacutainer selection, maximum correct response was recorded for calcium estimation (95%; n=89), followed by HbA1c (54%; n=50), Coagulation tests (35%; n=33) and

extremely low for hematology, biochemistry, serology and glucose estimation (Table 2). However, correct response among graduate nurses was higher than diploma holders in vacutainers related to HbA1c and coagulation tests. Comparing with their phlebotomy experience, we found almost similar percentages for each vacutainer asked except for few differences. We recorded better response in case of vacutainers for HbA1c & glucose estimation among respondents with < 5 years of phlebotomy experience. However, we recorded better response in case of

vacutainers for Coagulation tests, biochemistry, serology and hematology estimation among ≥ 5 years of phlebotomy experience (Table 2).

In case of questions related to other pre-analytical errors, better percentage of correct responses were recorded among nurses with less than 5 years of phlebotomy experience regarding patient preparation as 85% (n=47), followed by avoidance of habit of pushing the plunger of syringe forcefully as 80% (n=44), sample identification as 38% (n=21), correct order of sample collection in case of septicemia as

Table 2: Frequency of Correct Responses of Subjects against Questions asked for Pre-analytical Errors Related to Appropriate Vacutainer Selection Based on their Qualification Versus Phlebotomy Experience (N=93)

Qs asked about appropriate vacutainer selection for blood tests	Desired Correct Response	Qualification		Experience of Phlebotomy	
		Diploma holder	B.Sc. Hons	<5 yrs	≥ 5 yrs
		%(n)	%(n)	%(n)	%(n)
Calcium Estimation	EDTA vacutainer is contraindicated (n=89)	97 (63)	93 (26)	96 (53)	95 (36)
HbA1c Estimation	Purple top vacutainer containing EDTA (n=50)	52.3 (34)	57 (16)	56 (31)	50 (19)
Coagulation Tests	Blue top vacutainer containing sodium citrate (n=33)	29.2 (19)	50 (14)	25 (14)	50 (19)
Hematological Tests	Purple top vacutainer containing EDTA (n=6)	7.7 (5)	3.6 (1)	4 (2)	11 (4)
Biochemistry & Serology Tests **	Red top vacutainer containing no additive (n=4)	4.6 (3)	3.6 (1)	4 (2)	5 (2)
Glucose Estimation	Gray top vacutainer containing sodium fluoride (n=1)	0	3.6 (1)	2 (1)	0
TOTAL		65	28	55	38

** P=0.006

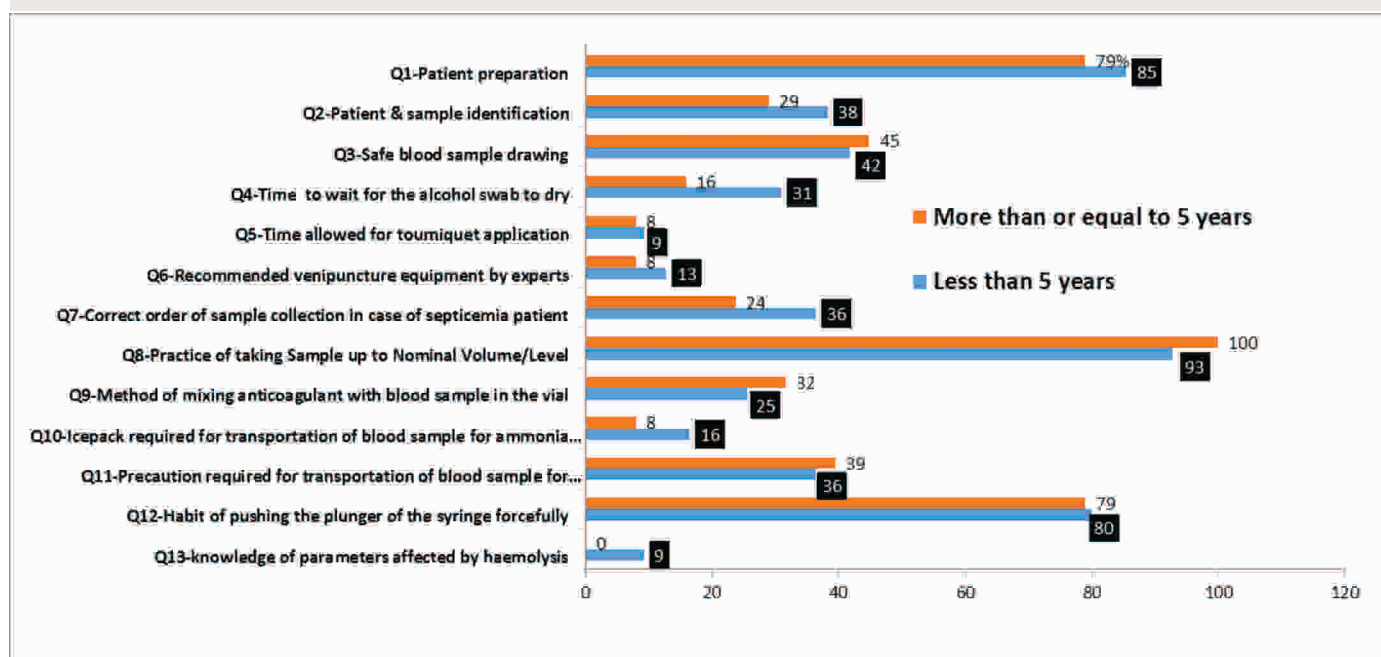


Figure 2: Frequency of Correct Responses against Questions asked for Errors of Pre-analytical Phase related to Collection and Transportation based on their Phlebotomy Experience (N=93)

36% (n=20), time allowed for alcohol swab to dry as 31% (n=17), icepacks required for transportation of blood sample to estimate ammonia as 16% (n=9), recommended equipment for venipuncture as 13% (n=7), parameters affected by hemolysis and time allowed for tourniquet application as 9% each (n=5) (Figure 2).

Conversely, better responses were recorded among nurses with ≥ 5 years of phlebotomy experience in habit of taking sample up to nominal volume as 100%, safe blood sample drawing using personnel protective equipment as 45% (n=17), precaution required for transportation of sample for Bilirubin estimation as 39% (n=15) and method of mixing of anticoagulant with blood sample as 32% (n=12). Surprisingly 76.3% nurses responded that they had never acquired training or workshop in proper blood sampling technique. Likewise, more than half of the subjects (58%) were not provided with any checklist for performing venipuncture procedure. Almost all respondents (97%) indicated usefulness of standard checklist for performing venipuncture if it would be available to them.

Discussion

Nurses, being the primary phlebotomists in our set up, play a central role in the quality of lab reports. In our country the need to bring the quality of nursing education to par with the developed world has been recognized. Today however, the nurses with a bachelor degree remain a minority, as evident in our study as well as an Indian study on awareness of nurses.¹³ Nurses with less than 5 years' experience are more in the current study and this finding is almost similar to a local study.¹⁴

In agreement with a multicenter survey in China showing lack of knowledge of nurses regarding phlebotomy,⁹ we found the majority of our respondents to score $<50\%$ correctly. Comparison of correct responses to the qualification of respondents showed slightly better understanding of pre-analytical phase among diploma holder nurses as compared to B.Sc holders, likely a consequence of a greater number of nursing staff with diploma, and hence, more respondents with this level of education in our hospitals. Respondents with less than 5 years' experience scored better compared to their more experienced colleagues, perhaps due to sampling or instrument biases as a greater number of nurses with less than 5 years of experience participated in this study. These two findings are similar to those of a local study.¹⁴

Incorrect vacutainer selection influences the measured concentration of analytes and thus compromises the reliability of lab results. In our study correct vacutainer selection was found to be extremely low

for hematology, biochemistry, serology and glucose estimation. Inadequate knowledge of appropriate vacutainers required for lab tests could be related with the limited variety of vacutainers available to nurses. The most recent study in India indicated frequency of pre-analytical errors as 0.05% due to incorrect vials selection.¹⁵ Our findings regarding correct vial selection are contrary to a survey in a developed country that showed almost 100% correct responses for appropriate vial selection by nurses.⁷ This disparity may be attributed to differences in the nurses' level of education and quality of training. However, in certain vacutainers selection, our B.Sc. respondents showed significantly better response as compared to diploma holders. More experienced respondents scored better than their colleagues regarding routinely used vacutainers reflecting their better clinical practice.

When performing lipid profile tests, to ensure a lipemic sample does not interfere with the recording of electrolytes, the phlebotomist must ensure that the patient has fasted before collecting the sample.¹² Our results regarding misidentification of samples and patients are in line with local studies which reported wrong practice of 83% respondents¹⁶ and 21% of errors in laboratory samples to be due to misidentification of patient⁵. When questioned on parameters affected by hemolysis, an important pre-analytical error, our respondents showed a level of awareness far below that of nurses in Croatian hospitals.¹⁷

Subjects were found to be less aware of the amount of time allowed for alcohol applied to skin to dry, comparable to the observation of a local study¹⁶ in which subjects didn't know even how to apply alcohol swab before venipuncture. Similarly, we observed poor awareness of recommended guidelines related to sampling procedures including regarding time allowed for tourniquet application, method of mixing of additive with blood sample and correct order of sample collection in multiple vacutainers. Conversely, correct response rate against these questions were much higher in Chinese nurses except correct order of sample collection.⁹

Few respondents showed awareness of proper transportation requirements for samples for bilirubin (39% correct) and for ammonia tests (16% correct). Unfortunately, 3/4th nurses in our study had never acquired training or workshop in phlebotomy techniques. This might be the reason of their inadequate knowledge of pre-analytical errors. Training or refresher courses may improve quality of work and has positive impact on awareness of phlebotomists, justified by the results of a Turkish study.¹⁸

Our study identified limited knowledge of our

phlebotomists either due to noncompliance to written SOPs (Standard Operating Procedures) of phlebotomy because of high workload, lack of training or inattention of their supervisors to ensure quality of pre-analytical phase of lab testing.

Irrespective of nurses' prior level of education and experience, there is a need for authorities to regularly arrange trainings or refresher courses, provide nurses with checklists and other helpful tools and to monitor the phlebotomy techniques practiced by nurses. Moreover, clinicians are to make diagnosis not relying on lab results solely but using clinical acumen so as to avoid misleading diagnosis and to ensure right treatment plan for patients.

Limitations

Our study on phlebotomists of public sector hospital that included a limited number of subjects. The authors recommend multicenter studies, involving more participants to be conducted for assessing the degree of awareness of the underestimated pre-analytical phase of laboratory testing amongst nurses as well as investigation into the flaws in the current system that can be improved upon.

Conclusion

The low quality of awareness of standard procedures relevant to the pre-analytical phase, ranging from vacutainer selection, venous blood sample collection, storage and transportation, as well inadequate availability of helpful resources such as checklists was identified by the current study. Until reforms in these systems are implemented to improve awareness amongst phlebotomists, the current situation of poor phlebotomy practice will persist to be the major cause of erroneous lab results.

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