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Knowledge of phlebotomy and specimen quality among laboratory personnel

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Abstract

Phlebotomy is a critical component of the pre-analytical stage in laboratory diagnostics, accounting for most laboratory errors. Inadequate phlebotomy practices, often due to limited knowledge, can lead to specimen rejection and compromise diagnostic accuracy. This study examined the relationship between medical laboratory technologists' knowledge of phlebotomy and the quality of collected blood specimens. An analytical observational study with a cross-sectional design was conducted across clinical laboratories. A total of 56 participants were selected using total sampling. Phlebotomy knowledge was assessed through a structured questionnaire, while specimen quality was evaluated via direct observation. Data were analyzed using descriptive statistics and the Chi-square test. The findings revealed varying levels of phlebotomy knowledge and a moderate proportion of unacceptable specimens. A significant association was identified between knowledge levels and specimen quality. These results underscore the importance of strengthening pre-analytical competencies through continuous education and targeted institutional support. Enhancing phlebotomy training can improve specimen integrity, reduce laboratory errors, and support broader efforts to advance diagnostic reliability and healthcare quality.

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1. Introduction

Laboratory services that provide accurate and timely diagnostic support can improve healthcare quality. Clinical laboratories are integral to the continuum of care, contributing significantly to disease diagnosis, therapeutic monitoring, and prevention through specimen examination (Khotimah & Nurhayati, 2022). In alignment with the Indonesian Ministry of Health Regulation No. 43 of 2013, laboratories must perform five essential functions: confirming diagnoses, identifying disease aetiology, monitoring therapeutic effectiveness, conducting health maintenance, and supporting preventive strategies (Tuntun et al., 2018). It highlights the important role that medical laboratory technologists play in determining the quality of healthcare services, providing essential data to support clinical decision-making, and enabling doctors to intervene accurately and effectively (Jayanti et al., 2024).

One of the primary roles of Medical Laboratory Technologists (MLTs) is to collect and analyze blood specimens in various clinical parameters (Sari, 2023). This laboratory testing process is divided into three sequential stages: pre-analytical, analytical, and post-analytical. The pre-analytical stage is the most prone to errors, accounting for approximately 48–68% of all errors that occur in the laboratory (Syuhada et al., 2021). This stage includes various activities performed before the sample is analyzed, such as patient preparation, sample identification, collection, handling, transportation, processing, and storage (Marsudi et al., nd). Pre-analytical errors, such as hemolysis, identification, and clotting, are commonly encountered

and can compromise diagnostic accuracy (Getawa et al., 2023). The most common errors in the pre-analytical phase include hemolysis (53.2%), insufficient specimen volume (7.5%), illegible handwriting (7.1%), patient identification errors, presence of clots, incorrect vacuum container or anticoagulant, inappropriate anticoagulant volume, specimens drawn from intravenous (IV) lines, and incorrect timing of specimen collection (Cahyani et al., 2019). As the initial stage of laboratory testing, the pre-analytical phase is fundamental in determining specimen quality and influencing the validity of subsequent analyses (Arista, 2020). For instance, in phlebotomy procedures, the improper use of vacuum tubes can compromise specimen integrity and result accuracy (Erdal et al., 2016).

Phlebotomy, the clinical procedure of collecting venous blood samples for laboratory testing, constitutes a core element of the pre-analytical process (Umar et al., 2023). However, procedural errors often arise due to limited training and a lack of updated knowledge among practitioners (Adiga & Adiga, 2017). The effectiveness of phlebotomy practices is highly dependent on the competence and knowledge level of MLTs, as these factors directly influence specimen quality and the likelihood of rejection due to pre-analytical faults (Qian et al., 2018; Munawaroh et al., 2021). Previous studies have affirmed the critical role of knowledge and training in improving specimen quality. Faridah (2020) and Rizki et al. (2024) demonstrated that knowledge significantly affects phlebotomy outcomes, although attitudinal and behavioral aspects were less strongly associated. Research by Dilshika et al. (2020) in Sri Lanka also reported high specimen rejection rates among healthcare workers with limited phlebotomy knowledge.

The important role of MTLs in phlebotomy and laboratory specimen quality needs to be examined more broadly in various settings. In the local context of Sangatta, phlebotomy procedures are predominantly performed by certified MTLs. However, access to standardized training and certification opportunities remains constrained, primarily due to geographic isolation and financial limitations. These barriers hinder the continuous professional development of laboratory personnel, subsequently affecting their ability to maintain consistent specimen quality (Lihabi, 2022). Therefore, a comprehensive investigation into how phlebotomy knowledge among MLTs correlates with specimen quality in underserved or geographically isolated healthcare settings remains both necessary and timely. This study aims to investigate the relationship between laboratory personnel's knowledge of phlebotomy and the quality of laboratory specimens in Sangatta City. The findings are expected to inform targeted interventions for quality improvement and professional development in medical laboratory practice. Moreover, the study contributes to the broader discourse on pre-analytical quality assurance in clinical laboratories by offering context-specific evidence from a geographically underserved region.

2. Method

2.1 Research Design and Participants

This study employed an analytical observational design with a cross-sectional approach, which is appropriate for assessing associations between variables at a single point in time (Subhaktiyasa, 2024b). The research was conducted in March 2025 across several clinical laboratories in Sangatta City, East Kalimantan, Indonesia. The target population consisted of all registered MTLs actively working in these laboratories. A total of 56 participants were selected using a total sampling technique to ensure representativeness of the population. The inclusion criteria were (1) certified MTLs actively involved in phlebotomy procedures during the data collection, and (2) individuals who provided informed consent. Exclusion criteria included personnel on leave or not performing phlebotomy-related tasks at the time of data collection.

2.2 Instruments and Data Collection

Data collection in this study employed two primary instruments: a structured knowledge questionnaire and an observational checklist for specimen quality, both developed based on the work of Indyanty et al. (2015). The knowledge questionnaire comprised 20 items constructed using the Guttman scale to assess respondents' comprehension of essential phlebotomy procedures, including patient preparation, blood collection techniques, specimen labeling, and appropriate selection and handling of collection tubes. To ensure content validity and clarity, the questionnaire was reviewed by two clinical laboratory experts (Subhaktiyasa, 2024a). Furthermore, the instrument underwent pilot testing to evaluate its psychometric properties, yielding statistically significant validity ($p < 0.005$) and a high reliability score with a Cronbach's alpha of 0.860. Specimen quality was assessed using an observational checklist aligned with institutional pre-analytical standards. Each blood specimen was classified as "acceptable" or

"unacceptable" based on predefined criteria, including hemolysis, clotting, insufficient volume, labeling inaccuracies, or inappropriate collection tubes. Observations were conducted in real-time during routine phlebotomy activities by trained observers blinded to the respondents' knowledge scores, thereby minimizing observer bias. This approach ensured that data collection reflected actual clinical practice and preserved the objectivity of quality assessments.

2.3 Data Analysis

Data were processed and analysed using Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics summarised respondent characteristics, knowledge levels, and specimen quality distribution (Subhaktiyasa et al., 2025). The association between phlebotomy knowledge and specimen quality was examined using the Chi-square test of independence. A p-value of less than 0.05 was considered statistically significant, indicating a meaningful relationship between the two variables.

2.4 Ethical Considerations

This study received ethical approval from the Institutional Review Board of STIKES Wira Medika Bali (approval number: 354/E.1.STIKESWIKA/EC/X/2024). All participants were provided detailed information regarding the study objectives, procedures, and confidentiality safeguards. Written informed consent was obtained prior to participation. The research team ensured that all data collected was kept confidential, anonymized, and used solely for academic purposes. No identifying information was disclosed in any publication or presentation from this study.

3. Results and Discussion

3.1 Results

This study involved 56 Medical Laboratory Technologists (MLTs) as respondents who met the inclusion criteria and consented to participate. The demographic and professional characteristics collected included gender, age group, educational attainment, years of work experience, and participation in phlebotomy-related training. These characteristics were assessed to provide a contextual understanding of the respondents' profiles and to explore potential associations with their knowledge levels and the quality of the specimens they handled.

Table 1. Respondent Characteristics

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	12	21.4
	Female	44	78.6
Age	20–25 years	16	28.6
	26–30 years	23	41.1
	31–35 years	10	17.9
	36–40 years	5	8.9
	>41 years	2	3.6
Education level	Diploma III	51	91.1
	Bachelor/Diploma IV	5	8.9
Work experience	0–5 years	5	8.9
	6–10 years	30	53.6
	11-15 years	8	14.3
	16-20 years	2	3.6
Phlebotomy Training Certificate	Available	18	32.1
	Not Available	38	67.9

Table 1 explains that most respondents were female (78.6%) and most were aged between 26 and 30 (41.1%). Most held a Diploma III as their highest educational qualification (91.1%) and had work experience of 0–5 years (53.6%). Only 32.1% of respondents had attended formal phlebotomy training or certification programs.

Table 2. Phlebotomy Knowledge Level of Respondents

Knowledge Level	Frequency (n)	Percentage (%)
Good	22	39.3
Fair	20	35.7
Poor	14	25.0

Table 3. Phlebotomy Knowledge Level of Respondents

Specimen Quality	Frequency (n)	Percentage (%)
Acceptable	35	62.5
Unacceptable	21	37.5

Table 2 presents the distribution of phlebotomy knowledge levels among respondents, showing that 39.3% demonstrated good knowledge, 35.7% were categorized as fair, and 25.0% were identified as having poor knowledge based on their responses to the structured questionnaire. Table 3 illustrates the quality assessment of blood specimens, revealing that 62.5% of the collected samples met the predefined acceptability standards, while 37.5% were classified as unacceptable. This finding highlights the persistence of pre-analytical errors, indicating that deviations from optimal practice may still occur despite the existence of standard operating procedures.

Table 4. Relationship Between Knowledge and Specimen Quality

Knowledge Level	Acceptable (n, %)	Unacceptable (n, %)	Total (n)	p-value
Good	17 (30.3%)	5 (8.9%)	22	0.041
Fair	14 (23.2%)	6 (10.7%)	20	
Poor	4 (7.1%)	10 (17.9%)	14	

Table 4 presents the Chi-square test results, which revealed a statistically significant association between phlebotomy knowledge and specimen quality ($p = 0.041$). Respondents with good knowledge were more likely to produce acceptable specimens, while those with poor knowledge demonstrated a higher proportion of unacceptable specimens. These findings indicate that the level of knowledge held by medical laboratory technologists plays a critical role in determining the quality of blood specimens collected during phlebotomy procedures.

3.2 Discussion

The present study highlights that many medical laboratory technologists possessed good phlebotomy knowledge, while a notable segment demonstrated limited understanding. These findings reinforce the assertion that knowledge shapes professional perception, technical behavior, and decision-making in clinical laboratory practices (Janah et al., 2023). Consistent with Arista (2020), cognitive understanding and accumulated work experience are pivotal in determining the accuracy of pre-analytical procedures. Her research demonstrated that individuals with strong theoretical foundations tend to yield higher-quality specimens, which aligns with the trend observed in this study.

Phlebotomy knowledge is not solely influenced by formal academic background, but also by duration of service and exposure to structured training (Rizkika et al., 2014; Parwati et al., 2022). It reinforces the growing consensus that continuous professional development and lifelong learning are critical for laboratory personnel to remain responsive to technological innovations and evolving clinical standards (Jaya et al., 2023). Sufficient knowledge supports precise decision-making, reduces pre-analytical errors, and enhances specimen integrity, especially during collection, handling, and transport.

Nevertheless, this study identified inconsistencies between knowledge and practice. Several respondents with high knowledge levels still produced suboptimal specimens. This paradoxical phenomenon suggests that knowledge alone does not guarantee procedural accuracy. Practical challenges such as time pressure, inadequate supervision, limited resources, or procedural stress may interfere with applying theoretical knowledge in clinical settings (Chita et al., 2022; Lihabi, 2022). These results underscore the well-documented gap between competence and performance in health professions education. The quality of laboratory specimens remains a central concern in clinical diagnostics. A considerable proportion of specimens analyzed in this study failed to meet quality standards, reaffirming the view that most laboratory errors arise during the pre-analytical phase (Getawa et al., 2023; Syuhada et

al., 2021). Hemolysis, improper labeling, clotted specimens, and inadequate volume continue to be prevalent issues, compromising diagnostic accuracy and patient safety. Such recurring problems highlight the importance of rigorous adherence to standardized procedures.

Tuntun et al. (2018) emphasized that consistent implementation of pre-analytical protocols, grounded in a comprehensive understanding of laboratory standards, plays a crucial role in error prevention. Therefore, institutional enforcement of standard operating procedures (SOPs) is essential in minimizing variability and enhancing consistency in phlebotomy practices. Interestingly, the study found that some technologists with moderate or poor knowledge levels produced acceptable specimens. This anomaly suggests that technical experience, ease of venous access, or strong institutional support systems—such as adequate supervision and routine mentoring—may compensate for limited theoretical preparation (Rosya et al., 2024; Rizki et al., 2024). These findings reinforce the understanding that professional performance is influenced by a dynamic interplay of knowledge, practical skills, environmental context, and institutional structure.

The statistically significant association between phlebotomy knowledge and specimen quality observed in this study further supports findings from previous research. Qian et al. (2018), Faridah (2020), and Indyanty et al. (2015) identified that adequate knowledge and appropriate training strongly correlate with high-quality specimen outcomes. However, contradictory cases in both directions, well-informed technologists performing poorly and under-informed ones succeeding, reveal the importance of investigating non-cognitive and contextual influences. Faridah (2020) notably reported a remarkably low specimen rejection rate in a separate facility, likely due to rigorous institutional SOP implementation and quality control programs.

These findings call for a more holistic quality assurance framework within clinical laboratories. Competency development must go beyond didactic knowledge to include hands-on simulations, structured practice, and longitudinal supervision. Prasetya et al. (2024) advocate for institutional investments in recurring training, certification access, and integrated quality monitoring systems to translate knowledge into consistent laboratory excellence. Furthermore, it is imperative to consider external patient-related factors. Difficulties in venous access—especially in pediatric, geriatric, or emergency cases—can hinder specimen quality despite proper technique. Laboratories must thus be equipped with standard equipment, adaptive tools, and procedural flexibility to accommodate real-world clinical variation.

The findings provide important insights into the relationship between knowledge and the quality of laboratory specimens, but they have limitations. The reliance on self-reported knowledge may introduce response bias, and the limited geographic scope within Sangatta may affect generalizability to broader populations. Future research should adopt mixed-method or longitudinal designs, incorporating direct observational assessments of practice. Moreover, further investigation into institutional, motivational, and systemic factors is warranted to understand better their role in enhancing specimen quality.

4. Conclusion

This study confirms a statistically significant relationship between medical laboratory technologists' (ATLMs) knowledge of phlebotomy and the quality of blood specimens collected in clinical laboratories across Sangatta City. The findings emphasize the critical importance of pre-analytical competence in ensuring accurate laboratory diagnostics and reducing specimen rejection rates. Respondents with higher knowledge levels were likelier to produce acceptable specimens, reinforcing the need for continuous training and competency-based certification in laboratory practice. These results contribute to quality improvement initiatives in health services by highlighting specific knowledge gaps that may compromise diagnostic outcomes. While the study offers practical insights for laboratory education and supervision, it is limited by its cross-sectional design, geographic focus, and reliance on self-reported knowledge assessments, which may affect external validity. Future research should consider longitudinal or mixed-method approaches to capture better the relationship between knowledge and procedural performance, including institutional factors such as supervision quality, infrastructure, and workload management. This study supports evidence-based enhancements in laboratory workforce development and informs policy frameworks to strengthen diagnostic reliability and patient safety in healthcare systems.

Conflict of Interest

The authors declare no conflict of interest.

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