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Abstract

Background: Blood transfusion is a critical, life-saving procedure frequently performed in intensive care units (ICUs). Nurses play a pivotal role in ensuring transfusion safety, yet knowledge gaps and practice deficiencies may compromise patient outcomes.

Aim: To assess nurses' knowledge and competency regarding safe blood transfusion in adult and pediatric ICUs at Alexandria University Hospitals.

Methods: A descriptive cross-sectional design was used, including all available ICU nurses (n = 63; 24 pediatric ICU, 39 adult ICU) using a convenience sampling method. A structured knowledge interview questionnaire and an observational competency checklist were used to collect the data.

Results: Most nurses (65.1%) had unsatisfactory knowledge, while 69.8% demonstrated competent transfusion practice. Age and years of nursing experiences were significantly associated with knowledge. In multivariate regression, years of nursing experience was the only significant predictor of knowledge (adjusted $R^2 = 0.182$), whereas practice was significantly predicted by age, prior involvement in transfusions, and expressed intent to attend training (adjusted $R^2 = 0.619$), with training intent the strongest individual predictor. Knowledge and practice were positively correlated ($r = 0.315$, $p = 0.012$).

Conclusion: Although nurses showed acceptable overall competency, substantial knowledge deficits were observed, particularly in pre-transfusion preparation and policy adherence. Structured training programs, continuous professional development, and standardized protocols are essential to bridge the knowledge–practice gap and strengthen transfusion safety for critically ill adults and children.

Keywords: Blood transfusion; Nursing competency; critical care units; Patient safety; cross-sectional study

Introduction

Blood transfusion is one of the life-saving interventions either administration of whole blood or a specific component [1]. According to World Health Organization (2017) report, nearly 54% of blood transfusions in low-income countries were administered to children younger than five years of age. Whereas in high-income countries individuals aged over 60 years accounted for up to 76% of transfusion recipients [2]. In both pediatric and adult critical care, transfusion aims to restore oxygen-carrying capacity, ensure hemodynamic stability, and rectify hematologic disturbances [3]. Despite its benefits, transfusion is not without risk, and strategies for children and adults differ due to physiological and clinical variations between the two populations [4].

Nurses, as frontline healthcare providers, play a fundamental role in ensuring the safety and quality of blood transfusion procedures [5]. Their responsibilities span the entire transfusion process, from verifying physician orders and preparing patients to identifying contraindications, confirming compatibility, and educating patients regarding potential risks [6]. Nurses are directly involved in quality assurance activities, including checking the expiration date, ensuring bag integrity, confirming patient identification, and preventing severe transfusion-related errors [7].

In practice, nurses act as advocates and protectors of patient well-being throughout the transfusion. They monitor vital signs, manage infusion rates, and observe patients during the critical first 15 minutes to promptly identify transfusion reactions such as fever, skin rashes, or respiratory distress

[8, 9]. After transfusion, they remain responsible for monitoring delayed complications and documenting all procedures in the patient record [10]. Nurses also contribute to institutional improvement through peer-led instruction, clinical education, and adherence to transfusion guidelines, which collectively enhance patient safety and foster a culture of accountability [11, 12].

Globally, advances in blood screening, component therapy, and molecular testing have significantly improved the safety of transfusion medicine. In Egypt, national policies and revised standards for blood transfusion (2023) have promoted safer practices through nurse training and educational initiatives [13]. These efforts highlight the pivotal role of nurses in translating guidelines into safe and effective clinical practice.

Gap in Knowledge

Despite the improvement in transfusion protocols, gaps remain in nurses' knowledge and competency regarding safe blood transfusion practices. Previous studies have revealed inconsistencies in adherence to protocols, particularly in areas such as patient identification, compatibility testing, and follow-up care [14]. Insufficient or outdated knowledge among nurses can lead to serious complications and compromise patient safety. Furthermore, differences in transfusion needs between pediatric and adult critical care settings underscore the importance of assessing nurses' knowledge and skills in both contexts. Limited research in Egypt has

systematically evaluated ICU nurses' competency in blood transfusion practices across adult and pediatric units, creating a clear need for this study. This study is conceptually grounded in Benner's Novice-to-Expert Model [15]. which posits that clinical competency develops through progressive stages of experiential learning from novice reliance on rules to expert tacit performance and guides the interpretation of the relationship between years of experience, declarative knowledge, and observed practice competency in this study.

Aim

This study aimed to assess nurses' knowledge and competency regarding blood transfusion of critically ill adults and children ICUs at Alexandria University Hospitals.

Methods

Study design

A descriptive research design was used.

Study Setting and Participants

This study was conducted in the Adult Intensive Care Unit (ICU) and the Pediatric Intensive Care Unit (PICU) of Alexandria University Hospitals, which serve Alexandria and the surrounding governorates such as El-Behera, Matrouh, and Kafr El-Sheikh.

A convenience sampling method was used. All accessible and eligible ICU nurses during the period of data collection were recruited, including 24 PICU nurses and 39 adult ICU nurses from

a total of 63 nurses to maximize representativeness and avoid sampling bias. Nurses were included if they had more than six months of ICU experience, directly involved in patient care and blood transfusion procedures, and willing to participate by providing informed consent.

Study instrument

Two tools were used to collect the necessary data.

Tool I: Nurses' Blood Transfusion Knowledge Interview Questionnaire:

This tool was developed by the researcher after reviewing recent and relevant literature to assess nurses' knowledge regarding blood transfusion [16, 17]. It consists of two parts. Part I: Sociodemographic characteristics (age, gender, qualifications, years of experience, and transfusion training); and Part II, Nurses' knowledge about equipment needed, preparation for blood transfusion, patient's preparation, nursing care during and after transfusion, complications, and transfusion policy. Total knowledge scores were converted to percentage score and classified as good knowledge (≥70%), satisfactory (60% to <70%), unsatisfactory (<60%).

Tool II: Nurses' Blood Transfusion Competency Observational Checklist. It was developed by the researcher after reviewing recent and relevant literatures [16- 20]. It comprised three phases — pre-transfusion phase, during transfusion phase, and post-transfusion phase— with total competency score converted to percentage scores and classified as competent (≥80%) or incompetent (<80%).

Validity and reliability

Both tools were translated into Arabic and back-translated into English to ensure linguistic accuracy and cultural appropriateness. Content and face validity were evaluated by a panel of five experts in adult critical care and pediatric nursing, who assessed each item for clarity, relevance, and representativeness. The results indicated a high degree of agreement, confirming both content and face validity. Construct validity was further examined through inter-item correlation analysis and item-total statistics, which confirmed the coherence of each subscale. Given the total study population of n = 63 (a total census), Confirmatory Factor Analysis was not applied, as this technique requires a minimum of approximately 200 participants to yield stable and trustworthy fit indices. Reliability was assessed using Cronbach's alpha, demonstrating good internal consistency for both instruments ($\alpha = 0.87$ for the knowledge questionnaire and $\alpha = 0.85$ for the competency checklist.

Pilot study

Pilot study was conducted on 10% of the total sample (7 nurses) to assess clarity, feasibility, and applicability of the tools. Minor modifications were made, and these nurses were excluded from the final sample.

Data collection

Data was collected over three months (March - June 2025). Each nurse was first observed individually while performing a blood transfusion using the competency checklist, followed by a structured interview to assess their knowledge using the questionnaire. Finally, the collected data were coded, entered, and analyzed.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee, Faculty of Nursing, Alexandria University (Approval No.: AU,2,386), in accordance with Declaration of Helsinki. Witness informed consent was obtained from the head nurses of PICU and ICU after explaining the aim of the study prior to observation. Written informed consent was obtained from all participants after explanation of the study objectives, voluntary participation, and the right to withdraw at any time without consequence. Confidentiality and anonymity of the collected data were strictly maintained, and all information was used for research purposes.

Statistical Analysis

Data were coded, entered, and analyzed using IBM SPSS Statistics version 28. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the demographic characteristics, knowledge scores, and competency scores of the participants. Inferential statistics, including independent t-tests and one-way ANOVA examined

differences in knowledge and competency based on demographic variables. Pearson's correlation coefficient assessed the relationship between nurses' knowledge and competency. Linear regression analyses were conducted to identify significant predictors of knowledge and competency. Statistical significance was set at $p \leq 0.05$.

Results:

Table 1 summarizes the demographic characteristics of the study sample (n = 63). Nearly half of the nurses were aged 25–<30 years (47.6%), followed by 30–<35 years (25.4%), 20–<25 years (20.6%), and ≥35 years (6.3%), with a mean age of 27.83 ± 3.84 years. Females constituted 60.3% of participants. The vast majority held a bachelor's degree in nursing (92.1%), while 3.2% had completed a two-year post–high school nursing institute, and the minority (1.6%) had a master's degree. Furthermore, the majority of nurses had less than 5 years of nursing experience (87.3%), with a mean of 2.32±2.62 years.

The same table presents that only 6.3% had attended any formal training on blood transfusion. When asked about areas requiring further training and educational support, nearly half identified sample collection (49.2%) as a priority. Blood bag preparation and storage, and blood donation were each reported by 35.6% of participants, while 28.8% expressed a need for training on adverse transfusion reactions, and 27.1% emphasized the importance of education on serious transfusion-related complications.

Table 2 presents nurses' knowledge levels. Overall, 65.1% of nurses demonstrated unsatisfactory knowledge and only 14.3% demonstrated a good of knowledge level with mean total knowledge score of *13.92 ± 5.34*; mean percentage score of *48.85 ± 19.06*. Knowledge related to patient preparation was insufficient in most of participants (63.5% unsatisfactory; 11.1% good). The highest proficiency was noted in receiving/collecting the blood bag (58.7% good, 27.0% unsatisfactory). while, the lowest performance was in preparatory nursing procedures before transfusion (85.7% of participants, 0% good). For nursing procedures after initiating transfusion, 55.6% scored unsatisfactory and 22.2% scored good. As regard blood transfusion complications, 46.0% of nurses scored unsatisfactory compared to 34.9% of them scored good. A concerning deficit was identified in blood transfusion policies and procedures (71.4% unsatisfactory, 0% good).

Table 3 shows nurses' blood transfusion competency levels. Overall, 69.8% of nurses were rated competent and 30.2% as incompetent with mean total score of 25.52±6.16 (percentage score of 82.33±19.87). Competency was the highest during transfusion, with 79.4% of nurses competent, followed by the pre-transfusion stage (71.4% competent), and the post-transfusion stage was the lowest competent (63.5% competent). These results suggest a relatively satisfactory level of practical skills overall, with post-transfusion practice representing a specific area for improvement.

Table 4 shows the relation between demographic data and their knowledge/practice scores. Gender

and educational level showed no significant association with nurses' knowledge or practice. Age had statistically significant impact on both knowledge ($F = 5.664$, $p = 0.002$) and practice ($F = 8.061$, $p = 0.001$). Similarly, years of experience was significantly correlated with knowledge ($F = 7.043$, $p = 0.002$) and practice ($F = 3.969$, $p = 0.024$). Additionally, participation in structured training programs was positively related to higher knowledge ($p = 0.009$) and improved practice ($p = 0.001$), emphasizing the crucial role of continuous education in enhancing transfusion safety.

Table 5 presents the linear regression analysis. For knowledge, only years of nursing experience emerged as a significant predictor ($B = 3.012$, $p = 0.038$). Other factors, including age and expressed intent to attend training courses, did not significantly predict knowledge levels. The model was statistically significant ($F = 4.450$, $p = 0.003$) and explained 18% of the variance (adjusted $R^2 = 0.182$).

In contrast, practice was more strongly influenced by multiple factors. Age ($B = 1.825$, $p = 0.019$), prior involvement in transfusion procedures ($B = 3.242$, $p = 0.011$), and expressed intent to participate in training programs ($B = 12.698$, $p < 0.001$) were all significant predictors of practice, with training-intent showing the strongest effect. Interestingly, years of nursing experience and knowledge scores were not significant contributors to practice ($p = 0.619$ and $p = 0.434$, respectively). The overall practice model demonstrated high explanatory power, accounting for 62% of the variance in practice scores (adjusted $R^2 = 0.619$, $F = 21.144$, $p < 0.001$). It should be

noted that the “expressed intent to attend training” variable reflects a reported attitude rather than actual training participation, and the intention–behavior gap must be acknowledged as a limitation when interpreting this predictor’s magnitude.

Table 6 shows a statistically significant positive relationship was revealed between overall knowledge and overall checklist performance ($r = 0.315$, $p = 0.012$). **Table 7** shows that the knowledge had a statistically significant positive effect on practice among the study participants ($B = 0.363$, $\beta = 0.315$, $t = 2.590$, $p = 0.012$). The 95% confidence interval (0.083–0.634) indicated that the relationship was precise and did not cross zero, further confirming the significance of the association. The overall model was significant ($F = 6.709$, $p = 0.012$) and explained 9.9% of the variance in practice ($R^2 = 0.099$, adjusted $R^2 = 0.084$).

Table 1: The Demographic Characteristics of the Studied Nurses. (n=63)

Demographic characteristic	No	%
Age		
20-<25	13	20.6
25-<30	30	47.6
30-<35	16	25.4
≥35	4	6.3
Mean±SD	27.83±3.84	
Gender		
Female	38	60.3
Male	25	39.7
Level of education		
Two years of institute after a high school diploma	2	3.2
Bachelor of Nursing	58	92.1
Masters	1	1.6
Other	2	3.2
Years of nursing experience		
<5	55	87.3
5- <10	4	6.3
10- <15	4	6.3
Mean±SD	2.32±2.62	
Attendance of blood transfusion training		
Yes	4	6.3
No	59	93.7
Needed training and educational support in blood transfusion -related areas. #		
Sample collection	29	49.2
Blood bag preparation and storage	21	35.6
Blood donation	21	35.6
Adverse reactions to blood transfusion	17	28.8
Serious complications of blood transfusion	16	27.1
Other	2	3.4

#: Multiple responses question.

Table 2: The Distribution of Nurses' Knowledge Levels Regarding Blood Transfusion Procedure (n=63)

Knowledge Domain	Unsatisfactory < 60 %		Satisfactory < 70 to 60 %		Good ≥ 70%	
	No	**%**	**No**	**%**	**No**	**%**
Patient Preparation	40	63.5	16	25.4	7	11.1
Receiving (Collecting) the Blood Bag	17	27.0	9	14.3	37	58.7
Preparatory Nursing Procedures Before Blood Transfusion	54	85.7	7	11.1	2	3.2
Nursing Procedures After Initiating Blood Transfusion	35	55.6	14	22.2	14	22.2
Blood Transfusion Complications	29	46.0	12	19.0	22	34.9
Issues Related to Blood Transfusion Policies and Procedures	45	71.4	0	0.0	18	28.6
Overall knowledge	**41**	**65.1**	**13**	**20.6**	**9**	**14.3**
Mean total score Min-Max Mean±SD			3.00 -22.00 13.92±5.34			
Mean percent score Min-Max Mean±SD			10.34 -78.57 48.85±19.06			

Table 3: Levels of Nurses' Blood Transfusion Competency (n=63)

Competency Domain	Incompetent No. (%)		Competent No. (%)	
Pre-Transfusion	18	28.6	45	71.4
During Transfusion	13	20.6	50	79.4
Post-Transfusion	23	36.5	40	63.5
Overall Competency	**19**	**30.2**	**44**	**69.8**
Total score	5.00-31.00 25.52±6.16			
Percent score	16.13-100.00 82.33±19.87			

Table 4: Relation Between Demographic Data and Knowledge and Practice (n=63)

Demographic characteristic	Knowledge				Practice			
	Mean	±SD	Test	p value	Mean	±SD	Test	p value
Age								
20-<25	12.77	4.21			20.38	7.29		
25-<30	12.30	5.90	F =		25.03	5.65	F =	
30-<35	16.00	3.16	5.664*	0.002*	29.50	2.48	8.061*	0.001*
≥35	21.50	0.58			30.00	2.00		
Gender								
Female	14.18	5.33	t =		25.21	6.27	t =	
Male	13.52	5.44	0.480	0.633	26.00	6.09	0.495	0.623
Level of education								
Two years at an institute after high school	18.50	2.12	F =		27.50	2.12	F =	
Bachelor of Nursing	13.79	5.49	0.533	0.662	25.43	6.37	0.280	0.840
Masters	12.00				22.00			
Other	14.00	0.00			28.00	0.00		
Years of nursing experience								
<5	13.07	5.12	F =		24.73	6.20	F =	
5- <10	18.00	2.00	7.043*	0.002*	31.00	0.00	3.969*	0.024*
10- <15	21.50	0.58			31.00	0.00		
Attendance of blood transfusion training								
No	14.10	5.46	t =		26.63	4.52	t =	
Yes	11.25	1.26	3.003*	0.009*	9.25	3.40	7.519	0.001*
Needed training and educational support in blood transfusion - related areas. #								
Sample collection	13.47	4.53			25.47	5.57		
Blood bag preparation and storage	11.67	6.54			27.00	5.20		
Blood donation	12.23	5.31	F =		27.00	4.69	F =	
Adverse reactions to blood transfusion	15.88	5.89	1.892	0.111	25.88	2.23	0.449	0.812
Serious complications of blood transfusion	16.75	4.85			27.50	4.15		
Other	19.00	0.00			29.00	0.00		

F: ANOVA test t = independent t- test *: Statistically significant at $p \leq 0.05$

Table 5: Linear Regression Analysis Showing the Effect of Demographic Characteristics on Nurses' Knowledge and Practice Regarding Blood Transfusion (n=63)

Predictor	Knowledge						Practice					
	B	Beta	t	p	95% CI		B	Beta	t	p	95% CI	
					LL	UL					LL	UL
Age	1.178	0.184	1.244	0.218	-0.717	3.072	1.825	0.247	2.416*	0.019*	0.313	3.337
Years of experience	3.012	0.302	2.126	0.038*	0.176	5.847	0.578	0.050	0.500	0.619	-1.740	2.897
Intent to attend training	0.119	0.006	0.042	0.967	-5.551	5.790	12.698	0.507	5.692*	0.001*	8.230	17.165
Knowledge	-	-	-	-	-	-	0.081	0.071	0.788	0.434	-0.126	0.289
	R^2= 0.235, adjusted R^2= 0.182, F= 4.450*, p= 0.003*						**R^2= 0.650, adjusted R^2= 0.619, F=21.144*, p<0.001***					

F,p: f and p values for the model
B: Unstandardized Coefficients
t: t-test of significance
LL: Lower limit
*: Statistically significant at $p \leq 0.05$
R2: Coefficient of determination
Beta: Standardized Coefficients
CI: Confidence interval
UL: Upper Limit

Table 6: Correlation Between Overall Knowledge and Overall Competency Scores (n=63)

	Overall checklist	
	R	P
Overall knowledge	0.315*	0.012*

r: Pearson coefficient
*: Statistically significant at $p \leq 0.05$

Table (7): Linear regression analysis for the effect of knowledge on practice (n=63)

	Practice					
	B	Beta	T	p	95% CI	
					LL	UL
Knowledge	0.363	0.315	2.590*	0.012*	0.083	0.634
	R^2= 0.099, adjusted R^2= 0.084,F=6.709*, p=0.012*					

Discussion

Nurses have a pivotal role in ensuring patient safety and minimizing risks associated with blood transfusion. Nurses are expected to provide quality care during the three phases of blood transfusion, beginning with the initial request, in addition to closely observing patients for adverse reactions both during and after the blood transfusion [21, 22]. This study aimed to assess nurses' competency regarding blood transfusion of critically ill patients in adult intensive care and pediatric intensive care units.

The principal finding of the current study was that most participants nurses had unsatisfactory level of knowledge, particularly regarding patient preparation, preparatory nursing procedures before transfusion, and blood transfusion procedures was insufficient in most participants' nurses. This result is in line with the study by Jogi et al., 2021[22], who found poor knowledge-level scores among participant nurses regarding key important information about blood transfusion**.** In addition, Badawy et al., 2024 [23] found that the majority of participant nurses had an unsatisfactory total level of knowledge regarding blood transfusion before implementing an educational blood transfusion module**.** Furthermore, a study by Abdelatif et al., 2025 [24] concluded that more than two-thirds of the nurses had an unsatisfactory knowledge level. Moreover, the results findings by Edea et al., 2024 [25] and Shaikh et al., 2023 [26] revealed that a significant proportion of their sample's nurses had inadequate knowledge of the appropriate blood transfusion**.** A study by Subhan et al., 2024 [21] revealed a moderate level of overall knowledge about blood transfusion among nurses. These results give evidence of gaps in training and education, and are supported by the current study participant nurses' response about areas related to blood transfusion that require further training, such as sample collection,

blood bag preparation, and storage, in addition to adverse transfusion reactions. This can assist in designing educational programs to promote safe blood transfusion.

The assessment of nurses' blood transfusion competencies showed that most participant nurses demonstrated an overall competent performance in blood transfusion procedures across the three phases: pre-transfusion, during transfusion, and post-transfusion. Pre-transfusion is a crucial stage involving patient identification, cross-matching, and preparation. Although the results suggest that nurses are generally aware of the importance of patient safety before initiating transfusion, about one-fifth of them were incompetent; still, a significant proportion lack essential competencies, which could potentially place patients at risk during transfusion procedures. In contrast, Badawy et al., 2024 [23] reported that the majority of nurses had an incompetent level of practice scores before the module implementation, while this percentage decreased significantly after the module implementation. In addition, the results of Jogi et al., 2021[22] revealed that participant nurses have poor scores in clinical practices relating to warming of blood products, posttransfusion patient monitoring, and disposal of blood bags. Furthermore, a study by Ali et al., 2022 [27] revealed that 90% of studied nurses had unsatisfactory nursing practices in relation to the assessment of safety practices during the blood transfusion procedure. A study by Abdelatif et al., 2025 [24] concluded that almost two-thirds of them had an incompetent practice level regarding the care of children undergoing blood and blood product transfusion. These findings highlight the urgent need for simulation-based training programs for nurses about safe blood transfusion.

The current study proved that there was a statistically significant positive relationship between overall knowledge and overall checklist performance. This may be attributed to the fact that once nurses are oriented about the underlying rationale of each step, they tend to carry it out

competently. This result aligns with Badawy et al., 2024 [23], who found a highly statistically positive correlation between the nurses' total Knowledge scores and their total practice scores before and after implementing the training module. Nevertheless, it is critical to theorize the knowledge–practice paradox that lies at the heart of this study's findings: 65.1% of nurses had unsatisfactory knowledge yet 69.8% were rated as competent in practice, and knowledge explained only 9.9% of the variance in practice ($R^2 = 0.099$). This dissociation deserves dedicated discussion rather than incidental mention. Several mechanisms may explain it. First, procedural memory, which governs habitual clinical tasks such as blood bag checks, IV line management, and vital sign monitoring, operates largely independently of declarative knowledge; nurses may perform steps correctly through accumulated repetition without being able to verbally articulate the underlying rationale. This is consistent with Benner's Novice-to-Expert Model, in which expert practitioners develop tacit competence that outpaces their theoretical articulation. Second, the relatively high competency threshold of ≥80% may overestimate true proficiency if nurses selectively perform competently during the structured observation session a well-documented Hawthorne effect. Third, the weak knowledge–practice correlation ($r = 0.315$) may partly reflect measurement artifact: the knowledge tool captured declarative recall (interview-based), while the competency tool captured procedural enactment (observation-based), two epistemologically distinct constructs. Future research should employ longitudinal designs and process-tracing methods to disentangle these mechanisms.

When investigating the relation between sociodemographic variables and nurse's knowledge and practice, the present study revealed that clinical experience was significantly correlated with knowledge ($p = 0.002$) and practice ($p = 0.024$), indicating that repeated practice and direct clinical involvement contributing to greater competency. This finding further emphasizing the

potential value of simulation-based training for nurses in enhancing competency level. Additionally, participation in structured training programs was positively related to higher knowledge ($p = 0.009$) and improved practice ($p = 0.001$). This result aligns with Edea et al. (2024), who concluded that work experience has a significant association with knowledge (Edea et al., 2024). In contrast, Jogi et al., 2021 [22] found that work experience had no significant relation with participant nurses' knowledge or practice-based questions.

Higher nursing qualifications are generally linked to critical thinking, advanced theoretical knowledge, and better clinical decision-making. The findings of the present study indicated no significant association between nurses' level of education and their knowledge or practice related to blood transfusion. Nurses with a two-year institute diploma had higher mean knowledge and practice scores than bachelor's-degree holders; however, this subgroup comprised only two nurses, so the comparison should not be interpreted as a meaningful education -related difference. This result is in line with a study by Jogi et al., 2021[22], who found no significant relation between nurses' scores for knowledge or practice-based questions and their qualification. On the other hand, the results of Ali et al., 2022 [27], indicated a positive and significant relationship between the safe nurses' practices and their level of education.

The result of the current study indicated that knowledge and practice scores significantly increased with age and years of experience. This may be attributed to their frequent clinical opportunities, accumulated clinical exposure, and maturity. In contrast, gender does not appear to influence participant nurses' knowledge or practice as there is equal opportunities for clinical practices and training regardless of gender in this setting. This result aligns with a study by Ali et al., 2022 [27], which found that age and years of experience had a significant and positive relationship with safe practices, while gender had no significant effect on both knowledge and

practice. On the other hand, Badawy et al., 2024 [23] and Soliman & Elhapashy, 2021[20], found no statistically significant relation between knowledge or practice before the implementation of the blood transfusion educational training module and the year of experience. As an exploratory observation only, the subgroup of nurses who had attended a training program (n = 4; 6.3%) appeared to have lower mean knowledge and practice scores than untrained nurses. Importantly, no inferential statistical conclusion can be drawn from a subgroup of four individuals; this cell size is far below the minimum threshold for any reliable parametric test. This observation must not be interpreted as evidence that training is ineffective or harmful. Rather, it most likely reflects pre-existing selection effects or the extremely limited power of a subgroup this small. Future studies with larger trained subgroups are needed to reliably examine the association between training attendance and competency outcomes. This exploratory note is consistent with the observation by Ali et al., 2022 [27], that indicated no statistically significant difference between safe nurses' practices and frequency of performing blood transfusions. Badawy et al., 2024 [23] found no statistically significant relation between knowledge or practice score before the implementation of the blood transfusion educational module with attending training.

Strengths and Limitations

A major strength of this study is that it was conducted in both adult and pediatric intensive care units of a large university hospital, which provided access to nurses working in high-acuity clinical settings where blood transfusion is routinely performed. Additionally, direct observation of transfusion practices minimized reporting bias and provided an objective assessment of competency.

However, several limitations should be acknowledged. The study was limited to a relatively small sample size (n = 63), which may restrict the generalizability of the findings. The use of a convenience sampling method without randomization could introduce selection bias and limit representativeness. Moreover, the study was conducted in a single geographic region, which may not reflect variations in practice across other hospitals or healthcare systems. Finally, the cross-sectional design restricts causal inferences between nurses' knowledge, practice, and demographic predictors.

Implications for nursing practice, education and research

The findings of this study emphasize the urgent need to strengthen nurses' knowledge regarding blood transfusion, particularly in pre-transfusion preparation and adherence to institutional policies, where the greatest gaps were identified. Despite acceptable levels of practice competency, the significant association between knowledge and practice indicates that improving theoretical understanding will directly enhance clinical performance.

Hospital administrators and nursing educators should prioritize structured, competency-based training programs and continuous professional development sessions on safe transfusion practices. Incorporating simulation-based training, case discussions, and regular refresher courses can reinforce both knowledge and skills. In addition, establishing standardized transfusion checklists, strengthening adherence to updated national transfusion guidelines, and integrating routine competency assessments into quality improvement initiatives can help minimize errors and improve patient safety.

Conclusion

This study revealed a significant gap between nurses' knowledge and practice regarding safe blood transfusion in adult and pediatric intensive care units. While the majority of nurses

demonstrated competent transfusion practices, their knowledge, particularly in pre-transfusion preparation and policy adherence, was predominantly unsatisfactory. The results further confirmed that years of experience, prior involvement in transfusion procedures, and expressed intent to attend training programs were significant predictors of improved knowledge and practice. Importantly, expressed intent to attend training emerged as the most influential individual factor in the practice regression model, though future studies should examine actual training attendance and its outcomes in larger samples to confirm this relationship.

These findings highlight the need for continuous professional development, structured training programs, and the integration of standardized transfusion protocols to bridge the gap between knowledge and practice.

Declaration

Ethical Considerations:

Ethical approval for this study was obtained from the Research Ethics Committee of the Faculty of Nursing, Alexandria University (Approval No.: AU,2,386), following the Helsinki guidelines.

Consent to Participate

Witness informed consent was obtained from the head nurses of PICU and ICU after explaining the aim of the study prior to observation. Written informed consent was obtained from all participants after explanation of the study objectives, voluntary participation, and the right to withdraw at any time without consequence. Confidentiality and anonymity of the collected data were strictly maintained, and all information was used for research purposes.

Consent for publication

Not applicable.

Data availability

Data are available on request from the corresponding author.

Competing interests

The researcher identifies no conflicts of interest.

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