

Assessment of nursing students' knowledge of blood transfusion and related factors

Avaliação do conhecimento de estudantes de enfermagem sobre transfusão sanguínea e fatores relacionados

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ABSTRACT

Objective: to assess nursing students' knowledge of blood transfusion and related factors. **Methods:** an observational, cross-sectional, analytical study conducted with 165 undergraduate nursing students. Students aged ≥ 18 years were included, and those with incomplete questionnaires were excluded. A structured instrument with adequate internal consistency was applied (Kuder–Richardson 20=0.84). The knowledge score was dichotomized as adequate ($\geq 50\%$ correct answers) and inadequate ($<50\%$), according to the literature. Analysis was performed using Pearson's Chi-square test, with estimation of odds ratio and 95% confidence intervals ($p < 0.05$). **Results:** inadequate knowledge predominated (66.7%). Higher rates of correct answers were observed in protocol-based safety practices, whereas weaknesses were identified in critical steps such as patient identification, clinical monitoring, and venous access management. Adequate knowledge was associated with more advanced semesters and technical nursing training ($p = 0.040$). **Conclusion:** students' knowledge was predominantly inadequate, with gaps in critical steps of transfusion safety. Educational factors, such as academic progression and prior experience, positively influenced this knowledge. **Contributions to practice:** the findings highlight the need to restructure teaching on blood transfusion in undergraduate nursing education, incorporating active methodologies, clinical simulation, and training focused on critical steps of the transfusion process. **Descriptors:** Blood Transfusion; Transfusion Reaction; Students, Nursing; Knowledge.

RESUMO

Objetivo: avaliar o conhecimento de estudantes de enfermagem sobre transfusão sanguínea e fatores relacionados. **Métodos:** estudo observacional, transversal e analítico, realizado com 165 estudantes de graduação em Enfermagem. Foram incluídos estudantes ≥ 18 anos e excluídos aqueles com questionários incompletos. Aplicou-se instrumento estruturado com consistência interna adequada (Kuder–Richardson 20=0,84). O escore de conhecimento foi dicotomizado em adequado ($\geq 50\%$ de acertos) e inadequado ($<50\%$), conforme literatura. Realizou-se análise por meio do teste do Qui-quadrado de Pearson, com estimativa de *odds ratio* e intervalos de confiança de 95% ($p < 0,05$). **Resultados:** predominou conhecimento inadequado (66,7%). Houve maior acerto em práticas protocoladas de segurança e fragilidades em etapas críticas, como identificação do paciente, monitorização clínica e manejo do acesso venoso. O conhecimento adequado associou-se à semestres mais avançados e formação técnica em enfermagem ($p = 0,040$). **Conclusão:** o conhecimento dos estudantes mostrou-se predominantemente inadequado, com lacunas em etapas críticas da segurança transfusional. Fatores formativos, como progressão acadêmica e experiência prévia, influenciam positivamente esse conhecimento. **Contribuições para a prática:** os achados evidenciam a necessidade de reestruturação do ensino sobre transfusão sanguínea na graduação em Enfermagem, com incorporação de metodologias ativas, simulação clínica e treinamentos focados em etapas críticas do processo transfusional. **Descritores:** Transfusão de Sangue; Reação Transfusional; Estudantes de Enfermagem; Conhecimento.

Introduction

Blood transfusion is a highly complex therapeutic intervention used in health care for severe clinical conditions, such as maintaining oxygen transport, volume replacement, and major surgical procedures⁽¹⁾. Although blood transfusion is supported by defined protocols, the transfusion process remains susceptible to operational failures associated with increased morbidity and mortality⁽²⁾.

Globally, hemovigilance systems have shown that errors related to blood transfusion are often associated with human failures and non-adherence to critical process steps, such as patient identification, blood component verification, and clinical monitoring⁽³⁾. In Brazil, hemovigilance data indicate that a significant proportion of transfusion reactions could be prevented through strict compliance with safe practices and strengthened training of health professionals, especially the nursing team, which is directly involved in all phases of the transfusion process⁽⁴⁾.

Safe transfusion practice is widely recognized as an essential nursing competency. The nurse's continuous involvement in patient care is crucial for the early identification of transfusion complications and for adherence to guidelines and operational identity-checking protocols, given their strategic role in implementing critical steps of blood transfusion⁽⁵⁻⁶⁾.

Relevant gaps in knowledge about blood transfusion have been identified among health professionals and students. Among nurses, knowledge has been classified predominantly as moderate, with significant proportions of low levels across the assessed dimensions⁽⁷⁾. Insufficient knowledge on the topic has also been observed, with a low proportion of individuals demonstrating adequate mastery, highlighting weaknesses in the academic training process⁽⁸⁻⁹⁾.

Despite the existence of these studies, methodological heterogeneity is observed among them, including variations in the instruments used, the criteria for classifying knowledge, and the cutoff points adopted, which limits the comparability of findings

across different settings. Furthermore, investigations conducted in the Brazilian context that systematically assess nursing students' knowledge across the different stages of the transfusion process—encompassing care procedures, safety practices, and early recognition of transfusion reactions—remain scarce⁽¹⁰⁾.

Given this scenario, it is necessary to deepen the understanding of nursing students' knowledge, considering not only overall performance but also the specific gaps related to the stages of transfusion practice. Therefore, this study aimed to assess nursing students' knowledge of blood transfusion and related factors.

Methods

Study design, period, and setting

This was an observational, cross-sectional, analytical study conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The study was carried out from July to September 2025 at a public university located in Northeastern Brazil, within the undergraduate nursing program.

Population and sample

The study population consisted of 377 nursing students. The sample size was calculated for a finite population, adopting a 95% confidence level and a 5% margin of error, resulting in a minimum sample size of 150 participants. At the end, the sample comprised 165 students, a number considered adequate to ensure the statistical robustness of the analyses.

Nursing students aged 18 years or older, regularly enrolled between the first and tenth semesters of the program, with active enrollment during the data collection period, accessible at the time of instrument administration, who voluntarily agreed to participate in the study, and who had the cognitive ability to understand and answer the questionnaire were included. Those who did not fully complete the instrument

or who did not have the cognitive ability to respond were excluded.

Participants were invited through classroom announcements and institutional channels (e-mail and messaging applications). The questionnaire was made available online via an electronic link and was completed individually and anonymously.

Study variables

Independent variables included sociodemographic and academic characteristics: age, sex, marital status, monthly income, semester of the course, technical nursing training, place of residence, and time spent studying outside the classroom.

The dependent variable was the level of knowledge about blood transfusion, assessed using a score composed of 35 true-or-false questions, with a total score ranging from 0 to 35 points. For analytical purposes, knowledge was categorized as adequate or inadequate, using a cutoff point of 50% correct answers, according to a criterion previously used in a study on knowledge of blood transfusion⁽¹⁰⁾, allowing standardization of the analysis. However, it is acknowledged that the use of a fixed cutoff point may simplify the classification of knowledge and may not capture intermediate levels of performance.

Data collection

Data were collected using a structured questionnaire administered in an online format. The instrument was developed by the investigators⁽¹¹⁾ based on the identification of the main dimensions of the transfusion process, including pre-, intra-, and post-transfusion care. The questionnaire consisted of two parts: the first included sociodemographic and academic data, and the second assessed knowledge about blood transfusion.

The knowledge instrument consisted of 35 statements distributed across three domains: transfusion care, adherence to safety practices, and transfusion

reactions. Responses were dichotomous ("correct" or "incorrect"). The use of dichotomous questions was chosen because it facilitates understanding and application in studies with a large number of participants, in addition to allowing objective score analysis.

For score calculation, each correct answer received 1 point and each incorrect answer received 0, resulting in a total score ranging from 0 to 35 points. The internal consistency of the instrument was assessed using the Kuder–Richardson 20 coefficient (KR-20), yielding a value of 0.91, which indicates high reliability.

Data analysis

Data were organized in an electronic spreadsheet (Microsoft Excel®) and subsequently analyzed using SPSS software, version 28.0. Initially, a descriptive analysis of the variables was performed, presenting absolute and relative frequencies for categorical variables and measures of central tendency and dispersion (mean and standard deviation) for continuous variables.

For inferential analysis, Pearson's Chi-square test was used to verify the relationship between the independent variables and the level of knowledge. The magnitude of this relationship was estimated using the odds ratio, with the respective 95% confidence intervals.

A statistical significance level of 5% ($p < 0.05$) was adopted. The choice of bivariate analysis was based on the distribution of the variables and the limitations in fitting multivariable models, ensuring greater robustness and stability of the estimates obtained.

Ethical aspects

The study was approved by the Research Ethics Committee of the Federal University of Maranhão, under opinion no. 7,417,274/2025, Certificate of Presentation for Ethical Consideration: 86612825.3.0000.0309. All participants were informed about the objectives and procedures of the study

and signed the Informed Consent Form, in accordance with the guidelines.

Results

The sample in this study consisted of 165 undergraduate nursing students, with a predominance of females (77.6%) and a mean age of 22.81 ± 3.32 years. Most participants were younger than 25 years (75.8%), were single (83.6%), and had a monthly income of up to one minimum wage or no income (58.2%). A greater concentration of students was observed in the more advanced semesters of the program (>5th semester), corresponding to 62.4% of the sample. Only 17.6% reported having technical nursing training, and 96.4% stated that they had not participated in specific training on blood transfusion.

Table 1 – Sociodemographic characteristics of the participants. Imperatriz, MA, Brazil, 2025

Variables	n (%)
Age (Mean $\pm$ Standard deviation: 22.81 ± 3.32)	
<25	125 (75.8)
≥ 25	40 (24.2)
Sex	
Female	128 (77.6)
Male	37 (22.4)
Marital status	
Single	138 (83.6)
Married/Common-law union/Divorced/Widowed	27 (16.4)
Monthly income* (minimum wage)	
Up to 1	96 (58.2)
1–2	52 (31.5)
>2	17 (10.3)
Semester	
$\leq 5^o$	62 (37.6)
>5 ^o	103 (62.4)
Place of residence in relation to the university	
Nearby neighborhoods	72 (43.6)
Distant neighborhoods	58 (35.2)
Neighboring regions/inland areas	35 (21.2)
Study time outside the classroom (hours/day)	
Up to 1	91 (55.2)
2–4	60 (36.4)
>4	14 (8.5)

(the Table 1 continue...)

Variables	n (%)
Study time outside the classroom (hours/day)	
Up to 1	91 (55.2)
2–4	60 (36.4)
>4	14 (8.5)
Had a class on blood transfusion	
Yes	32 (19.4)
No	133 (80.6)
Has technical nursing training	
Yes	29 (17.6)
No	136 (82.4)
Training in blood transfusion	
Yes	6 (3.6)
No	159 (96.4)

*Current minimum wage: R\$1.518,00

In the domain of blood transfusion care, a high frequency of correct answers was observed in both groups, especially for items related to hand hygiene, use of personal protective equipment, double-checking of data, conduct in the event of a transfusion reaction, and the maximum infusion time of up to 4 hours, all of which showed a minimal occurrence of incorrect responses. In contrast, items requiring greater clinical judgment showed a lower proportion of correct answers, such as identity verification by only one professional, monitoring restricted to the start of the transfusion, observation limited to the first 10 minutes, the use of a large-bore catheter, and medication administration through the same venous access, highlighting gaps in knowledge related to transfusion safety.

In the domain of adherence to safety practices and transfusion reactions, a high percentage of correct answers was maintained for the essential items, especially double-checking, hand hygiene, use of personal protective equipment, continuous monitoring, reporting of reactions, verification of blood components, recording of vital signs, and traceability. However, greater variability was observed in specific aspects, such as identity verification by a single professional, the use of a small-bore catheter, a maximum infusion time of 6 hours, donor selection, and the use of an exclusive administration set with a filter, indicating specific weaknesses, particularly among students in the earlier semesters (Table 2).

Table 2 – Questionnaire items with correct and incorrect answers from nursing students on blood transfusion. Imperatriz, MA, Brazil, 2025

Variables	≤ 5 ^o semester		> 5 ^o semester	
	Correct n (%)	Incorrect n (%)	Correct n (%)	Incorrect n (%)
Blood transfusion care				
Hand hygiene is one of the key practices for patient safety prior to a blood transfusion.	62 (100.0)	0 (0)	101 (98.0)	2 (2.0)
Before the transfusion, the patient's identity may be verified by a single healthcare professional.	36 (58.0)	26 (42.0)	72 (70.0)	31 (30.0)
The nursing staff must wear personal protective equipment during the transfusion procedure.	62 (100.0)	0 (0)	103 (100.0)	0 (0)
The patient's vital signs should be monitored only once, at the start of the transfusion.	57 (91.9)	5 (8.1)	98 (95.1)	5 (4.9)
In the event of a transfusion reaction, the transfusion should be stopped immediately and the physician notified.	62 (100)	0 (0)	103 (100.0)	0 (0)
The double-check should involve verifying the patient's name and the blood bag's identification.	62 (100.0)	0 (0)	101 (98.0)	2 (2.0)
The nurse should monitor the patient only during the first 10 minutes after the transfusion begins.	39 (62.9)	23 (37.1)	78 (75.7)	25 (24.3)
Venous access for transfusion should be established using a large-bore catheter.	49 (79)	13 (21)	91 (88.3)	12 (11.7)
Medications should be administered through the same intravenous line used for transfusions.	57 (91.9)	5 (8.1)	97 (94.2)	6 (5.8)
The maximum duration of a blood transfusion should not exceed 4 hours.	62 (100.0)	0 (0)	103 (100.0)	0 (0)
Compliance with safety practices				
Adherence to the double-checking of patient data is essential to ensuring transfusion safety.	62 (100.0)	0 (0)	103 (100.0)	0 (0)
Hand hygiene performed before a transfusion procedure prevents healthcare-associated infections.	62 (100.0)	0 (0)	103 (100.0)	0 (0)
Personal protective equipment must be worn throughout the entire transfusion process.	62 (100.0)	0 (0)	103 (100.0)	0 (0)
Monitoring the patient's vital signs before, during, and after the transfusion is essential for the early detection of reactions.	62 (100.0)	0 (0)	103 (100.0)	0 (0)
Patient identification can be verified by a single healthcare professional to ensure security.	41 (61.6)	21 (33.9)	84 (81.6)	19 (18.4)
The use of small-bore catheters may be appropriate without compromising the effectiveness of the transfusion.	44 (71.0)	18 (29.0)	82 (79.6)	21 (20.4)
Informing the patient and their family about the benefits and possible transfusion reactions is part of providing safe care.	62 (100.0)	0 (0)	103 (100)	0 (0)
The maximum duration of a blood transfusion should be limited to 6 hours.	48 (77.4)	16 (22.6)	87 (84.5)	16 (15.5)
In the event of a transfusion reaction, the transfusion must be stopped immediately and the bag returned to the blood bank for analysis.	62 (100.0)	0 (0)	103 (100)	0 (0)
Medications can be administered through the same intravenous line used for transfusions, provided it is compatible.	43 (69.4)	19 (30.6)	81 (78.6)	22 (21.4)
Transfusion reactions				
An immediate transfusion reaction occurs during or up to 24 hours after the transfusion.	59 (95.1)	3 (4.9)	99 (96.1)	4 (3.9)
A delayed transfusion reaction occurs more than 24 hours after the transfusion.	59 (95.1)	3 (4.9)	101 (98)	2 (2)
The healthcare professional should monitor patients and report any adverse reactions immediately.	62 (100)	0 (0)	102 (99)	1 (1)
Donation candidates do not need to undergo a preliminary screening.	47 (75.8)	15 (24.2)	87 (84.4)	16 (15.6)
It is mandatory to verify that the blood product matches the recipient's information prior to the procedure.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
It is mandatory to check and record vital signs at the time of transfusion.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
Check vital signs 10 minutes after the transfusion has been started.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
Note the start time of the transfusion after receiving the blood product.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
Proper venous access does not require a dedicated filter-equipped device.	62 (100.0)	62 (100.0)	88 (85.4)	15 (14.6)
Check the label, expiration date, visual inspection, and temperature of the bag before transfusion.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
Stop the transfusion and notify a doctor if a reaction occurs.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
Check the patency of the puncture site and the catheter size before the transfusion.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
The maximum infusion time should not exceed 4 hours.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
Stapling the bag labels to the front of the checklist is recommended for traceability.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)
In the event of a complication involving a miscarriage, the pregnancy must be referred for evaluation.	62 (100.0)	0 (0)	102 (99.0)	1 (1.0)

When the total knowledge score on blood transfusion was dichotomized based on a 50% correct-answer cutoff, inadequate knowledge predominated, being identified in 110 (66.7%) students, whereas 55 (33.3%) were classified as having adequate knowledge. These findings indicate that, in light of this cutoff point, most participants did not achieve the minimum satisfactory performance on the instrument applied.

It was observed that, despite the high percentages of correct answers on specific items of the instrument, especially those related to standardized safety practices, the overall knowledge score was predominantly classified as inadequate. This finding may be explained by the distribution of errors across the different items, including those considered critical in the transfusion process. Considering that the final score results from the sum of all responses, the occurrence of errors across multiple items, even when not individually predominant, negatively affected the participants' overall performance.

In the bivariate analysis, a significant relationship was observed between adequate knowledge and academic semester ($p=0.040$), with students in more advanced semesters being twice as likely to present adequate knowledge ($OR=2.00$; 95% CI 1.01–3.96). Likewise, technical nursing training was positively associated with the outcome ($OR=2.00$; 95% CI 1.02–3.91; $p=0.040$). The other variables did not show a statistically significant relationship (Table 3).

Table 3 – Factors related to adequate knowledge of blood transfusion. Imperatriz, MA, Brazil, 2025

Variables	Appropriate n (%)	Inappropriate n (%)	OR (CI95%)	p-value*
Sex				
Female	43 (36.7)	85 (63.3)	1.00	–
Male	12 (26.8)	25 (73.2)	0.63 (0.31–1.28)	0.190
Semester				
≤5 ^a	15 (24.2)	47 (75.8)	1.00	–
>5 ^a	40 (38.8)	63 (61.2)	2.00 (1.01–3.96)	0.040
Nursing Technician				
No	38 (28.3)	98 (71.7)	1.00	–
Yes	17 (44.2)	12 (55.8)	2.00 (1.02–3.91)	0.040
Training in blood transfusion				
No	53 (33.3)	106 (66.7)	1.00	–
Yes	2 (33.3)	4 (66.7)	1.00 (0.17–5.74)	1.000
Age (years)				
< 25	35 (36.5)	61 (63.5)	1.00	–
≥25	20 (29.0)	49 (71.0)	0.71 (0.36–1.38)	0.300

*Pearson's Chi-square test; OR: Odds Ratio; CI: Confidence Interval

Discussion

This study assessed nursing students' knowledge of blood transfusion and related factors. Inadequate knowledge and inconsistent performance were prevalent, with greater proficiency in standardized safety practices and weaknesses in critical stages of the transfusion process, such as patient identification, clinical monitoring, and venous access management— aspects directly related to patient safety. Furthermore, adequate knowledge was related to the semester level and technical training, highlighting the influence of experience on the consolidation of transfusion competencies. Although this finding reinforces evidence previously described⁽¹⁰⁾, it is important to note that the classification of knowledge based on a 50% cutoff point should be interpreted with caution, since this criterion, although widely used, may oversimplify the complexity of the construct being assessed and fail to capture intermediate levels of knowledge.

Regarding the students' profile, a predominance of female students and young individuals was observed, a pattern frequently described in nursing education both nationally and internationally⁽¹²⁻¹³⁾. Although most participants were in advanced semesters, the findings revealed gaps in their knowledge of blood transfusion. The high percentage of students who had never participated in specific training in this area and who had not had access to content related to the topic during their undergraduate studies indicates the existence of gaps in their education, which could compromise patient safety and the quality of care provided.

When analyzing the different areas of knowledge, a mixed performance was observed among the students. There was a high percentage of correct answers regarding fundamental safety practices, such as hand hygiene, use of personal protective equipment, and double-checking, indicating mastery of protocol-based content. However, weaknesses persist in more complex stages of the transfusion process, which require greater attention and clinical judgment⁽¹⁴⁾. Such evidence has been obtained through structured instru-

ments, based on questionnaires that assess knowledge at the different stages of the transfusion process⁽¹⁵⁾. This pattern suggests that teaching has prioritized the reproduction of protocol-based practices, which may not adequately foster the development of the clinical reasoning necessary for decision-making in complex situations of transfusion practice.

It was found that the highest rates of errors were concentrated in steps that require clinical judgment and attention to technical parameters of blood transfusion, including patient identification, monitoring of vital signs, observation time, maximum infusion rate, and the administration of medications through the same venous access, consistent with studies highlighting similar critical points in clinical practice⁽¹⁶⁻¹⁷⁾. These findings indicate the persistence of weaknesses in critical stages of the transfusion process, such that mastery of these competencies requires not only knowledge of care protocols but also a stronger connection between technical training, clinical reasoning, and supervised practice⁽¹⁸⁻¹⁹⁾.

A predominance of inadequate knowledge regarding blood transfusion was observed among nursing students, highlighting weaknesses in the educational process related to blood transfusion, exacerbated by a lack of structured teaching strategies and a limited supply of theoretical content and specific training. This finding supports the evidence that the low frequency of transfusion reactions acts as a limiting factor in students' practical experience in recognizing and managing these situations⁽²⁰⁾. It is worth noting that the integration of theoretical instruction and clinical simulation contributes to the enhancement of knowledge and decision-making in these contexts⁽²¹⁻²²⁾.

In the bivariate analysis, academic progress during the semester and technical training in nursing were significantly associated with a higher level of knowledge, indicating that progressive exposure to content and clinical practice contributes to the consolidation of transfusion competencies. This result reinforces that learning in hemotherapy is not limited

to theoretical instruction but depends on practical experience and exposure to real clinical situations, consistent with studies demonstrating better performance among students with greater academic experience and prior training in the field. This pattern is also described in the literature, both among students and among professionals in the early stages of their academic or professional careers⁽²³⁻²⁴⁾. However, the exclusive use of bivariate analysis limits the ability to control for confounding factors, which prevents the identification of independent associations between variables; therefore, these results should be interpreted with caution.

Among nurses, much like undergraduate students, knowledge of blood transfusion has been predominantly rated as low or moderate, with gaps in critical stages of the process⁽¹⁰⁾. Notable deficits include knowledge regarding the time required for collection and transport of blood components, monitoring of vital signs, and management of adverse transfusion reactions⁽²⁵⁾. Furthermore, factors such as professional experience, access to protocols and guidelines, and participation in training are associated with higher levels of knowledge⁽²⁶⁾.

Despite the gaps identified, the findings demonstrate a greater consolidation of knowledge regarding standardized care steps, particularly the adoption of safe practices in the transfusion process, which follow widely established protocols⁽²⁷⁾. This result is consistent with the literature in indicating that transfusion safety relies on the implementation of structured care, systematic verification of the procedure, and continuous training of teams—key elements for the prevention of errors and adverse events^(11,28).

Thus, the findings of this study reinforce the fact that, although students demonstrate mastery of basic safety practices, significant gaps persist in critical aspects of the transfusion process. This points to the need to review and improve teaching strategies, with greater integration between theory and practice, with the aim of training professionals who are better prepared to work safely in transfusion therapy. There-

fore, rather than merely highlighting gaps, this study points to the need to reorient nursing education strategies, with a focus on developing clinical competencies critical to transfusion safety.

Study limitations

However, some limitations should be noted. Although the study made it possible to identify students' level of knowledge regarding blood transfusion, it did not delve deeper into the assessment of clinical practices or how this knowledge is applied in real-world care settings, which limits our understanding of the relationship between theoretical knowledge and practical performance in the context of blood transfusion. Furthermore, because this was a cross-sectional study, it was not possible to track changes in knowledge over time.

The fact that the study was conducted at a single institution also limits the generalizability of the findings to other educational contexts. Additionally, the absence of multivariate analysis limits the identification of the independent effect of factors associated with knowledge, as it is not possible to control for potential confounding variables. Added to this is the possibility of biases inherent in the use of a self-administered instrument, such as the interpretation of questions and the potential consultation of external sources while completing the questionnaire, in addition to possible social desirability bias, since participants may have responded according to what they consider most appropriate or expected. In this regard, there is a clear need for longitudinal, multicenter studies with experimental designs that assess knowledge on the subject and further explore the relationship with clinical practice and transfusion safety.

Contributions to practice

The findings of this study highlight gaps in nursing students' knowledge regarding critical stages of blood transfusion, particularly patient identification,

vital sign monitoring, observation time, and venous access management—aspects directly related to patient safety.

In practice, the results point to the need to strengthen education on blood transfusion, with an emphasis on critical content and greater integration between theory and practice, through active learning methods and simulated training. Furthermore, the relationship between greater knowledge and academic progress in the semester, as well as technical training, reinforces the importance of progressive educational strategies throughout the undergraduate program, contributing to the development of professionals who are better prepared for safe transfusion practice.

Conclusion

The study revealed a prevalence of inadequate knowledge regarding blood transfusion among nursing students, with greater proficiency in standardized safety protocols but weaknesses in critical stages of the transfusion process, particularly those related to patient identification, clinical monitoring, observation time, and venous access management.

It was also observed that higher levels of knowledge were associated with the students' progress through the semester and their technical nursing training, indicating that progressive exposure to content and practice contributes to the consolidation of transfusion competencies. Taken together, these findings reinforce the need to strengthen educational strategies targeting the identified critical points, with greater integration between theory and practice, aiming to train professionals who are better prepared for safe transfusion practice.

Authors' contributions

Conception and design or data analysis and interpretation: **Oliveira JS, Soares FMM**. Drafting of the manuscript or significant critical revision of the intellectual content: **Oliveira JS, Sousa KAV, Conceição BS**,

Borges AR, Rodrigues ABFL, Santos MIT, Soares FMM. Final approval of the version to be published and agreement to be responsible for all aspects of the manuscript related to the accuracy or integrity of any part, ensuring that any issues are properly investigated and resolved: **Soares FMM.**

Data availability

The authors state that all datasets are available in the body of the article.

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