

The Effectiveness of Safe Blood and Blood Products Transfusion Training for Intensive Care Nurses

Yoğun Bakım Hemşirelerine Verilen Güvenli Kan ve Kan Ürünleri Transfüzyonu Eğitiminin Hemşirelerin Bilgi Düzeylerine Etkisi

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Abstract

Objective: Nurses play an essential role in blood transfusion, and more than half of the steps in the transfusion chain are dependent on the nurses' knowledge, awareness, and skills. This study was conducted to determine the effect of safe blood and blood products transfusion training on the knowledge of nurses in the intensive care unit (ICU).

Method: This quasi-experimental pretest-posttest designed research was conducted with (n=166) voluntary ICU nurses. Apretest evaluated the knowledge of nurses on blood and blood product transfusion. Then, a training was provided to nurses and pop-up informative screen messages were sent via the hospital information system each time when they sign in the system. A posttest was performed one month after the completion of the blood and blood products transfusion training. $P < .05$ was accepted as statically significant.

Results: It was found that 48.8% of the intensive care nurses participating in the study were between 21-25 years old, 62.7% were women, 52.4% were bachelor's degree graduates, and 56.0% of them had 1-5 years of experience. Mean blood and blood products transfusion knowledge score of the nurses was 60.25±8.92 before intervention and it increased to 78.17±8.19 after the intervention, which was statistically significant ($P < .001$).

Conclusion: It is found that blood and blood products transfusion knowledge of nurses was increased with the training and messages sent on hospital information system. It is recommended that in-service training programs in line with up-to-date guidelines on blood and blood products transfusion should be provided to nurses, practice should be observed after the training, and blood transfusion boards at the institutions should be facilitated for efficiency.

Keywords: Blood transfusion, intensive care, knowledge, nursing, training

Öz

Amaç: Hemşireler kan transfüzyonunda önemli bir rol oynamaktadır; transfüzyon zincirinin yarısından fazlası onların bilgi, farkındalık ve becerilerine bağlıdır. Bu çalışma, güvenli kan ve kan ürünleri transfüzyonu konusundaki eğitimin, yoğun bakım ünitesinde çalışan hemşirelerin bilgi düzeylerine etkisini değerlendirmeyi amaçlamıştır.

Yöntem: Bu yarı deneysel ön test-son test çalışması, gönüllü olarak katılan 166 yoğun bakım hemşiresini içermektedir. İlk olarak, hemşirelerin kan ve kan ürünleri transfüzyonu konusundaki bilgi düzeylerini değerlendiren bir ön test yapılmıştır. Daha sonra hemşirelere eğitim verilmiş ve hastane bilgi sistemi üzerinden her girişlerinde bilgilendirici ekran mesajları gönderilmiştir. Eğitimden bir ay sonra bir son test yapılmıştır. İstatistiksel anlamlılık $P < .05$ olarak belirlenmiştir.

Bulgular: Çalışmaya katılan yoğun bakım hemşirelerinin %48,8'i 21-25 yaş aralığında, %62,7'si kadındır, %52,4'ü lisans mezunu ve %56,0'ı 1-5 yıl deneyime sahiptir. Hemşirelerin kan ve kan ürünleri transfüzyonu bilgi puan ortalaması müdahale öncesi 60,25±8,92 iken müdahale sonrası 78,17±8,19 olarak bulunmuş ve aradaki fark istatistiksel olarak anlamlı bulunmuştur ($P < .001$).

Sonuç: Çalışma, eğitim ve hastane bilgi sistemi üzerinden gönderilen mesajların uygulanmasıyla hemşirelerin kan ve kan ürünleri transfüzyonu bilgi düzeyinin anlamlı şekilde arttığını ortaya koymuştur. Çalışma, kurumlarında güncel kılavuzlara uygun iç eğitim programları sağlanması, eğitim sonrası uygulama adımlarının takibi ve sağlık kurumlarında transfüzyon komitelerinin etkin işleyişinin teşvik edilmesi gerektiğini önermektedir.

Anahtar Kelimeler: Bilgi düzeyi, eğitim, hemşirelik, kan transfüzyonu, yoğun bakım

INTRODUCTION

The worldwide need for blood and blood products is increasing. As a result of the increase in demand, minimizing the errors in all of the phases in supplying blood and blood products and transfusion became a crucial pillar of maintaining patient safety.¹

Blood transfusion is considered a form of tissue transplantation.^{1,2} Therefore, unlike other treatment interventions, it necessitates specific controls during unique confirmation steps, as well as careful observation throughout the transfusion process and related practices. Otherwise, it can lead to serious reactions threatening the life of the patient.^{3,4} Developing checklists for the clinical transfusion process and patient safety for safe blood transfusion (SBT) practices is of vital importance in hospitals.⁵

Blood transfusion is a frequent practice among patients in the intensive care unit (ICU). In 2021 alone, over 1.7 million units of red blood cell were administered in critical care settings across the United States.⁶ In spite of the clinical benefits of blood transfusion, there is the possibility of error at any stage of the transfusion process, which can cause serious and dangerous complications in the patient. Nurses play a major role in this process, and more than half of the chain of blood transfusion depends on nursing practice.^{6,7}

To execute a safe blood and blood product transfusion, nurses, who are practitioner, should be equipped with sufficient knowledge and skills. During the transfusion, nurses equipped with knowledge and skills in giving the right blood to the right patient, properly informing the patient about the transfusion, keeping the blood in proper conditions, observing the patient for possible signs of unintended reactions, preventing potential complications and interventions for emerging complications may contribute to decreasing mortality and morbidity rates.³⁻⁵ Insufficient knowledge and skills, insufficient interpersonal communication within the treatment team, and lack of attention are reported to be principal factors that endanger the safety of the transfusion.⁸⁻¹⁰

Background

Complications that may emerge during blood transfusion range from minimal complications that do not bare life risk to critical lethal reactions that may cause death with highly reported mortality and morbidity rates.¹¹⁻¹⁵ In the United Kingdom 1359 blood transfusion errors were reported in 2017 and 1451 errors in 2018. Twenty-three error cases were inspected and 12 of them were found to be associated with improper cold chain management, 2 of them were found to be associated with the duration of the transfusion, 2 of them were found to be associated with labeling errors, and 5 of them were found to be associated with miscellaneous storage and usage errors.¹⁴

Nurses having insufficient knowledge before blood transfusion training are reported in a study by Şahin.¹¹ Also, healthcare professionals are reported not to have enough up-to-date knowledge on blood and blood product transfusion.^{10,12} For instance, in a study conducted in the emergency service surgery clinic and internal diseases clinic, interventions of nurses observed and found that nearly half of the nurses did not wash their hands before blood transfusion, one-quarter of nurses did not use gloves before transfusion, did not inform the patient or the companion about blood transfusion and did not check the blood order form.⁴ These studies point out that nurses do not have sufficient knowledge of SBT practices and they do not pay attention to principles of SBT practices. In a recent study in the literature, it is shown that ICU nurses have a moderate or low level of knowledge regarding transfusions. Additionally, there is a significant deficiency in knowledge regarding the procedures for labeling blood sample tubes, determining transfusion flow rates, replacing transfusion administration sets, and observing and managing transfusion reactions. Nurses with higher levels of education have been found to have significantly better knowledge, highlighting the importance of continuous education for ICU nurses.¹⁶ In another study, while the overall practice score of ICU nurses regarding blood transfusion guidelines was satisfactory, their practice levels concerning blood transfusion requests and documentation of the transfusion process were found to be inadequate. Therefore, it has been highlighted that periodic refresher training sessions are needed for critical care nurses on updated blood transfusion guidelines, with a specific focus on checking blood requests

and documenting transfusions. These trainings are expected to enhance nurses' practices, optimize patient safety, and reduce blood transfusion-related complications in ICUs.¹⁷

In light of this information, looking closely at the outcomes of blood transfusion practices, particularly the high mortality and morbidity rates, knowledge of ICU nurses on blood transfusion and their practical skills need to be supported and promoted by training with up-to-date information on blood and blood products transfusion.^{10,11,13}

Nurses, performing the transfusion, and having up-to-date information on safe blood and blood product transfusion would accomplish a successful and safe transfusion, while performing evidence-based interventions would contribute to decreasing mortality and morbidity associated with unsafe transfusion practices.

Aims

This study aims to evaluate the effectiveness of planned training on safe blood and blood products transfusion and to make a significant contribution to clinical practice.

H₀: Training on safe blood and blood products transfusion do not have any positive effect on knowledge of ICU nurses.

H₁: Training on safe blood and blood products transfusion have effect on knowledge of ICU nurses.

METHODS

Study Design: This study was conducted as a pretest-posttest style quasi-experimental study at a Kahramanmaraş Sütçü Imam University Training and Research Hospital. The bed capacity of the hospital was 747 beds and there were 483 nurses, employed at the hospital. The hospital had 169 ICU beds and 197 nurses were working at ICUs.

Sample of the Research: The universe of the study is comprised of 197 ICU nurses working at internal medicine, surgical and pediatric ICUs in the hospital. Twelve nurses who did not volunteer to participate in the study and 19 nurses who were absent on the day of training, totally 31 nurses, were not enrolled in the study. The pretest was completed in July-August 2019 and the posttest was completed in October-November 2019 by 166 nurses.

Safe blood and blood products transfusion training: A guideline as training materials were created in line with the up-to-date information in the literature.^{5,8-13,18-25} The dates, duration and content of the training were coordinated with the director of nursing care services, nurse educator coordinator, nurse educators, ICU supervisor nurses, responsible physicians of blood bank and ICUs at the hospital.

Training face-to-face

The participating nurses were provided in three sessions classes in the hospital meeting room with an hour long training in. Training included the 1st Part (Content, volume, reactions, storage conditions, and features of blood and blood products)^{5,8-10} and the 2nd part (blood and blood product transfusion evidence-based practices).^{10-13,20-26,29} During the training verbal lecture with slide presentation and interactive training with questions and answers methods were used. Also, the equipment and materials used in transfusion (infusion pump, transfusion set, blood and blood products) were demonstrated during the presentation. Training materials prepared by the researchers were delivered to participants during and after the training. It was left as a guideline and the presentations to the clinics after the training and uploaded to the common nursing service areas of the clinic computers.

Training with pop-up informative screen messages

During the month following the training, short statements about safe blood transfusion were uploaded to the hospital information system as pop-up informative screen messages created by the researchers. The messages were arranged in accordance with the topics covered in the face-to-face training and the questions that were answered incorrectly in the pre-test. Nurses were not able skip the pop-up informative screen message without

clicking the read button each time when they signed in the hospital information system with their unique password. Some of the pop-up informative screen messages were as follows;

“Transfusion set and the needle for transfusion should not be used more than 4 hours!”

“Intravenous access of the patient for whom blood or blood product transfusion is planned should be ready before blood/blood product is delivered to the clinic!”

“The only blood product that can be kept at room temperature is thrombocyte suspensions!”

“Transfusion of plasma products must be A,B,O blood groups compatible. No Cross Match or Rh compatibility required”

“In case of an emerging reaction during the transfusion, first stop the transfusion and keep the intravenous access open!”

Data collection: Data collection form developed by the researchers in line with the literature.^{3,5,8,11,20-23} Nurses descriptive information form had questions for gender, age, education, total experience, ICU experience, having SBT training, etc. The questionnaire used to assess nurses' knowledge of blood transfusion consisted of a total of 40 questions. First part of the training evaluation questionnaire had 20 questions for knowledge of nurses on blood and blood products (content, volume, reactions, storage conditions and other features of blood and blood products). The second part of the training evaluation questionnaire had 20 questions for the practices of participants (verbal order, confirmation of patient information, catheter choice, blood transfusion, usage of leucocyte filter, blood transfusion rate and duration, safety of blood in the blood bank, etc.).²⁴⁻³⁰ For first part of 20 questions for nurses' knowledge of nurses on blood and blood products had 4 options (1 correct and 3 wrong answers), while the second part of 20 questions had 2 options (true/false). For scoring, each of the 40 answers counted 2,5 points with a maximum score of 100 points. In preparation of the data collection form, the drafts were sent to 5 subject experts for review but it still cannot be defined as a scale or a formal inventory.

Before using the questionnaire, it was evaluated with expert opinions from three academic nurses, and one physician from blood transfusion board of hospital. The feedback received was used to revise and refine the questionnaire. Also before starting the study, to test the understandability of the data collection form, it was delivered to 10 nurses working at the internal medicine department, where blood and blood products are often used and a nurse working at hemovigilance, training and blood transfusion board of the hospital. The data collection form was tailored according to the feedback. Pre-test and Post-test was delivered to volunteering ICU nurses in a face-to-face interview by the researchers at their shift time. Completing the pretest took 15-20 minutes. For avoiding the interaction among nurses and misdirection of answers, each interview was performed face-to-face and one-by-one.

Data analysis: Statistical analysis of the data was conducted by IBM SPSS for Windows 22.0 (IBM SPSS Corp., Armonk, NY, USA) software. The responses of the ICU nurses for the descriptive questions in the first part of the data collection form were independent variables of the study. Dependent variable of the study was mean score of blood transfusion knowledge of ICU nurses. The normality of the variables was tested with the *Shapiro-Wilk* test. *Paired sample t test* and *Wilcoxon* test were used for the pretest-posttest comparison. For evaluating the difference among groups *Mann Whitney U test*, *Kruskal Wallis test*, *One-Way ANOVA* and *post hoc-Tamhane t2 test* were used. $P < ,05$ was accepted as statistically significant.

Ethical principles of the study: Before start of the study local ethical board approval was obtained (Hasan Kalyoncu University. Date: 14.06.2019, no: 2019/46). Also, official approval was provided by the institution in which the study was conducted. ICU nurses within the universe of the study were informed about the aim of the study and they signed the informed consent form after giving the verbal consent.

RESULTS

The mean age of nurses participating in the study was 26.83 ± 3.85 years, 48.8% of them were 21-25 years of age, 62.7% of them were female, 53.6% of them were married, 52.4% of them had bachelor's degree and 56% of them had 1-5 years of professional experience. The majority of the participants (80.1%) had 1-5 years of ICU experience, 19.3% of them were working in neonatal ICU, 81.3% of them did not have ICU nursing certificate, 53.6% of them had previous transfusion training, 24.1% of them were given transfusion training within 0-6 months, 50% of them perceived their knowledge on transfusion as good. It was also reported that 69.3% of them had seen a transfusion reaction in the ICU, 81.9% had not experienced a transfusion reaction during a procedure they performed, and 91% checked the expiry date of the blood product each and every time. (Table 1).

Table 1. Distribution of sociodemographic and professional features of ICU nurses (n= 166)

Characteristics	n	%	Mean±SD
1. Age	21-25 years	81	48.8
	26-30 years	55	33.1
	31-35 years	25	15.1
	36-39 years	5	3
			26.83±3.853
2. Gender	Female	104	62.7
	Male	62	37.3
3. Marital Status	Married	89	53.6
	Single	77	46.4
4. Education	High School	48	28.9
	Vocational School	20	12
	Bachelor's Degree	87	52.4
	Postgraduate Degree	11	6.6
5. Professional Experience (years)	1-5 years	93	56
	6-10 years	63	38
	11-15 years	9	5.4
	.16-20 years	1	0,6
			5.42±3.016
6. ICU Experience (years)	1-5 years	133	80.1
	6-10 years	27	16.3
	11 years and more	6	3.6
			3.9±2.695
7. Intensive Care Unit	Internal Medicine	19	11.4
	Pulmonary Diseases	14	8.4
	Neurology	12	7.2
	General Surgery	9	5.4
	Anesthesiology	24	14.5
	Neonatal	32	19.3
	Pediatric	16	9.6
	Cardiology	18	10.8
	Obstetrics and Gynecology	6	3.6
	Cardiovascular Surgery	6	3.6
Neurosurgery	10	6	
8. Intensive Care Nursing Certificate	Yes	31	18.7
	No	135	81.3
9. SBT training	Yes	89	53.6
	No	77	46.4
10. Date of previous SBT training (n=89)	0-6 months	40	24.1
	7-12 months	14	8.4

	13-24 months	21	12.7
	24 months and more	14	8.4
11. Self-perception of knowledge on transfusion	Good	83	50
	Moderate	80	48.2
	Poor	3	1.8
12. Witnessing a transfusion reaction in ICU	Yes	51	30.7
	No	115	69.3
13. Experiencing a transfusion reaction	Yes	30	18.1
	No	136	81.9
14. Checking the expiry date of the blood product	Always	151	91
	Sometimes	13	7.8
	No need to check	2	1.2

Before the training, there was no statistically significant difference in the mean knowledge scores when comparing groups based on education level, age, professional experience, and whether they had an ICU nursing certificate (respectively; $P = .30$, $P = .292$, $P = .882$, $P = .61$) (Table 2).

Table 2. Comparison of Mean Pretest Scores According to Descriptive Features (n=166)

	Mean±SD	Max.	Min.	IQR	Median	Test (z. χ^2) P
Education						
High School-Vocational School (n=68)	59.15±8.63	80	37.5	12.5	60	z=-1.036 P = .300
Bachelor's-Postgraduate Degree (n=98)	61.02±9.08	80	37.5	13.13	60	
Age						
21-30 years (n=81)	59.41±9.07	80	37.5	13.75	60	z=-1.055 P = .292
31 years and more (n=85)	61.05±8.75	80	45	12.5	60	
Professional experience (years)						
1-5 years (n=93)	60.24±8.52	80	37.5	10	60	z=-.149 P = .882
6 years and more (n=73)	60.27±9.47	80	37.5	15	60	
Intensive Care Nursing Certificate						
Yes (n=31)	60.48±7.56	72.5	42.5	7.5	60	z=-.510 P = .61
No (n=135)	60.2±9.23	80	37.5	15	60	
Intensive Care Unit						
Internal Medicine Sciences ICUs (n=45)	61.88 ±8.15	80	45	8.75	60	$\chi^2=2.569$ P = .277
Surgical Sciences ICUs (n=73)	60.13±8.3	75	37.5	11.25	60	
Pediatric Sciences ICUs (n:48)	58.9±10.1	80	37.5	16.88	57.5	
ICU Experience (years)						
1-5 years (n=133)	60.5±9.17	80	37.5	15	60	z=-.575 P = .565
6 years and more (n=33)	59.24±7.86	77.5	42.5	11.25	60	

Each correct response counted for 2.5 points. Z=Mann Whitney U Test; χ^2 =Kruskal Wallis Test. $p<0.05$ accepted as statistically significant.

There was a statistically significant difference in comparison of after training mean knowledge scores according to the ICUs in which the participants work. After training mean knowledge score of nurses working in internal medicine ICUs was 77.77 ± 8.36 while it was 76.74 ± 7.65 in surgical ICUs and 80.72 ± 8.41 in pediatric ICUs. The statistically significant difference was among nurses working in surgical ICUs and pediatric ICUs after the training ($P = .029$) (Table 3).

Table 3. Comparison of mean posttest scores according to descriptive characteristics

	Mean \pm SD	Max.	Min.	IQR	Median	Test (z, χ^2) P
Education						
High School-Vocational School (n=68)	77.68 \pm 7.68	95	55	10	77.5	z= -.737
Bachelor's–Postgraduate Degree (n=98)	78.52 \pm 8.56	95	55	12.5	78.75	P = .461
Age						
21-30 years (n=81)	77.71 \pm 7.24	92.5	55	10	77.5	z= -.805
31 years and more (n=85)	78.61 \pm 9.03	95	55	9.03	80	P = .421
Intensive Care Nursing Certificate						
Yes (n=31)	78.79 \pm 8.48	95	62.5	15	77.5	z= -.385
No (n=135)	78.03 \pm 8.15	95	55	12.5	80	P = .7
Intensive Care Units						
Internal Medicine Sciences ICUs (n=45)	77.77 \pm 8.36	92.5	55	12.5	80	$\chi^2=6.714$ P = .035*
Surgical Sciences ICUs (n=73)	76.74 \pm 7.65	90	57.5	12.5	77.5	
Pediatric Sciences ICUs (n=48)	80.72 \pm 8.41	95	55	12.5	80	
Professional experience (years)						
1-5 years (n=93)	77.09 \pm 8.01	92.5	55	10	77.5	z= -1.923
6 years and more (n=73)	79.55 \pm 8.27	95	57.5	12.5	80	P = .540
ICU Experience (years)						
1-5 years (n=133)	77.7 \pm 8.23	95	55	12.5	77.5	z= -1.427
6 years and more (n=33)	80.07 \pm 7.89	95	67.5	13.75	82.5	P = .154

Each correct response counted for 2.5 points, Z=Mann Whitney U Test; χ^2 =Kruskal Wallis Test, P <0.05 accepted as statistically significant.

The leading three items to which ICU nurses responded correctly before the training was “There is no need to wash hands before blood transfusion” (96.4% responded as wrong), “The most common and the most important sign and symptom associated with acute hemolytic transfusion reaction are fever and trembling” (n=149, 89.8% responded as correct) and “Hypothermia may emerge in case of transfusion of a high volume of cold blood in a short time to the patient” (89.2% responded as correct). The leading items to which ICU nurses responded incorrectly before the training were “The only blood product that can be kept at room temperature is thrombocyte suspension” (n=103, 62% responded as wrong) and “If the physician orders blood transfusion during the shift, even if there is only one nurse at the shift, the nurse makes the controls by him/herself and performs the blood transfusion alone” (60.2% responded as correct).

The leading three items to which ICU nurses responded correctly after the training were “There is no need to wash hands before blood transfusion” (98.8% responded as wrong), “The most common and the most important sign and symptom associated with acute hemolytic transfusion reaction are fever and trembling” (98.2% responded as correct) and “Hypothermia may emerge in case of transfusion of a high volume of cold blood in a short time to the patient” (94% responded as correct). The leading items to which ICU nurses responded incorrectly after the training was “If a central catheter is used for blood transfusion, central venous blood pressure should be measured during transfusion” (40.4% responded as correct) and “If the physician orders blood transfusion during the shift, even if there is only one nurse at the shift, the nurse makes the controls by him/herself and performs the blood transfusion alone” (38.6% responded as correct). The majority of the ICU nurses responded to have read the pop-up screen messages (86.1%) (Table 4).

Table 4. Distribution of Pre-Training and Post-Training Responses of ICU Nurses on Questions Regarding the Knowledge and Implementation of Blood and Blood Product Transfusion (N=166)

Questions	Pre-test				Post-test			
	Correct		Incorrect		Correct		Incorrect	
Questions for knowledge on blood and blood products	n	%	n	%	n	%	n	%
1. What is hemovigilance?	140	84.3	26	15.7	164	98.8	2	1.2
2. Which of the following is true for the urgent implementation of blood components determined by WHO?	79	47.6	87	52.4	142	85.5	24	14.5
3. Which of the following is true regarding safe blood transfusion?	135	81.3	31	18.7	154	92.8	12	7.2
4. Which of the following blood products should not be cross-matched?	54	32.5	112	67.5	104	62.7	62	37.3
5. If the blood that is kept to be given to the patient is delayed for two hours, how do you store the blood during this period?	61	36.7	105	63.3	103	62	63	38
6. Which method is suitable for warming the blood if it is necessary?	102	61.4	64	38.6	139	83.7	27	16.3
7. In which situations is it not recommended to warm the blood?	65	39.2	101	60.8	101	60.8	65	39.2
8. In which of the following blood transfusions can be given at the normal rate?	129	77.7	37	22.3	158	95.2	8	4.8
9. What is the blood group that can be given to your patient if an emergency transfusion is required and the blood group is not known yet?	70	42.2	96	57.8	117	70.5	49	29.5
10. Which of the following can be given via the same IV route during blood product infusion?	134	80.7	32	19.3	153	92.2	13	7.8
11. What do you do if the patient develops a reaction during blood transfusion?	132	79.5	34	20.5	153	92.2	13	7.8
12. Which of the following is/are the symptoms of a blood transfusion reaction?	156	94	10	6.0	161	97	5	3
13. Which is incorrect for the definition of massive transfusion?	35	21.1	131	78.9	81	48.8	85	51.2
14. Which of the following about platelets is false?	21	12.7	145	87.3	66	39.8	100	60.2
15. Which of the following is incorrect for Erythrocyte Suspension?	61	36.7	105	63.3	88	53	78	47
16. Which is false about whole blood?	75	45.2	91	54.8	112	67.5	54	32.5
17. Which of the following information is false about fresh frozen plasma?	112	67.5	54	32.5	135	81.3	31	18.7
18. Which of the following is not an indication for use of cryoprecipitate?	55	33.1	111	66.9	101	60.8	65	39.2
19. Which of the following is not a disease transmitted by blood transfusion?	159	95.8	7	4.2	165	99.4	1	0.6
20. Which of the following is checked for safe transfusion before blood transfusion?	129	77.7	37	22.3	139	83.7	27	16.3

Questions for knowledge practices on safe blood and blood products transfusion	Pre-test				Post-test			
	Correct		Incorrect		Correct		Incorrect	
	n	%	n	%	n	%	n	%
1. Blood and blood products can be administered with a verbal order.	142	85.5	24	14.5	149	89.8	17	10.2
2. Confirmation of cross-match test result and patient information by a nurse before transfusion is enough.	91	54.8	75	45.2	127	76.5	39	23.5
3. In case of any complication during blood transfusion, it should be reported on safe reporting system.	141	84.9	25	15.1	154	92.8	12	7.2
4. If the physician orders blood transfusion during the shift, even if there is only one nurse at the shift, nurse makes the controls by him/herself and performs the blood transfusion alone.	66	39.8	100	60.2	102	61.4	64	38.6
5. There is no need to wash hands before blood transfusion.	160	96.4	6	3.6	164	98.8	2	1.2
6. A narrow diameter catheter should be preferred to avoid erythrocyte hemolysis	103	62	63	38	146	88	20	12
7. The blood product received from the blood bank should be checked before it is administered to the patient.	75	45.2	91	54.8	121	72.9	45	27.1
8. If a patient is ordered to have two units of whole blood, I keep the second one in room temperature ready for infusion while administering the first one.	79	47.6	87	52.4	115	69.3	51	30.7
9. Fresh frozen plasm should not be administered without leucocyte filter.	86	51.8	80	48.2	111	66.9	55	33.1
10. Blood transfusion decreases the mortality and morbidity risk of the patient.	54	32.5	112	67.5	103	62	63	38
11. Blood transfusion rate is gradually increased every 15 minutes.	117	70.5	49	29.5	130	78.3	36	21.7
12. If pediatric unit form of the blood is not available during blood transfusion, the ordered volume of blood can be withdrawn with an injector and administered by an injector pump in order to avoid wastage.	108	65.1	58	34.9	141	84.9	25	15.1
13. If a central catheter is used for blood transfusion, central venous blood pressure should be measured during transfusion.	73	44	93	56	99	59.6	67	40.4
14. Cross Match Test analyzes the compatibility between donor erythrocytes and recipient serum.	132	79.5	34	20.5	144	86.7	22	13.3

15.	The only blood product that can be kept in room temperature is thrombocyte suspension.	63	38	103	62	110	66.3	56	33.7
16.	The blood product completing the testing in the blood bank and being ready transfusion is 100% safe.	107	64.5	59	35.5	140	84.3	26	15.7
17.	One unit of erythrocyte suspension increases hemoglobin count nearly by one unit.	105	63.3	61	36.7	147	88.6	19	11.4
18.	The most common and the most important sign and symptom associated with acute hemolytic transfusion reaction are fever and trembling.	149	89.8	17	10.2	163	98.2	3	1.8
19.	Hypothermia may emerge in case of transfusion of a high volume of cold blood in a short time to the patient.	148	89.2	18	10.8	156	94	10	6
20.	Erythrocyte suspension and fresh frozen plasma should be administered within 30 minutes once it is out of the blood bank fridge.	98	59	68	41	133	80.1	33	19.9
* Rate the pop-up informative screen messages sent on the hospital information system according to their effect on your practice ranging from "0 – was not beneficial" to "10 – very beneficial". (n=147).				Min: 0	Max: 10		6.44±2.25		

Pretest-posttest comparisons revealed a statistically significant difference in before and after training mean knowledge scores which were focused on content, volume, reactions and storage conditions of blood and blood products and implementation of transfusion by ICU nurses ($P < .001$). Transfusion knowledge score of the nurses was 60.25 ± 8.92 before intervention and it increased to 78.17 ± 8.19 after intervention with a statistically significant difference. Also, pretest-posttest comparisons revealed a statistically significant difference in before and after training mean practice knowledge scores which were focused on implementation of transfusion by ICU nurses ($P < .001$) (Table 5).

Table 5. Comparison of Pre-Training and Post-Training Mean Knowledge Scores of ICU Nurses.

Parts	Pre-training			Post-training			Test (t) P
	Mean±SD	Min	Max	Mean±SD	Min	Max	
1. Part (questions for content, volume, reactions, storage conditions and features of blood and blood products)	28.67±5.97	12.5	42.5	38.19±5.97	17.5	50	-9.771 <.001**
2. Part (questions for blood and blood product transfusion practices)	31.58±5.83	15	42.5	39.98±4.77	25	47.5	-10.098 <.001**
Total knowledge score of safe blood and blood product transfusion	60.25±8.92	37.5	80	78.17±8.19	55	95	-10.562 <.001**

t=Student t test, ** $P < .001$

DISCUSSION

There are only a few studies on the effects of safe blood and blood products transfusion training on knowledge of ICU nurses.^{7,13,23} It is found that nurses (n=166) participating in this study were to have moderate level of knowledge on safe blood and blood product transfusion before the training. There are studies reporting poor level of knowledge on safe blood and blood product transfusion among nurses.³⁰⁻³³ There are also studies reporting moderate level of knowledge on safe blood and blood product transfusion among nurses.^{8,31,32} Lack of knowledge on blood transfusion among nurses is reported to cluster on some key points.^{8,34,35} Similar to the reports lack of knowledge is observed to be on “content, volume, reactions, storage conditions and other features of blood and blood product” and “implementation and practices of blood and blood product transfusion” in this study. These findings underline the need for promotion of knowledge on safe blood transfusion among nurses. Given the fact that ICUs are departments in which blood and blood product transfusions are often performed and nearly half of the nurses participating in the study were having a bachelor’s degree education, a moderate level of knowledge on safe blood and blood product transfusion among nurses is suggested to bear a significant threat to patient safety.

In comparison of knowledge on safe blood and blood product transfusion among nurses after the training, it is shown that nurses working in pediatric ICUs were to have significantly higher mean knowledge score compared to nurses working in other ICUs. Köker et al., (2022), have emphasized that blood and blood product transfusions in pediatric intensive care units cause more early transfusion reactions in children compared to adults. They highlighted the need for more careful preparation and monitoring of blood and blood products given to pediatric patients. Additionally, they noted that nurses working in pediatric intensive care units encounter more cases related to this issue compared to other nurses and should be more knowledgeable about hemovigilance.¹⁸ This finding may reflect a higher sensibility on safe blood and blood products transfusion, giving particular importance to in-service training and a provoked awareness in nurses working in pediatrics due to the vulnerable nature of patients/children to whom they provide nursing care.^{18,35-37}

In this study, a statistically significant difference is found among mean knowledge scores before and after training in fields of content, volume, reaction, storage conditions, and implementation of blood and blood products. A positive increase is observed in all mean knowledge scores after training. In line with the previous studies, this finding suggests a positive effect of a training on safe blood and blood product transfusion on knowledge^{31,32}. The importance of regular and continuous post-graduation training is obvious.

It is very pleasing to observe that the majority of participants in this study were aware of the signs and symptoms of early-phase transfusion reactions. This finding may be due to the fact that all participants have frequently encountered early-phase transfusion reactions either in the intensive care units where they currently work or in other units where they have previously worked. Since most reactions occur in the early phases of transfusion and may have been more frequently observed, knowledgeable and attentive healthcare professionals can contribute not only to ensuring safe transfusions but also to reducing mortality and morbidity rates.

However, it is quite thought-provoking to observe that more than half of the participants in the study responded incorrectly to the question about whether central venous pressure should be measured during transfusion if a central catheter is used. It is generally not recommended to measure central venous pressure simultaneously from a central catheter that is being used for blood transfusion. Measuring blood pressure from the catheter during the transfusion may lead to inaccurate measurements and evaluations. Central venous pressure is typically measured after the transfusion is complete and the intravenous fluid set has been changed. This ensures that the measurements are accurate and reliable.^{25,26} The catheter and the transfusion set must be changed within the specific timelines in line with safe transfusion practices. Non-standard practices may do more harm than good to the patient, even lead to irreversible life-threatening risks.²⁵⁻²⁸

The perception of participating nurses on the effect of these pop-up informative screen messages on their practice was moderate with a mean score of 6.44 points over 10 points. The moderate perception of the effect may be due to the limited number and content of the pop-up informative screen messages. Nevertheless, the

need for integration of technology, particularly reminder messages, into the training process cannot be neglected.³¹⁻³⁷

Limitations of the study: One of the limitations of this study is the sample which is comprised of nurses from a single medical treatment facility. Another limitation of this study is that the data were collected through face-to-face interviews to ensure that nurses completed all questions thoroughly. However, this method may have led to nurses providing responses they believed were desired. Additionally, the lack of observational data is a limitation of this study. There were no observations for the implementation of blood and blood product transfusion. The content validity index was not calculated for the question forms used in this study. Finally, it could not be distinguished in this study whether nurses were affected by the training given or by pop-up messages.

CONCLUSION

It is found in this study that almost half of the participating nurses had attended a previous in-service training, course, or activity, more than half of them did not witness a transfusion reaction, the majority of them checked the expiry date before using a blood or blood product and most of them read the pop-up informative screen messages sent on hospital information system. Knowledge of ICU nurses on safe blood and blood product transfusion was promoted after the training.

It is recommended that hospital administration and clinical directors should pay more attention to blood and blood transfusion-associated health risks and provide in-service training programs delivered with alternative training methods and developed in line with up-to-date guidelines. The training program on safe blood and blood product transfusion should have more practical aspects, healthcare professionals should attend these training programs regularly and be encouraged to follow the updated guidelines, and observations should be executed in clinical practice after training.

Ethics Committee Approval: Before start of the study local ethical board approval was obtained (Date: 14.06.2019; no:2019/46). Also, official approval was provided by the institution in which the study was conducted.

Informed Consent: ICU nurses within the universe of the study were informed about the aim of the study and they signed the informed consent form after giving the verbal consent.

Peer-review: Externally peer-reviewed.

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