International Egyptian Journal of Nursing Sciences and Research (IEJNSR)

Original Article

Effectiveness of Implementing a Training Module about Blood Transfusion on Pediatric Nurses' Competence

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ABSTRACT

Background: Blood transfusion is considered a highly successful and potentially life-saving treatment, especially for pediatric patients. However, ensuring effective and safe administration of blood transfusions requires proper education and training for pediatric nursing staff. **Aim:** This study aimed to examine the effectiveness of implementing a training module about blood transfusion on pediatric nurses' competence. **Design:** The study utilized a quasi-experimental approach, employing a one-group pre- and post-test design. **Settings:** The research was conducted at five departments within the Mansoura University Children's Hospital, including hematology, pediatric intensive care unit, emergency, surgical, and medical departments. **Subjects:** A convenient sample of 80 pediatric staff nurses was included in the current study. **Tools:** Data were collected using a structured interview questionnaire to assess nurses' knowledge levels and a blood transfusion competency checklist to evaluate their practices before, during, and after the training module. **Results:** The results showed a highly statistically significant difference in the mean scores of nurses' knowledge levels and practice regarding blood transfusion before and immediately after the training intervention ($P<0.001^{**}$). **Conclusion:** The application of a blood transfusion training module for pediatric nurses improved their knowledge regarding blood transfusion. Furthermore, they demonstrated improvement in practical skills, leading to a higher practice score than before the training. **Recommendation:** The study recommended organizing regular training programs, using simulation-based learning, encouraging continuing education, facilitating collaboration and peer learning, standardizing procedures, fostering a safety culture, promoting multidisciplinary collaboration, and engaging in quality improvement initiatives.

Keywords: Blood Transfusion, Competence / Performance, Pediatric Nurses' Training module.

Introduction

Blood transfusion is considered a highly effective and potentially life-saving treatment, especially in pediatric patients. It is also considered an integral part of modern medicine. It is common in pediatrics, especially preterm infants, children with hematologic malignancies or blood disorders, and children in pediatric intensive care units. In some high-risk Intensive Care Unit (ICU) populations, nearly 5% of pediatric patients received at least one blood transfusion during their hospital stay. Up to 50% of critically ill children admitted to a pediatric intensive care unit (PICU) receive one or more red blood cell (RBC) transfusions during their stay, and up to 75% of children hospitalized for 7 or more days **(Wadia, et al., 2020).**

Blood is an important product in modern medical practice. Red blood cells (RBCs) are used to improve oxygen transport to tissues during bleeding and anemia. Red blood cell transfusion is one of the mainstays of pediatric treatment for anemia and is one of the few drugs that can adequately restore tissue oxygenation when oxygen demand exceeds supply **(Fiala et al., 2021).**

Transfusion practice is the administration of plasma-derived blood components or products to patients in accordance with national guidelines and current requirements of law. Hospital transfusion medicine is all about ensuring that the right blood is safely administered to the patient when clinically necessary **(Loua, et al., 2019).** Red blood cell transfusion is a common procedure, as 90% of very low birth weight infants receive red blood cell transfusions during their stay in the neonatal ward. Red blood cell transfusions are thought to benefit neonates with acute perinatal blood loss and severe anemia. However, there is growing concern about its association with serious medical conditions such as necrotizing enterocolitis (NEC) and intraventricular hemorrhage **(Aboalqez, et al., 2021; Kalteren, et al., 2022).**

Blood transfusion is a complex multi-step process involving members of various professional groups. Nurses, doctors, laboratory scientists, pharmacists, as well as donors and recipients. Transfusions of blood products to children carry a higher risk of harm than adults. These risks can result from the omission of critical controls (shortcuts) or from believing that someone else is responsible for safe blood transfusions **(Kumar, et al., 2018).**

Nurses should be familiar with and experienced in the transfusion process. A strict aseptic technique must be followed when receiving blood bags from blood donation service providers, applying blood to clients, and disconnecting. Wash hands and wear gloves. It is very important to assess the size of the IV catheter and blood-receiving vein. Depending on the clinical setting and hospital policy, additional vital sign measurements such as oxygen saturation during transfusion should be considered **(Odom-Forren, 2016).** Nursing training consists of theoretical education and practical training aimed at preparing for the nursing profession. With ever-changing children's needs and new developments in treatment, it is critical that nursing staff continue to be educated. Nursing education is never-

ending as nurses constantly need to learn new skills and concepts throughout their careers **(Elewa and Elkattan, 2017; Tuomikoski, et al. 2020).**

Significance of the study

Pediatric patients require Blood Transfusions (BT) in a variety of settings. Several studies of blood transfusion in adults recommend balanced transfusions to improve outcomes. However, it is unclear whether these results apply to the pediatric population. Pediatric patients had twice as many transfusion reactions as adults and had higher overall response rates **(Fawley, et al., 2018)**.

Patient safety is an important part of healthcare. Therefore, it has been advocated to use evidence-based transfusion guidelines (EBP) to improve transfusion practices. There is evidence that human error remains a major cause of morbidity and mortality associated with blood product transfusions, with potentially serious consequences for sick children **(Brooks & Combest, 2018).** Transfusion quality, efficacy, and safety are based on caregiver knowledge and practice. Inappropriate BT practices can jeopardize the child's safety and cause complications that can lead to death in some recipients. Therefore, adherence to transfusion guidelines can reduce both administrative and clinical errors. Therefore, education and training of pediatric nurses who provide BT are important issues in order to establish efficient and safe blood transfusion management. Additionally, the use of competency transfusion guidelines should provide staff with the theoretical foundation and technical skills to ensure safe and efficient transfusion practice **(Bayoumi & El-Nagger, 2020).**

Aim of the study

This study aimed to examine the effectiveness of implementing a training module about blood transfusion on pediatric nurses' competence**.** To achieve this aim the study set out to:

1. Assess the level of knowledge of pediatric nurses regarding blood transfusion before and after the implementation of the training module.

2. Assess the practices of pediatric nurses' regarding blood transfusion before and after undergoing the training module.

3. Develop and implement a training module on safe blood transfusion tailored to the specific needs of pediatric nurses.

Research Hypothesis:

H1. The application of a blood transfusion training module for nurses is expected to improve their knowledge regarding blood transfusion.

H2. After completing the blood transfusion training module, pediatric nurses are expected to demonstrate improved practical skills, leading to a higher practice score than before the training.

Operational Definition

Training module: This is an instructional guide primarily used for teaching and learning step-by-step procedures. Training modules also can be used to present more factual information. It is carried out for the purpose of teaching skills, and practical experience **(Ros & Neuwirth, 2020)**

Nursing competence: Nursing competence refers to the ability of a nurse

to perform their job duties effectively and efficiently (**Fukada, 2018).**

Subjects and Method

Study Design

A quasi-experimental study one group pre and post-test design used in this study.

Study Settings

The study was carried out in Mansoura University Children's Hospital (MUCH) at departments where blood transfusion events are common. These included; the hematology department, pediatric intensive care unit, emergency, surgical, and medical departments.

Study Subjects

During the data collection period in MUCH, the study included a convenience sample consisting of on-duty nurses from the previously mentioned departments. To be eligible for inclusion, nurses needed to have at least 6 months of work experience in pediatric wards and a willingness to participate in the study. Nurses who changed their workplace during the study or were absent from attending more than one training session were excluded from the study.

Tools of data collection: Data was collected through using the following tools:

Tool (I): Blood transfusion knowledge questionnaire: it included two parts as follows:

Part 1: Nurses sociodemographic questionnaire: It was developed by the researcher to collect data on nurses' socio-demographic characteristics such as age, gender, qualifications, and years of experience related to blood transfusion.

Part 2: A modified version of the Routine Blood Transfusion Knowledge Questionnaire (RBTKQ): that was developed by **Hijji et al. (2012)** and adopted to use in the current study. The current version of the RBTKQ included seven sections and a total of 43 items. Thirty-two of these were knowledge items (2 true-false; 20 multiple-choice; 10 multiple-response) Section A (8 items) elicits information about nurses' demographics and training. Sections B throughout F examined the pediatric nurses' knowledge aspects of blood bag collection from the blood bank and patient preparation prior to, pre-transfusion initiation nursing responsibilities, post-transfusion initiation nursing responsibilities, and complications related to blood transfusion (33 items). Finally, Section G (2 items) addressed issues related to hospitals' blood transfusion policies and procedures. The satisfactory level of nurses' knowledge was defined as a score of ≥80%, whereas the unsatisfactory level of nurse's knowledge was indicated by a score of <80%. A correct answer was assigned a value of 1, while an incorrect answer was assigned a value of zero.

Tool (11): Blood Transfusion Observational Checklist: developed by researcher after reviewing the related guidelines (**National Institute for Health and Care Excellence 2016; Bezerra, et al., 2018 and Scott, et al., 2019).** It contained fourteen (40) procedure step items, classified as: eight steps (8) before blood transfusion, eighteen steps (18) during blood transfusion, four steps (4) after blood transfusion and ten steps (10) for blood transfusion reaction. Scoring system valued as total items = 40 and scored by done correctly = 1 or done incorrectly / not done = zero. The competence level for best nurse's practice was ≥80% and the incompetency level was <80%.

Validity and reliability:

A jury of five experts in medicine and nursing examined the validity of tools, and all necessary modifications were made. Using Cronbach alpha and test-retest methods, all tools were checked for internal consistency and reliability. This questionnaire has a Cronbach alpha of 0.761, with a correlation coefficient of 0.457 **(Hijji et al., *2012)***. The checklist for the observation of blood transfusions has a Cronbach alpha of 0.854 (r= 0.577).

Pilot Study:

To demonstrate the feasibility and applicability of the tools, a pilot study was conducted on ten percent of the total subjects (8 nurses) prior to data collection. It also helps to approximate the time needed to complete the interview prior to data collection. Based on the findings of the pilot study, necessary modifications were made accordingly. The subjects of the pilot study were excluded from the study's total sample to avoid data contamination.

Data collection process:

During the period between April and September 2023, data for this study was collected. Researchers were present at the study settings three days a week, from 9 A.M. to 12 P.M., to conduct individual interviews with the nurses. The study tools, including a questionnaire, were used for these interviews. After explaining the questionnaire to the nurses, they marked their answers. The study nurses were divided into small groups. The data collection process comprised three phases: the assessment phase, the implementation phase, and the evaluation phase. **The first phase:** the assessment stage, involved conducting a "pre-test" before commencing the blood transfusion training module. **The second stage** encompassed the implementation of the blood transfusion training module, and the **third stage** involved evaluation at two months after the implementation of the blood transfusion training module to evaluate intervention outcomes through a post-test.

Assessment phase: Assessment of the nurses' competence regarding blood transfusion at Mansoura University Children's Hospital Pediatric Intensive Care Unit (PICU), Emergency, Surgical, Medical, and Hematology department pre and post-training module implementation. A study was carried out to assess the knowledge gap among nurses and evaluate their performance in administering blood transfusions to children. The researchers aimed to identify common practical errors made by pediatric nurses during this process. Additionally, they also examined the characteristics of the nurses and the educational resources available in the hospital for further analysis in subsequent stages.

Implementation phase: Utilizing the conclusions drawn from the assessment phase, specific objectives, priorities, and anticipated results were devised to address the pediatric nurses' skill requirements and areas of insufficient knowledge concerning blood transfusion. The application of the blood transfusion training module aimed to improve the nurses' competence regarding blood transfusion through four sessions; including ten minutes for open discussion and pediatric nurses’ feedback. A set of performance goals was prepared by the researcher for nurses' performance before, during, and after blood transfusion, focusing on nurses' errors.

The training module

The aim of this training module was to enhance the competencies of nurses in safely administering blood transfusions according to the latest international standards. It was created in straightforward Arabic language by researchers who evaluated the specific needs of nurses. The module incorporated insights from various reputable sources, such as nursing books, articles, periodicals, magazines, and online resources, to reflect current practices in patient blood transfusion.

The training module spanned four consecutive sessions. The topics covered included blood and blood products, blood functions, indications and contraindications for blood transfusion, potential complications and reactions, and the roles of nurses during the transfusion process. Additionally, the content highlighted precautionary measures before, during, and after transfusions, as well as general guidelines for managing adverse reactions to blood transfusions. Each session lasted approximately one hour, with half an hour dedicated to theoretical instruction and the other half an hour for practical training.

To effectively educate the nurses, the researchers employed various teaching strategies such as mini-lectures, case-based discussions, and small group discussions. They utilized different media, including PowerPoint presentations, figures, and diagrams, to aid in the training process. After the theoretical sessions, the nurses underwent three practical demonstrations and re-demonstrations of blood transfusions (pre-transfusion, during, and post-transfusion) conducted by the researcher in a clinical setting. Prior to its implementation, the training module underwent a rigorous review by a committee of experts to ensure its accuracy and evidence-based coherent practices.

Evaluation phase: Nurses' competence was assessed before, immediately after and follow-up after two months of implementation of the blood transfusion training module using the previously mentioned study tools. The researchers evaluated the nurses' practices regarding the transfusion of blood by using the study tools. They attended different study settings during evening and night shifts, five days a week, to observe and evaluate nurses' performance regarding blood transfusion. They used an observation checklist and made two observations for each nurse, conducting the assessment over a month. Comparison between nurses' before, immediately after, and follow-up after two months of module implementation to determine the effect of the blood transfusion training module sessions on nurses' performance.

Ethical considerations

Ethical approval was obtained from the ethical committee of the Faculty of Nursing Mansoura University (Ref. No. 0445), the manager of Mansoura University Children's Hospital, and the head of all participating departments. All nurses received a participant information sheet and signed an informed consent; voluntary participation, anonymity, and confidentiality were all guaranteed. Any participant has the right to withdraw from the study at any time without any responsibility.

Data Analysis

The data collected was processed, organized, and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics such as frequencies and percentages were used to present the data for qualitative variables, while means and standard deviations were used for quantitative variables. For comparing quantitative continuous data before and after implementing the module, the student t-test was employed. As for comparing qualitative variables, the Chi-square test and Fisher's exact test were used. A significance level of *P (p-value) was set at 0.05, and **P-value ≤ 0.001 was considered exceptionally significant.

Results

Table (1) clarified that the mean age of studied nurses was 35.2 ±6.3 years old and the majority of them graduated from technical institutes and diploma degrees of nursing (47.5% and 37.5%, respectively). Regarding nurses' Experience with blood transfusion, 85% of them had 10 – 15 years of experience with a mean of 12.4 ±5.3 years. More than one-third of them (38.8%) never previously participated in a formal training program about blood transfusion.

Figure (1), demonstrates the distribution of the nurses' according to their departments, as about half of the studied nurses were working in the Hematology department and Pediatric intensive care unit (25.0% for each) and 23.8% of them belonged to the emergency department. Related to the number of blood transfusions performed over the past 6 months was 1 – 4 times in about half of them (47.5%).

Table (2) showed the distribution of the studied nurses' level of knowledge regarding blood transfusions before, immediately and two months after implementation of the training module. There were a highly statistical significance between issues relating to patient preparation, blood pack collection, pre-transfusion initiation nursing activities, post transfusion initiation nursing activities and issues, and complications related to blood transfusion (<0.001** for each) before implementation the training module and the immediate and after two months of the implementation.

Figure (2) illustrate that, the majority of the studied nurses 90.0% had an "unsatisfactory" total level of knowledge regarding blood transfusion before the module implementation compared to 7.5% and 17.5% immediately and two months after the module implementation, respectively. There were highly statistically significant differences between nurses' total level of knowledge regarding blood transfusion before and immediately after the module implementation, and between before and follow-up after 2 months of the module implementation (X^2 = 108.968, P <0.001**, X^2 = 84.575, P <0.001**, respectively).

Figure (3) represented that, only 25.0% of nurses had a competent level of practice scores before the module implementation, while this percentage increased immediately after the module implementation and 2 months later to reach 82.5% and 67.5%, respectively. There were highly statistically significant differences between nurses' total level of practice related to blood transfusion before and immediately after the module implementation, and finally between before and follow-up after 2 months of the module

implementation (X^2 = 53.199, P <0.001**, X^2 = 29.063, P <0.001**, respectively).

The presentation of of nurses' practice regarding blood transfusions before, immediately and two months after implementation of the training module are illustrated in **Table (3).** A highly statstical significant difference were found before, during and after blood transfusion between before the implementation and the immediate and three months after the implementation of the training module.

The relationship between characteristics of the studied nurses related to blood transfusion and their knowledge scores before, immediately, and two months after implementation of the training module is clarified in **Table (4).** In relation to pediatric nurses' years of experience with blood transfusion, nurses with experience of more than 10 years more frequently had satisfactory scores of knowledge immediately and two months post the module implementation (X2=36.757, P<0.001** and X2=60.124, P<0.001**, respectively). Nurses who received formal training about blood transfusion once and more than one time also more frequently had satisfactory scores of knowledge immediately and two months after the implementation of the training module (X^2=10.253, P=0.006* and X^2=12.215, P=0.002*, respectively). Concerning nurses' departments pediatric nurses who work in hematology, intensive care units, and emergency departments were more frequently to have satisfactory scores of knowledge at follow-up after two months of the implementation of the training module (X^2=29.176, P<0.001**).

Regarding the relationship between characteristics of pediatric nurses related to blood transfusion and their practice scores before, immediately and two months after implementation of the training module, **Table (5)** revealed that, studied nurses with experience of more than 10 years more frequently had a competent level of practice immediately and two months post the module implementation (X^2=47.604, P<0.001** and X^2=29.321, P<0.001**, respectively). In addition, Nurses' who received formal training about blood transfusion once and more than one time also more frequently had a competent level of practice immediately and two months after the implementation of the training module (X2=9.195, P=0.010* and X2=25.958, P<0.001**). In relation to pediatric nurses' departments, pediatric nurses who worked in hematology, intensive care units, and emergency departments were more frequently to have a competent level of practice at follow-up after two months of the implementation of the training module (X^2=16.599, P=0.002* and X^2=22.572, P<0.001**, respectively).

Table (6) clarified that there was a highly statistically positive correlation between the pediatric nurses' total Knowledge scores about blood transfusion and their total practice scores before, immediately and after two months of the training module implementation (X^2 = 19.472, P = <0.001** and X^2 = 21.905, P = <0.001**, respectively).

Table (1). Characteristics of the studied nurses		
Item	**N=80**	**%**
Age (Years)		
20 – 30	20	25.0
30 – 40	39	48.8
> 40	21	26.3
Mean ±SD	35.2 ±6.3	
Nursing qualification		
Diploma degree of nursing	30	37.5
Technical Institute degree of nursing	38	47.5
Bachelor's degree of nursing	12	15.0
Nurses' Experience about Blood Transfusion Procedure		
Years of Experience in blood transfusion		
< 10	12	15.0
10 – 15	68	85.0
Mean ±SD	12.4 ±5.3	
Previously participation in formal training program about blood transfusion		
Never	31	38.8
Once	29	36.3
More than one time	20	25.0
Number of blood transfusions performed over the past 6 months #		
None	28	35.0
1 – 4	38	47.5
5 – 8	10	12.5
9 – 12	4	5.0

 # Numbers not mutually exclusive

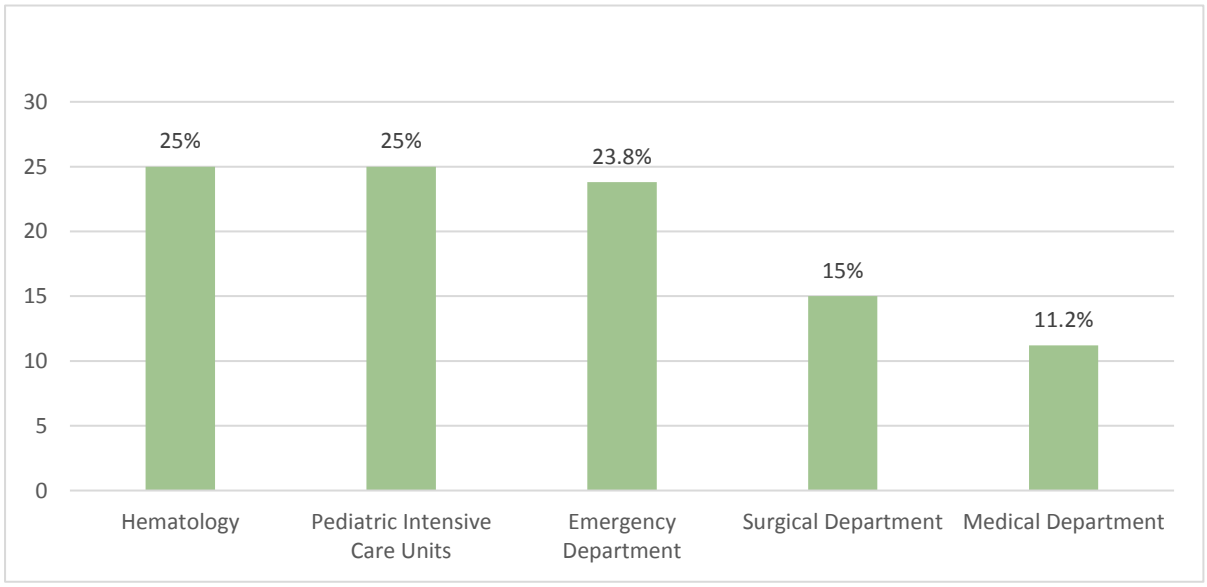

Figure 1. Distribution of Nurses' According to their Departments

Table (2). Distribution of the Studied Nurses' Level of Knowledge Regarding Blood Transfusions Before, Immediately and Two Months After Implementation of The Training Module

	Before				Immediately After				After 2 Months				Chi – Square			
	Unsatisfactory Knowledge		Satisfactory Knowledge		Unsatisfactory Knowledge		Satisfactory Knowledge		Unsatisfactory Knowledge		Satisfactory Knowledge		Before / Immediate After		Before / After 2 months	
	N	%	N	%	N	%	N	%	n	%	n	%	X^2	P	X^2	P
Issues Relating to Patient Preparation	69	86.3	11	13.8	7	8.8	73	91.3	11	13.8	69	86.3	96.340	<0.001 **	84.100	<0.001 **
Blood Pack Collection	71	88.8	9	11.3	8	10.0	72	90.0	10	12.5	70	87.5	99.240	<0.001 **	93.039	<0.001 **
Pre-Transfusion Initiation Nursing Activities	75	93.8	5	6.3	4	5.0	76	95.0	17	21.3	63	78.8	126.044	<0.001 **	86.035	<0.001 **
Post Transfusion Initiation Nursing Activities and Issues	72	90.0	8	10.0	7	8.8	73	91.3	18	22.5	62	77.5	105.641	<0.001 **	74.057	<0.001 **
Complications Related to Blood Transfusion	74	92.5	6	7.5	6	7.5	74	92.5	12	15.0	68	85.0	115.600	<0.001 **	96.643	<0.001 **
Total Knowledge Level	72	**90.0**	8	10.0	6	7.5	74	**92.5**	14	17.5	66	**82.5**	108.968	**<0.001 ****	84.575	**<0.001 ****

* Statistical significance at 0.05 level

** Highly statistical significance at 0.001 level

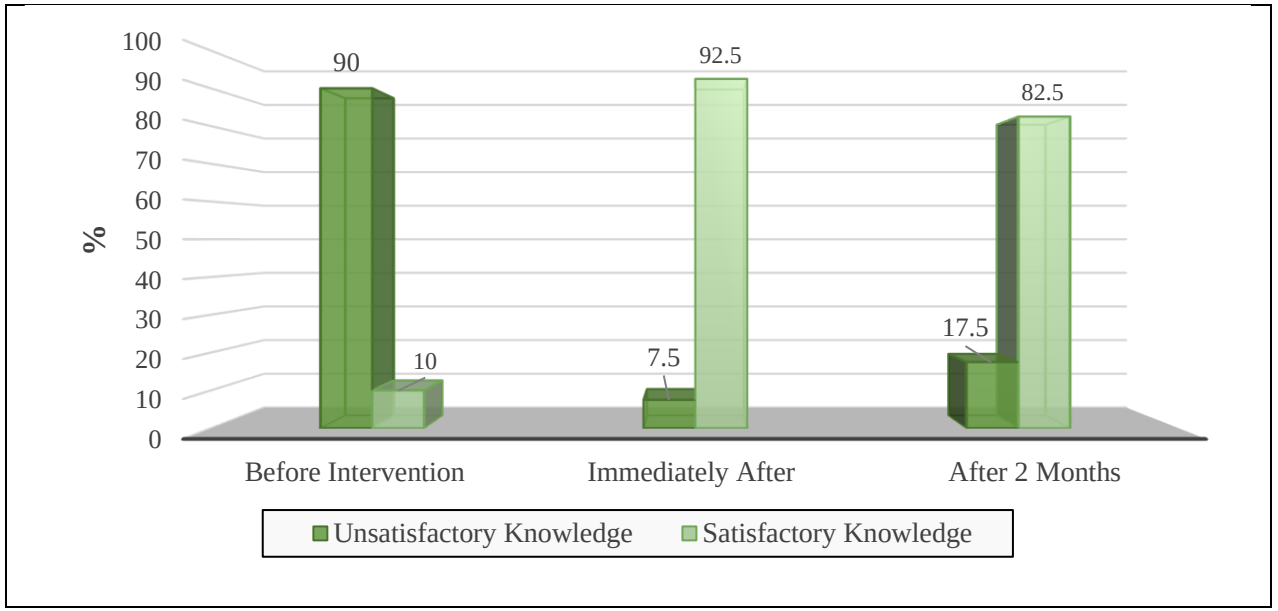

Figure (2). Percentage Distribution of the Studied Nurses' Level of knowledge regarding blood transfusions

Table (3). Comparison of Nurses' Practice Regarding Blood Transfusions Before, Immediately and Two Months After Implementation of The Training Module

	Before				Immediate After				After 2 Months				Chi – Square			
	Incompetent Practice		Competent Practice		Incompetent Practice		Competent Practice		Incompetent Practice		Competent Practice		Before / Immediate After		Before / After 2 months	
	N	%	N	%	N	%	N	%	n	%	N	%	X^2	P	X^2	P
Before Blood Transfusion	60	75.0	20	25.0	16	20.0	64	80.0	24	30.0	56	70.0	48.521	<0.001 **	32.481	<0.001 **
During Blood Transfusion	59	73.8	21	26.3	13	16.3	67	83.8	25	31.3	55	68.8	53.434	<0.001 **	28.972	<0.001 **
After Blood Transfusion	61	76.3	19	23.8	14	17.5	66	82.5	29	36.3	51	63.8	55.441	<0.001 **	26.006	<0.001 **
Total Checklist Score	60	**75.0**	20	25.0	14	17.5	66	**82.5**	26	32.5	54	**67.5**	53.199	**<0.001 ****	29.063	**<0.001 ****

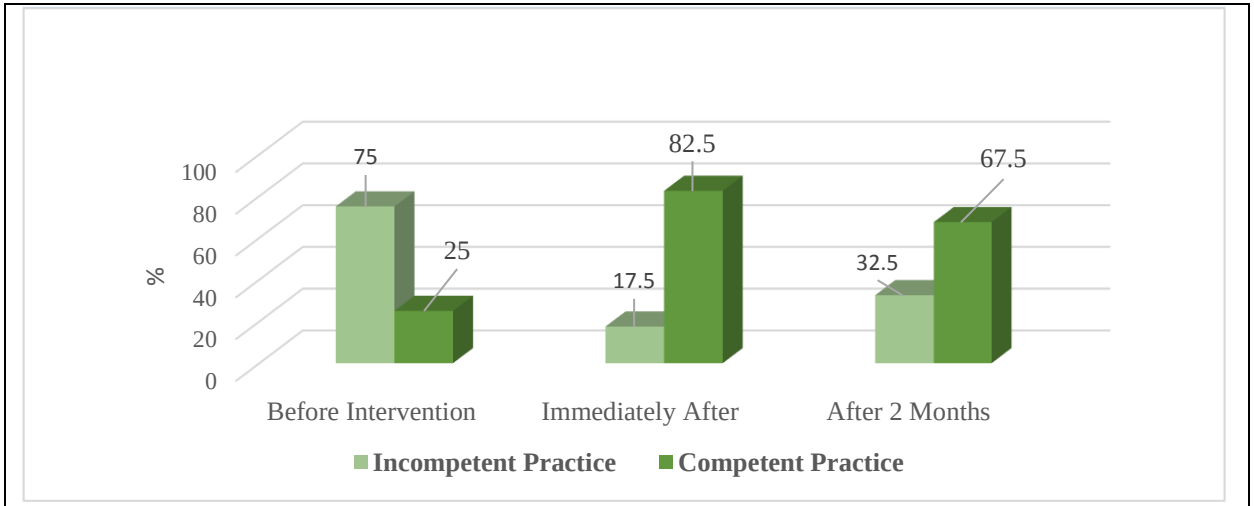

Figure 3. Comparison of Nurses' Practice regarding blood transfusions

Table (4). Relationship between Nurses' Experience about Blood Transfusion Procedure and their Knowledge Scores Before, Immediately and Two Months After Implementation of the Training Module

Nurses' Experience about Blood Transfusion Procedure	Before				Immediate After				After 2 Months			
	Unsatisfactory Knowledge (n=72)		Satisfactory Knowledge (n=8)		Unsatisfactory Knowledge (n=6)		Satisfactory Knowledge (n=74)		Unsatisfactory Knowledge (n=14)		Satisfactory Knowledge (n=66)	
	N	%	N	%	N	%	N	%	N	%	n	%
Years of experience with blood transfusion												
< 10	10	13.9	2	25.0	6	100.0	6	8.1	11	78.6	0	0.0
> 10	62	86.1	6	75.0	0	0.0	68	**91.9**	3	21.4	66	**100.0**
Fisher's exact test	X2=0.697, P=0.403				**X2=36.757, P<0.001****				**X2=60.124, P<0.001****			
Formal training about blood transfusion												
Never	30	41.7	1	12.5	6	100.0	25	33.8	11	78.6	20	30.3
Once	25	34.7	4	50.0	0	0.0	29	**39.2**	3	21.4	26	**39.4**
More than one time	17	23.6	3	37.5	0	0.0	20	**27.0**	0	0.0	20	**30.3**
Fisher's exact test	X^2=2.600, P=0.272				**X^2=10.253, P=0.006***				**X^2=12.215, P=0.002***			
Number of blood transfusions nurse performed over the past 6 months												
None	27	37.5	1	12.5	4	66.7	24	32.4	11	78.6	17	25.8
1 – 4	33	45.8	5	62.5	2	33.3	36	48.6	3	21.4	35	**53.0**
5 – 8	9	12.5	1	12.5	0	0.0	10	13.5	0	0.0	10	**15.1**
9 – 12	3	4.2	1	12.5	0	0.0	4	5.4	0	0.0	4	6.1
Fisher's exact test	X2=2.707, P= 0.439				X2=3.268, P=0.352				**X2=14.603, P=0.002***			
Department												
Hematology	19	26.4	1	12.5	3	50.0	17	23.0	0	0.0	20	**30.3**
Intensive care unit	16	22.2	4	50.0	2	33.3	18	24.3	0	0.0	20	**30.3**
Emergency	19	26.4	0	0.0	1	16.7	18	24.3	7	50.0	12	**18.2**
Surgical	11	15.3	1	12.5	0	0.0	12	16.2	7	50.0	5	7.6
Medical	7	9.7	2	25.0	0	0.0	9	12.2	0	0.0	9	13.6
Fisher's exact test	X^2=6.420, P=0.169				X^2=3.642, P=0.475				**X^2=29.176, P<0.001****			

Table (5). Relationship between the Studied Nurses' Experience about Blood Transfusion Procedure and their Practices Scores Regarding Blood Transfusion and Before, Immediately and Two Months After Implementation of the Training Module N= (80)

Nurses' Experience about Blood Transfusion Procedure	Before				Immediately After				After 2 Months			
	Incompetent Practice (n=60)		Competent Practice (n=20)		Incompetent Practice (n=14)		Competent Practice (n=66)		Incompetent Practice (n=26)		Competent Practice (n=54)	
	N	%	N	%	N	%	N	%	N	%	n	%
Experience on blood transfusion wards												
< 10	8	13.3	4	20.0	10	71.4	1	1.5	12	46.2	0	0.0
> 10	52	86.7	16	80.0	4	28.6	65	**98.5**	14	53.8	54	**100.0**
Fisher's exact test	X^2=0.523, P=0.470				**X^2=47.604, P<0.001****				**X^2=29.321, P<0.001****			
Formal training about blood transfusion												
Never	27	45.0	4	20.0	10	71.4	21	31.8	20	76.9	11	20.4
Once	20	33.3	9	45.0	4	28.6	25	**37.9**	6	23.1	23	**42.6**
More than one time	13	21.7	7	35.0	0	0.0	20	**30.3**	0	0.0	20	**37.0**
Fisher's exact test	X2=4.049, P=0.132				**X2=9.195, P=0.010***				**X2=25.958, P<0.001****			
Number of blood transfusions you performed over the past 6 months												
None	19	31.7	9	45.0	4	28.6	24	36.4	16	61.5	12	22.2
1 – 4	27	45.0	11	55.0	10	71.4	28	42.4	10	38.5	28	**51.9**
5 – 8	10	16.7	0	0.0	0	0.0	10	15.2	0	0.0	10	18.5
9 – 12	4	6.7	0	0.0	0	0.0	4	6.1	0	0.0	4	7.4
Fisher's exact test	X2=5.744, P=0.125				X2=5.216, P=0.157				**X2=15.154, P<0.001****			
Department												
Hematology	13	21.7	7	35.0	2	14.3	18	**27.3**	5	19.2	15	**27.8**
Intensive care unit	13	21.7	7	35.0	1	7.1	19	**28.8**	3	11.5	17	**31.5**
Emergency	17	28.3	2	10.0	9	64.3	10	15.2	8	30.8	11	**20.4**
Surgical	10	16.7	2	10.0	2	14.3	10	15.2	10	38.5	2	3.7
Medical	7	11.7	2	10.0	0	0.0	9	13.6	0	0.0	9	16.7
Fisher's exact test	X^2=4.738, P=0.315				**X^2=16.599, P=0.002***				**X^2=22.572, P<0.001****			

Table (6). Correlation between Total scores of Pediatric Nurses' Knowledge and Practice Regarding Blood Transfusion Before, immediately After and Two Months after Implementation of The training module N=80						
	Unsatisfactory Knowledge		Satisfactory Knowledge		Fisher's exact test	
	N	%	N	%	X^2	P
Knowledge Level Before Training Module						
Practice Level Before Training Module	**(n=72)**		**(n=8)**			
Incompetent Practice	55	76.4	5	62.5		
Competent Practice	17	23.6	3	37.5	0.741	0.389
Knowledge Level Immediately After Training Module						
Practice Level Immediately After Training Module	**(n=6)**		**(n=74)**			
Incompetent Practice	5	83.3	9	12.2		
Competent Practice	1	16.7	65	87.8	19.472	<0.001**
Knowledge Level after 2 Months Training Module						
Practice Level after 2 Months Training Module	**(n=14)**		**(n=66)**			
Incompetent Practice	12	85.7	14	21.2		
Competent Practice	2	14.3	52	78.7	21.905	<0.001**

Discussion

Blood transfusion is a lifesaving procedure for many children. The pediatric nurse plays a critical role in the healthcare team involved in the care of pediatric patients undergoing blood transfusion. Nurses' education consists of the theoretical and practical training provided to nurses with the purpose of preparing them for their duties as nursing professionals. It is very important for nursing staff to engage in plenty of ongoing training as the needs of patients continue to change and there are massive advances in the field of health care. The education of nurses never stops as they are required to continually master new skills and concepts throughout their careers **(Elewa & Elkattan, 2017).**

Among the nurses who completed the study, the highest percentages of them were in the age group 30 to less than 40 years with a mean age of 35.2 ±6.3 years old. Their academic profile showed that the majority of them graduated from technical institutes followed by diploma holders which might reflect the current condition of

nursing qualification, this is due to the high demand of Egyptian hospitals for nursing staff and the shortage of bachelor's degree graduates staff. This finding is supported by **Kafl & El-Shahat, (2020)** in their study about "Effect of an Educational Program on Nursing Care Practices regarding Pediatric Transfusion-Dependent β -Thalassemia Major". They found in their study that, three-quarters of the nurses had a diploma degree in nursing.

Regarding nurses' Experience with blood transfusion, the majority of them had 10 – 15 years of experience with a mean of 12.4 ±5.3 years and at the same time more than one-third of them never received formal training about blood transfusion, this may be due to lack of concern of such training due to their preoccupation with work pressures. From the researcher's point of view, such training is obligatory, and their attendance should be organized and coordinated in proportion with their working conditions. These findings matched with **Ibrahim, et al., (2019)** in their study "Effect of Implementing Educational Program about Safety Blood Transfusion on the Nurse's Knowledge and Practice" reported that more than half of nurses reported that they never had any post-qualifying training program in blood transfusion. The current study goes in harmony with **Saillour, et al., (2002)** who mentioned that insufficient knowledge and poor practice were attributed to a deficiency in orientation or training.

Transfusion safety demands the proper functioning of many interconnecting factors and processes rather than a single human completing a task. The current study selects nurses belonging to different departments where blood transfusion procedures are performed frequently to represent the common knowledge and practice of pediatric nurses in the selected settings and reflect the impact of the training module on their knowledge and practice level. Thus, the present demonstrated that the majority of the studied nurses were working in the Hematology department, Pediatric intensive care unit, and emergency department. The nurses from these departments were chosen as the focus for the study and module implementation for many reasons including a high number of patients, urgency of blood transfusion procedures, low staff-to-patient ratios, time pressures, high workload, and high stress. Furthermore, its necessity appeared with the finding of the current study which showed that the number of blood transfusions performed over the past 6 months was 1 – 4 times in about half of them, which indicates the high workload. This selection is congruent with the study of **Vaghar, (2018)** titled "The Impact of an Educational Program on Blood and Blood Products Transfusion on Nurses' Level of Knowledge and Performance" who focused on the need to improve nurses' knowledge and performance about the blood transfusion and the important role of nurses who handling patients more frequently with blood transfusion, it seems necessary to develop educational programs to improve their level of knowledge and practice.

To enhance the expertise and skills of pediatric nurses concerning blood transfusion procedures, it was crucial to evaluate their current levels of knowledge and practical experience. The majority of the studied nurses had an "unsatisfactory" total level of knowledge regarding blood transfusion before the module implementation. While immediately and two months after the module implementation, this level of knowledge

improved to "satisfactory". Also, there were highly statistically significant differences between nurses' total level of knowledge regarding blood transfusion before and immediately after the module implementation, and between before and after 2 months of the module implementation. These findings were congruent with **Ibrahim, et al., (2019)** in the study "Effect of Implementing Educational Program about Safety Blood Transfusion on the Nurse's Knowledge and Practice" who reported Knowledge deficits for many aspects of safe blood transfusion before the program which was improved after the implementation of the educational program with a highly statistical between before and after the implementation.

When assessing the influence of a training program on nurses' practical competence in blood transfusion, the study revealed enhanced practice scores both immediately after implementation and two months later. The findings demonstrated a significant and statistically noteworthy disparity in nurses' overall practice levels regarding blood transfusion before versus immediately after the module's implementation, as well as before versus two months after its implementation. This finding is congruent with **Abbass, et al., (2022)** who investigated the "Effect of Training Program Based on ADDIE Model on Pediatric Nurses' Performance Regarding Blood Transfusion: A Randomized Clinical Trial" reported higher scores of nurses' performance in post-test in the intervention group than pretest stage. From the researchers' point of view, it is possible that nurses are not motivated to perform the standardized nursing practice because hospital facilities and resources are not available, as well as a lack of training courses. The study revealed that before implementing the training module, the nurses' knowledge and execution of certain practices were inadequate. This lack of proficiency could have an adverse effect on the quality of nursing care provided by them. However, after undergoing the blood transfusion training module, there was a significant improvement in both knowledge and practice among the studied nurses. This suggests that the training module effectively enhanced their abilities and competence in this area.

The current study showed the relationship between characteristics of pediatric nurses related to blood transfusion knowledge and practice scores before, immediately, and two months after implementation of the training module. In relation to pediatric nurses' years of experience with blood transfusion, there was a highly statistically significant relation between years of experience with more than 10 years and the satisfactory scores of knowledge and the competent level of practice. These findings were in the same line with **Khalil, et al, (2013)** who revealed in their study "Impact of Implementing a Designed Nursing Intervention Protocol on Nurses' Knowledge and Practice Regarding Patients Undergoing Blood Transfusion" showed that the competent nurses' performance is gained from continued nursing education that supports their clinical experience. Also, the present study ascertained this concept by the finding that there was a statistically significant relation immediately and two months after the implementation of the training module between pediatric nurses' who received formal training about blood transfusion once and more than once time and the

satisfactory scores of knowledge and the competent level of practice.

The current study proved that there was a highly statistically positive correlation between the pediatric nurses' total Knowledge scores about blood transfusion and their total practice scores before, immediately, and after two months of the training module implementation. These findings were congruent with **Salem, et al., (2019)** in their study "Effect of Implementing Nursing Intervention Program on Nurses' Knowledge and Practice Regarding Children Undergoing Blood Transfusion" who demonstrated that, there was a positive correlation between total nurses' knowledge and practice regarding blood transfusion immediately after post implementation of their training program which implemented at Pediatric Medicine Departments at Benha University Hospital, Egypt.

Conclusion

Application of a blood transfusion training module for pediatric nurses improved their knowledge regarding blood transfusion. Furthermore, they demonstrated improvement in practical skills, leading to a higher practice score than before the training.

Recommendations

The following recommendations are suggested based on the results of the current study:

1. Organize regular training programs for pediatric nurses specifically focused on blood transfusion procedures. These programs should cover the latest guidelines, safety protocols, and best practices related to blood transfusions in pediatric patients.
2. Use simulation-based learning methodologies to train pediatric nurses about blood transfusion procedures.
3. Encourage pediatric nurses to pursue continuing education opportunities related to blood transfusion procedures. This can include attending workshops, conferences, or seminars that provide updates on the latest research and advancements in the field of pediatric transfusion medicine.
4. Establish standardized protocols and guidelines for blood transfusion procedures in pediatric patients. These should address critical aspects such as patient identification, blood product handling, administration techniques, and monitoring during and after transfusion. Regularly update these protocols to align with current evidence-based practice.
5. Foster a culture of safety within the pediatric nursing team. Emphasize the importance of double-checking procedures, verifying patient information, and adhering to infection control protocols during blood transfusion. Encourage open communication and reporting of any potential safety concerns or near-misses.
6. Encourage collaboration between pediatric nurses, physicians, pharmacists, and other healthcare professionals involved in blood transfusion procedures. This interdisciplinary approach promotes shared knowledge, fosters a culture of learning, and ensures comprehensive and coordinated care for pediatric patients.

Acknowledgment

The researchers want to announce appreciation and great thanks to all those who supported in conducting and accomplishing this study.

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