An Educational Bundle to Secure Nursing Competency toward Safe Blood Transfusion

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Abstract

Blood is a unique and scarce resource that must be used cautiously to ensure its safety and efficacy. Blood transfusion is a lifesaving medical intervention, but without basic information about each step, the importance of each one related to each other, and when safe practices are not followed, transfusion of blood can create life-threatening risks. Nurses have a dynamic role in blood transfusion procedures; their skills and knowledge remain essential keys to ensure safe blood transfusion. ***Study aim:*** evaluate the effect of the educational bundle on securing nursing competency toward safe blood transfusion. ***Study Design:*** a quasi-experimental design. ***Setting:*** blood disorders, emergency, and oncology departments at Zagazig University Hospitals, Al Sharkia Governorate, Egypt. ***Subject:*** all available nurses (50) who are working at the previously mentioned settings. ***Tools:*** A structured interview questionnaire to assess nurses' socio-demographic characteristics and their knowledge about safe blood transfusion process; and blood transfusion observational checklist were used to collect data. ***Results***: the highest percentage of participant nurses their age was 25-30 years and had ≤5 experience years in blood transfusion. There were a statistically significant difference and improvement of the total nurses' knowledge and their practice competency toward safe blood transfusion after educational bundle implementation compared to before it, and there was a positive statistically significant correlation between total nurses' knowledge and practice regarding safe blood transfusion pre and post-implementation of the educational bundle as well as between their total pre and post practices. Moreover, the commonest errors in the blood transfusion process that lead to an adverse reaction as reported by participants' nurses included blood incompatibility followed by not check vital signs pre, during and post-transfusion. ***Conclusions:*** The implementation of the educational bundle had a positive effect on improving the nurses' knowledge and their practice competency toward safe blood transfusion. ***Recommendations:*** continually perform regular in-service training and follow-up to nurses' performance and motivation to updating their knowledge and practices.

Keywords: Educational Bundle, Nursing Competency, Safe Blood Transfusion.

Introduction:

Blood is a body liquid that provides necessary nutrients and oxygen in the cells and carries metabolism waste products away from those same cells, it is capable of saving the lives of millions, and the only safe blood supply available in the world is by voluntary givers. In most countries, demand for blood and blood products is still growing as the human life expectancy is growing and new aggressive surgical and therapeutic methods have been applied which require large quantities of blood and blood products **(Kebadnew Mulatu et al., 2017)**. Globally, the trend of blood transfusion has grown from 85 million transfusion units in 2012 to 112.5 million donations in 2016 **(WHO, 2017)**.

Blood transfusion is the transfer to the circulation of the patient (the receiver) whose blood is deficient in quantity or quality through a disease or accident a volume of blood obtained from the healthy person (a donor) **(Kebadnew Mulatu et al., 2017)**. Blood transfusion is an essential part of each country's healthcare system and is the commonest treatment in which transfused blood and its component are used properly to save and support patients' lives **(Belousov, 2018)**. Transfusion of blood is considered safe, but like so many other clinical techniques, it is linked to clinical or health risks, including adverse effects that arise as a result of mistakes and under optimal care during transfusion process **(Davis et al., 2011)**, or maybe as a

result of failure to conduct essential checks and perhaps the assumption that someone else is responsible for safety transfusion **(WHO, 2017)**. Transfusion risks refer to the reactions or complications during or after blood transfusion, besides the fact of being related to it. These include bacterial contamination, acute hemolytic effects caused by ABO system incompatibility, anaphylaxis reactions, and fluid overload. These complications may be non-immune connected with human error; or immune, linked to the organic response mechanisms to the blood transfusion **(de Mattia & de Andrade, 2016)**.

The conducting of blood transfusion has five stages, four of them related to nursing performance which includes elaboration before collecting blood units from the storage site, blood bag gathering, pre-transfusion measures, and post-transfusion measures and monitoring to preserve patients' safety **(Bielby et al., 2011)**. The nurse must remain with the patient and carefully monitor him during the first 15 minutes for transfusion reactions because it usually appears before the first 50 mL of the unit has been transfused. If a reaction occurs, promptly stop the transfusion and report the practitioner, measure vital signs 15 minutes after the beginning of the transfusion and any time that the patients' status warrants during the transfusion, closely monitor the flow rate, and check the IV insertion area for signs of infiltration **(Kluwer, 2016)**.

Blood transfusion is a complicated multistep operation involving members of several different professional groups; nurses, doctors, laboratory scientists as well as, donors and recipients **(WHO, 2017)**. Nurses have a critical role in ensuring blood transfusion safety because the nursing team is accountable for knowing the indications for transfusions, checking data to prevent errors, guiding patients on blood transfusion, detecting, acting in compliance with transfusion reactions, and documenting the procedure **(Tavares et al., 2015)**. The nurse on the front line of patient care must be skillful at administering blood products safely and handling adverse reactions promptly and with confidence **(Connelly & Powers, 2013)**.

The nurse should be conscious of his/her responsibility for the competency of care given to the patients, the institution, ethics, laws, and occupational standards, as well as performance that contributes to the appraisement of care and the patients' satisfaction **(Ndambuki, 2013)**. Competency of care are indicating that the right things are being done right, improving the outcomes for patients, their families, and their communities **(Burhans & Alligood, 2010)**; it is an optimal equilibrium between possibilities realized and a framework of norms and values. The competency of nursing care make a vital difference in patient outcomes and safety, optimal nurse staffing is a critical element in improving the quality of patients' care and preventing complications **(Aslani et al., 2010)**.

Nursing performance competency and safety of transfusion is based on nurses' information and skillfulness, which lead to decreasing the hazards of blood transfusion **(Belousov, 2018 & Al Nasr, 2016)**. Nurses with evidence-based knowledge on the principles of blood transfusion are probable to carry on safe blood transfusions and help to prohibit transfusion-associated morbidities and mortalities. Nurses are required to know every step of a safe blood transfusion process thoroughly. The outcomes of studies that evaluating nurses' blood transfusion knowledge reveal a necessity to improve nurses' knowledge, practice, and competency. Some studies have shown that nurses did not have adequate information concerning blood transfusion criteria, prevention of possible adverse reactions, and safe blood transfusion practices **(Lahlimi et al., 2015)**.

It is very important for nurses to receive theoretical and practical education to prepare them for their tasks as nursing care specialists. Nursing staff needs to engage in plenty of ongoing training as well the needs of patients continue to change and there are new developments in the procedure, the education of nurses never stops as they are required to continually master new skills and concepts throughout their career **(Taher et al., 2013)**. Hence the present study was aimed to evaluate the effect of the educational bundle on securing nursing competency toward safe blood transfusion.

Significance of the study:

Blood Transfusion is a daily practice in clinical departments, despite its vital role in saving lives and enhancing patients' life, it is associated with risks **(Kafando et al., 2017)**. WHO reported in 2011 that over 9 million patients in 90 different countries receive blood yearly **(Flood & Higbie, 2016)**.Failure to follow correct procedures, inadequate processes, omitting steps, or wrong procedure being performed; inadequate knowledge about safe blood transfusion practices among nurses can lead to adverse consequences in the transfusion recipients **(Bellamy, 2018)**. According to most reports in 2019 blood transfusion errors continue to occur, which represents 84.1%, possibly preventable an account 5.6% and not preventable 10.3%. Moreover, transfusion-related deaths represent 29.4%; the most prevalent cause of transfusion-related deaths was the transfusion-associated circulatory overload, and patient identification errors when taking the blood sample **(Annual Serious Hazards of Transfusion Report (SHOT), 2019)** which represent 42.6%. The safety and efficiency of the transfusion operation are dependent on the knowledge and practices of nurses who carry out the procedure. The bad practice may lead to preventable hazards that may threaten patients' integrity. Published studies indicated that nurses' performance varied across contexts and high pointed that patients received under optimal care and improper transfusion culminated in death or morbidity **(Kozier et al., 2018)**. To improve health professionals' performance, persistent training of health workers involved in blood transfusion should be an integral part of the work plans of the health care facilities **(Kafando et al., 2017)**.

Aim of the Study:

This study aimed to evaluate the effect of the educational bundle on securing nursing competency toward safe blood transfusion through:

- Assessing nurses' knowledge and practice competency regarding safe blood transfusion.
- Design and implement an educational bundle based on previously assessed nurses' actual needs regarding safe blood transfusion.
- Evaluating the effect of the educational bundle on nurses' knowledge and practice competency regarding safe blood transfusion.
- Determine the statistical relation between nurses' knowledge, and practice competency scores regarding safe blood transfusion.

Research hypotheses:

To achieve the study's aim the following research hypotheses were formulated:

1. The educational bundle will improve the nurses' knowledge and practice competency regarding safe blood transfusion.
2. There will be a statistically significant relation between nurses' knowledge, and practice competency scores regarding safe blood transfusion pre-post implementation of the educational bundle.

Subjects and Method:

Research Design:

A quasi-experimental, pre-post design was used to achieve the study's aim.

Settings:

The study carried out in hematological, emergency & oncology departments at Zagazig University Hospitals, Al Sharkia governorate, Egypt.

Subjects:

All available nurses (50), who work in the previously mentioned settings; providing direct clinical care to patients, and accept to participate in the study.

Tools of Data Collection:

Tool I: A Structured Interviewing Questionnaire: It was designed by the researchers after reviewing related literature to assess the nurses' socio-demographic characteristics and knowledge about blood transfusion. It had the following two sections:

(1) Socio-demographic characteristics: includes 12 closed-end questions covered studied nurses' age, gender, marital status, qualifications, residential area, salary, general experience years in nursing and blood transfusion, number of sharing in blood transfusion per week, attendance of training courses regarding safe blood transfusion, and the presence of written guidance about safe blood transfusion policy in the ward.

(2) Nurses' knowledge questionnaire: This part was used to assess nurses' knowledge about blood transfusion, its adverse reactions, and their management of reactions. It was adapted from **Hijji et al., (2012)** and developed by the researchers after reviewing previous and recent available related literatures **(Abd Elhy & Kasemy, 2017; Kumarage et al., 2017; Kozier et al., 2018)**. This part integrated "49" questions in the form of multiple-choice and true/false questions, it covered five areas of nurses' knowledge as the following:

1. **Nursing activities before initiation blood transfusion**, it consisted of 9 questions, five of them related to the patient preparation as "the appropriate time to make assures from the presence and patency of IV access line of blood transfusion, a suitable time to request a blood package from the blood bank, the immediate nurses' decision toward incomplete physician's order about blood transfusion, the information should be given to the patient before blood transfusion, and time of recording the baseline vital signs before initiating blood transfusion", and four questions related to the blood package requisition as "the information should a nurse have to ensure collecting the right blood for the right patient, the suitable methods to transport blood package from the blood bank to department, the first action of the nurse when collecting A^- unit of blood from the bank for a patient whose blood group is A^+ positive, and the nurses' action when forget to transfuse blood package for 1-2hr in an emergency situation".
2. **Nursing activities for initiation of blood transfusion** consisted of 7 questions about the most important nursing actions with regards to the patient that the nurse must do for initiate transfusion, the cases in which blood warming must indicate prior transfusion, the best time to start transfusion when received blood in the department at 4.00 PM, the method of handling blood bag in the ward after obtaining it, the most important three steps to properly identify the right patient before initiating the transfusion, the suitable filter size of blood transfusion set, and the cases in which acceptable not to check patients' details at the bedside before blood administration.
3. **Nursing activities during and after blood transfusion** consisted of 11 questions about the routine nursing activities that should perform just after starting the blood transfusion until it ends, complications of rapid administration of cold blood through the central venous route in the right atrium, the rate to initiate blood transfusion for the adult patient, the maximum duration to use blood administration set in continuous multiple transfusions, the maximum duration for administers a unit of blood completely to the patient, the indications of slow blood transfusion, the solutions/agents can be safely mixed with the transfusion of blood, the time of recording vital signs in the 1^{st}, 2^{nd} and 3^{rd} hour after starting a transfusion at 2:00 PM, and the time and duration of observing the patient for a possible transfusion reaction.
4. **Adverse reactions of blood transfusion** consisted of 10 questions about the common causes of fatal transfusion reactions occurrence, the most complication of blood transfusion, the usual complaints of patients related to transfusion adverse reactions, causes of acute hemolytic reaction, allergic reaction, Febrile, a Non-Hemolytic Reaction, septic reaction, circulatory overload, air emboli, and hypothermia during a blood transfusion.
5. **Nursing management for blood transfusion adverse reactions** consisted of 12 questions related to the nursing

interventions that could minimize the risk of developing acute transfusion reactions, the immediate nursing interventions of acute transfusion reactions, the nursing interventions that protect the patient from blood transfusion complications, the first nursing intervention should take to handle the patients' allergic transfusion reactions, the nursing interventions related to delayed hemolytic reaction, mild and severe febrile non-hemolytic reaction, allergic reaction, bacterial infection, hypocalcemia, hyperkalemia, and air embolism due to blood transfusion.

- **The scoring system for knowledge:** For each item, a correct answer was scored "**1**" and the incorrect "**zero**". For each area of knowledge, the scores of the items were summed-up and the total divided by the number of the items, giving a mean score for the area, which was converted into a percent score. The nurses' knowledge was considered satisfactory if the percent score was ≥80% and unsatisfactory if <80% based on data entering and statistical analysis.

Tool II: Blood transfusion Observational Checklist:

This tool was used to assess the level of nurses' practices regarding safe blood transfusion pre/ post-intervention. It was adopted from **Kozier et al., (2018)**, it included "21steps" categorized as three phases: Preparation Phase "4 steps", which covered the studied nurses' preparation skills before blood transfusion, Performance Phase "14steps", which covered the studied nurses' skills during a blood transfusion, and Terminate Phase of the transfusion"3steps", which covered the studied nurses' skills post to blood transfusion.

- **The scoring system for practice:** A score of "**1**" was given for complete done and a score of "**zero**" was given for incomplete done/not done. For each practice part the scores of the items were summed-up and the total divided by the number of the items, giving a mean score for the area, these scores were converted into percent scores, the practice was considered competent if the percent score was ≥80% and incompetent if <80% based on data entering and statistical analysis. This high cutoff-point was set due to the critical situation the nurse is dealing with, which necessitates a very high level of knowledge and practice.

Tools validity and reliability:

Tools were presented to five experts including three of the medical–surgical nursing field from the Faculty of Nursing, Zagazig University, and two professors of the medical field (hematologists & oncologist professor), to test its content validity, then modifications were done according to the experts' judgment on the clarity of sentences, appropriateness of content and sequence of items. Regarding reliability, the internal consistency reliability of all items of the tools was assessed using Chronbach's Alpha test. It was 0.85 for knowledge (tool I) & 0.87 for practice (tool II).

Ethical consideration

Official permission was obtained from Dean the Faculty of nursing and directors of the previously mentioned settings before starting the study. Strict confidentiality was ensured throughout the study process. All nurses were assured that their data was used for research purposes only and each one was informed of the right to withdraw from the study at any time without giving any cause.

Pilot study:

A pilot study was carried out on 10% (5 nurses) from the total number of nurses to assess the clarity and applicability of the study tools, as well as to estimate the time needed for data collection. Nurses in the pilot study were excluded from the actual study sample since some modifications were done.

Fieldwork:

A. Preparatory stage (Assessment stage):

- The fieldwork was carried out from the beginning of September to the end of December 2018 in the previously mentioned settings after taking official permissions to collect the data. The actual fieldwork started by meeting researchers with nurses throughout the work shifts and obtained their informed consent verbally after introduced researchers to participant's and gave them a complete background

about the study and its aim, then the pre-test format was distributed to collect the required data. The researchers were meeting the participants individually during the morning and afternoon shifts to collecting pretest data through filling the structured questionnaire to assess the nurses' sociodemographic characteristics and knowledge about safe blood transfusion (Tool I), then an observational checklist (Tool II) was collected by the researchers through observing the nurses' during their actual practices with the patients. The average time required for completion of each tool was around 20-30 minutes.

B. Implementation stage (Intervention stage):

- Once the assessment phase was completed, the educational bundle was designed by the researchers according to previously assessed nurses' needs obtained from the assessment phase. It was designed to improving and updating nurses' knowledge and their practice competency about safe blood transfusion. The educational bundle was included different audiovisual aids: a booklet with CD-ROOM, illustrated videos, leaflets, and posters which designed in a simple Arabic language based on the review of relevant literature (nursing textbooks, journals, and internet resources) and experts opinions, also included both knowledge and practical training sessions, furthermore, "WhatsApp" group was constructed for continuously contact between researchers and participants.
- The educational bundle was implemented to nurses through previously mentioned audiovisual aids and theoretical and practical training sessions. The theoretical content was given through four theoretical sessions that covered the blood donation process, blood transfusion process, blood transfusion adverse reactions, nursing management for adverse reactions, safety measures throughout blood transfusion, and nurses' responsibilities toward the transfusion process. While practical content covered demonstration of safe blood transfusion procedure by researchers and re-demonstration by studied nurses through eight practical training sessions at hospital quality management unit, the nurses were divided into ten small groups, each group included from five nurses. Moreover, the researchers were available for more clarification whenever needed throughout a social channel (E. mail & WhatsApp).

C. Evaluation stage (Post-intervention stage):

- To evaluate the effectiveness of the educational bundle on securing nursing competency toward safe blood transfusion, the studied nurses' knowledge and practice was evaluated pre-post implementation of educational bundle. Within four months after complete the explanation and providing the nurse a time to re-demonstrate the procedure; a post-test was done by using the same pretest questionnaire and an observational checklist **(Tool I &Tool II)**. The effectiveness of educational bundle was based on the finding of differences or no between pre-intervention stage (baseline evaluation) and post-intervention stage

Statistical analysis:

Data entry was done using a compatible personal computer. The Statistical Package for Social Sciences (SPSS version 20.0) was used. The content of each tool was coded, categorized, and then analyzed. Data were presented using descriptive statistics in the form of frequencies and percentages for qualitative variables and means and standard deviations for quantitative variables. Quantitative continuous data were compared by using student t-test in case of comparisons between the mean scores of the studied group before and after implementation of the educational bundle. The qualitative studied variables were compared using the Chi-square test. Pearson correlation analysis was used for assessment of the inter-relationships between the nurses' knowledge and practices about blood transfusion. A statistically significant difference was considered when P-value ≤ 0.05 and a highly statistically significant difference were considered when P-value ≤ 0.001.

Results:

Table 1: Socio-Demographic Characteristics of Participants' Nurses (n=50).

Demographic characteristics		No	%
Age :	Less than 25 years	15	30.0
	25-30 years	21	42.0
	31-35 years	4	8.0
	More than 35 years	10	20.0
	Mean ± SD:	**25.20 ± 2.22**	
Gender:	Male	4	8.0
	Female	46	92.0
Marital state:	Married	37	74.0
	Unmarried	13	26.0
Qualification:	Secondary nursing school	16	32.0
	Technical institute	33	66.0
	Bachelor	1	2.0
Residence:	Urban	49	98.0
	Rural	1	2.0
Salary:	Enough	37	74.0
	Not enough	13	26.0
Attendance of workshops or training program about safe blood transfusion:	Yes	32	64.0
	No	18	36.0
The Presence of written guidance about safe blood transfusion policy:	Yes	39	78.0
	No	11	22.0
If yes, the nurses read the written guidance:	Yes	32	64.0
	No	18	36.0

Table 1 shows that 42 % of participant nurses was 25-30 years old, the majority of them (92%, and 98% respectively) were females and lives in urban areas, about three quarters were married and had enough salary (74%), two-thirds of them had a nursing technical institute (66%). Nearly two-thirds had attended previous workshops related to blood transfusion (64%), more than three fourth reported that written guidance for safe blood transfusion in the ward was available (78%) and 64% of them were read it.

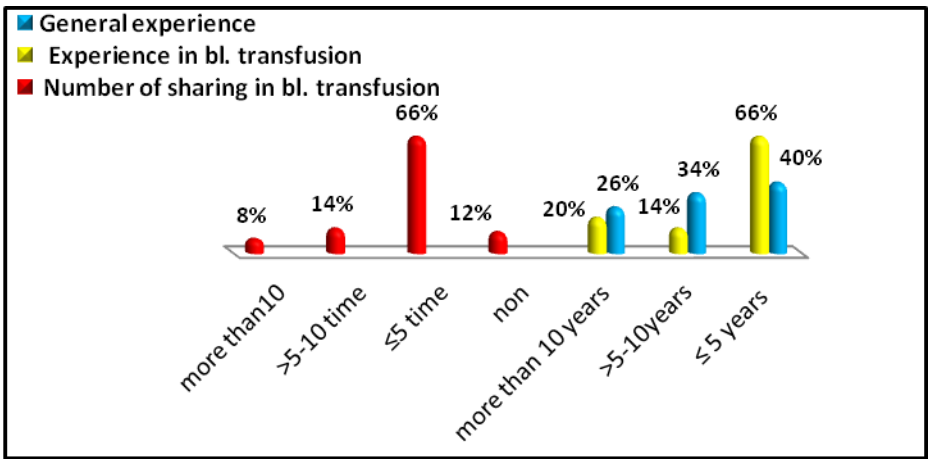

Figure 1: Distribution of participant nurses according to their experiences (n=50)

Figure 1 demonstrates that 40% of the studied nurses had general experience in the nursing field ≤ 5 years, 34% had from >5-10 experience years, while only 26% of them had more than 10 experience years. Regarding nurses' experience years in blood transfusion practice, the same figure reveals that 66% of nurses had ≤5 experience years in blood transfusion, and only 20% of them had more than 10

experience years. Also, this figure illustrates that 66% of nurses were sharing in blood transfusion less than or equal 5 times weekly, while only 8% of them were sharing more than 10 times weekly.

Table 2: The satisfactory knowledge of participants' nurses about nursing activities before initiation blood transfusion pre and post-intervention (n=50):

Items	Satisfactory Knowledge ≥ 80				χ^2	P- value
	Pre - intervention		Post - intervention			
	No	%	No	%		
Patient preparation:						
The appropriate time to assure from the IV access line presence.	35	70.0	50	100.0	3.556	.059*
A suitable time to request a bl. package from the blood bank.	33	66.0	47	94.0	9.800	.002**
The nurses' decision toward incomplete physician's order about bl. transfusion.	3	6.0	40	80.0	37.000	.000**
The information is given to the patient before bl. transfusion.	43	86.0	49	98.0	4.500	.034*
The time of recording the baseline vital signs before initiating bl. transfusion.	36	72.0	49	98.0	11.267	.001**
Blood package requisition:						
The information should a nurse have to ensure collecting the right blood for the right patient.	18	36.0	46	92.0	28.000	.000**
The suitable methods to transport bl. package from the blood bank to the department.	35	70.0	49	98.0	14.000	.000**
The nurses' action when collecting A^- unit of blood from the bank for a patient whose blood group is A^+ positive.	4	8.0	30	60.0	26.000	.000**
The nurses' action when forget to transfuse bl. package for 1-2hr.	21	42.0	43	86.0	18.615	.000**
Total	**25**	**50.0**	**45**	**90.0**	**36.28**	**.000****

(*) Statistically significant difference at p≤ 0.05 (**) highly statistically significant difference at p≤ 0.01

Table 2 indicates that only half of participants' nurses (50%) had total satisfactory knowledge about nursing activities before initiation of blood transfusion (patient preparation and blood package requisition) pre-intervention of the educational bundle, while most of them (90%) had a total satisfactory knowledge post-intervention of the educational bundle, with a highly statistically significant difference and improvement post-intervention in most knowledge items especially related to nurses' decision toward incomplete physicians' order for blood transfusion and their action when collecting A^- unit of blood from the bank for a patient whose blood group is A^+ (p=.000).

Table 3: The satisfactory knowledge of participants' nurses about nursing activities for initiate blood transfusion pre and post-intervention (n=50).

Items	Satisfactory Knowledge ≥ 80				χ^2	P-value
	Pre - intervention		Post - intervention			
	No	%	No	%		
The most important nursing actions with regards to the patient that the nurse must do for initiate transfusion	10	20.0	47	94.0	37.000	.000**
Indications for blood warming before transfusion.	33	66.0	47	94.0	9.800	.002**
The best time to start transfusion when received blood in the department at 4.00 PM.	21	42.0	35	70.0	10.889	.001**
The method of handling blood bag in the ward after obtaining it.	4	8.0	34	68.0	30.000	.000**
The most important three steps to properly identify the right patient for initiating the transfusion.	44	88.0	50	100.0	6.000	.014**
The suitable filter size of blood transfusion set.	4	8.0	23	46.0	17.190	.000**
The cases in which acceptable not to check patients' details at the bedside before blood administration.	32	64.0	50	100.0	18.000	.000**
Total	**22**	**44.0**	**41**	**82.0**	**49.000**	**.000****

(*) Statistically significant difference at p≤ 0.05 (**) highly statistically significant difference at p≤ 0.01

Table 3 illustrates that only 44% of studied nurses had a total satisfactory knowledge pre-intervention of the educational bundle about nursing activities for initiation blood transfusion, while the majority (82%) of them had satisfactory knowledge post-intervention, with a highly statistically significant difference and improvement post-intervention compared to pre-intervention in all knowledge items especially was related to the method of handling blood bag in the ward after obtaining it and the suitable filter size of blood transfusion set (*p*=.000).

Table 4: The satisfactory knowledge of participants' nurses about nursing activities during and after blood transfusing pre and post-intervention (no=50).

Items	Satisfactory Knowledge ≥ 80				χ^2	P-value
	Pre - intervention		Post – intervention			
	No	%	No	%		
Routine nursing activities perform just after starting blood transfusion until complete.	28	56.0	49	98.0	18.182	.000**
The complications of rapid administration of cold blood through the central venous route in the right atrium.	18	36.0	43	86.0	23.148	.000**
Rate of initial blood transfusion for adult patient.	17	34.0	39	78.0	22.000	.000**
The maximum duration to use blood administration set in continuous multiple transfusions.	3	6.0	24	48.0	19.174	.000**
The maximum duration for administers a unit of blood completely to the patient.	26	52.0	44	88.0	18.000	.000**
The indications of slow blood transfusion.	20	40.0	37	74.0	12.565	.000**
The solutions/agents can be safely mixed with the transfusion of blood.	19	38.0	37	74.0	10.125	.001**
The time of measuring vital signs in the 1st hour after starting a transfusion.	44	88.0	48	96.0	2.667	.102
The time of measuring vital signs in the 2nd hour after starting a transfusion.	24	48.0	42	84.0	14.727	.000**
The time of measuring vital signs in the 3rd hour after starting a transfusion.	19	38.0	40	80.0	19.174	.000**
The time and duration of observing the patient for possible adverse reactions during and after transfusion.	16	32.0	36	72.0	18.182	.000**
Total	**22**	**44.0**	**40**	**80.0**	**50.000**	**.000****

(*) Statistically significant difference at p≤ 0.05 **(**) highly statistically significant difference at p≤ 0.01**

Table 4 indicates that slightly more than two-fifth of studied nurses (44%) had a total satisfactory knowledge pre-intervention of the educational bundle about nursing activities during and after blood transfusion, while the majority of them (80%) had total satisfactory knowledge post-intervention, with a highly statistically significant difference and improvement in most nurses' knowledge items post-intervention compared to pre-intervention especially was related to the maximum duration to use blood administration set in continuous multiple transfusions (*p*=.000).

Table 5: The satisfactory knowledge of participants' nurses about adverse reactions of blood transfusion pre and post-intervention (no=50).

Items	Satisfactory Knowledge ≥ 80				χ^2	P-value
	Pre - intervention		Post - intervention			
	No	%	No	%		
Common Causes of fatal transfusion reactions occurrence.	21	42.0	38	76.0	12.565	.000**
Most complication of blood transfusion	9	18.0	21	42.0	7.200	.007**
Usual complaints of patients related to transfusion adverse reaction	24	48.0	44	88.0	16.667	.000**
Causes of acute hemolytic reaction.	26	52.0	49	98.0	23.000	.000**
Causes of an allergic reaction.	10	20.0	38	76.0	26.133	.000**
Causes of Febrile, a Non-Hemolytic Reaction.	22	44.0	46	92.0	22.154	.000**
Causes of septic reaction.	25	50.0	45	90.0	20.000	.000**
Causes of circulatory overload.	29	58.0	48	96.0	19.000	.000**
Causes of transfusion air emboli.	37	74.0	45	90.0	5.333	.021*
Causes of transfusion hypothermia.	44	88.0	47	94.0	1.286	.257
Total	**25**	**50.0**	**42**	**84.0**	**40.091**	**.000****

(*) Statistically significant difference at p≤ 0.05 **(**) highly statistically significant difference at p≤ 0.01**

Table 5 clarifies that there were a highly statistically significant difference and improvement in most nurses' knowledge items about adverse reactions of blood transfusion as well as in total knowledge score post-intervention of educational bundle compared to their knowledge pre-intervention ($p \leq 0.01$), also the major satisfactory knowledge of nurses pre-intervention was about causes of hypothermia during a blood transfusion, that had improved in post-intervention but not reaches to statistical significance (p=.257).

Table 6: The satisfactory knowledge of participants' nurses about Nursing management of blood transfusion adverse reactions pre-post-intervention (no=50).

Items	Satisfactory Knowledge ≥ 80				χ^2	P-value
	Pre - intervention		Post - intervention			
	No	%	No	%		
Nursing interventions that minimize the risk of acute transfusion reactions.	38	76.0	44	88.0	13.520	.000**
Immediate nursing interventions for acute transfusion reactions.	47	94.0	50	100.0	3.000	.083
Nursing interventions that protect the patient from bl. transfusion reactions.	16	32.0	47	94.0	27.457	.000**
First nursing intervention should take to handle the patients' allergic transfusion reactions.	11	22.0	36	72.0	23.148	.000**
Nursing interventions related to Delayed Hemolytic reaction.	16	32.0	39	78.0	21.160	.000**
Nursing interventions related to mild Febrile non-hemolytic reaction.	21	42.0	42	84.0	21.000	.000**
Nursing interventions related to severe Febrile non-hemolytic reaction.	23	46.0	43	86.0	16.667	.000**
Nursing interventions for an allergic blood transfusion reaction.	21	42.0	46	92.0	25.000	.000**
Nursing interventions related to blood transfusion bacterial infection.	28	56.0	48	96.0	18.182	.000**
Nursing interventions related to hypocalcemia due to blood transfusion.	35	70.0	44	88.0	5.400	.020*
The nursing interventions related to hyperkalemia due to blood transfusion.	13	26.0	27	54.0	9.800	.002**
The nursing interventions related to air embolism of blood transfusion.	15	30.0	37	74.0	14.700	.000**
Total	24	48.0	41	82.0	49.000	.000**
Overall nurses' knowledge	**28**	**56.0**	**48**	**96.0**	**18.182**	**.000****

(*) Statistically significant difference at p≤ 0.05 **(**) highly statistically significant difference at p≤ 0.01**

Table 6 illustrates that less than half of nurses (48.0%) had a total satisfactory knowledge about nursing management of blood transfusion adverse reactions pre-intervention of the educational bundle, while post-intervention, the majority of them (82.0%) had a total satisfactory knowledge about it, with a highly statistically significant difference and improvement post-intervention in most nurses' knowledge items especially was related to the first nursing intervention should take to handle the patients' allergic transfusion reactions (*p*=.000). Generally, the overall satisfactory nurses' knowledge about safe blood transfusion pre-intervention was 56% that improved to 96% in post-intervention of the educational bundle.

Table 7: The satisfactory total practices of safe blood transfusion pre and post-intervention among participants' nurses (n=50).

Blood transfusion phases	Competent Practice ≥ 80				χ^2	P- value
	Pre - intervention		Post - intervention			
	No	%	No	%		
Preparation Phase[4]*	31	62.0	44	88.0	37.356	.000**
Performance Phase [14]*	33	66.0	43	86.0	47.000	.000**
Terminate Phase of the transfusion[3]*	36	72.0	46	92.0	50.000	.000**
Overall nurses' practice	**33**	**66**	**45**	**90**	**47.563**	**.000****
	Mean ± SD 8.2±2.1 Rang =1-21					

Maximum** **χ^2 = Chi-square test** * Highly statistically significant difference at p≤ 0.01**

Table 7 shows that there were a highly statistically significant difference and improvement of nurses' practices about safe blood transfusion in all blood transfusion procedure phases post-educational bundle intervention compared to pre-intervention (*p*=.000). Generally, the overall competent nurses' practice of safe blood transfusion pre-intervention was 66% that improved to 90% in post-intervention of the educational bundle with Mean ± SD 8.2±2.1 and rang from 1-21.

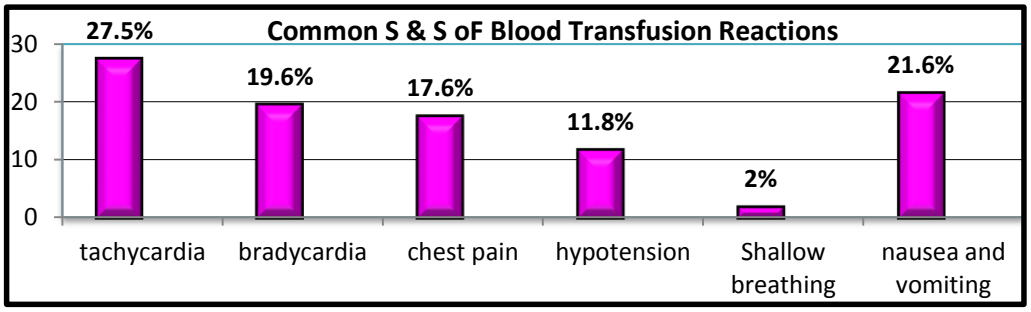

Figure 2: Distribution of the commonest signs and symptoms of blood transfusion adverse reactions as reported by participants' nurses (n=50)

Figure 2 demonstrates that tachycardia, nausea, and vomiting followed by bradycardia and chest pain was the commonest signs and symptoms of blood transfusion adverse reactions as reported by participants' nurses (27.5%, 21.6%,19.6%, &17.6%) respectively, while the less common signs and symptoms were shallow breathing followed by hypotension (2% & 11.8%) respectively.

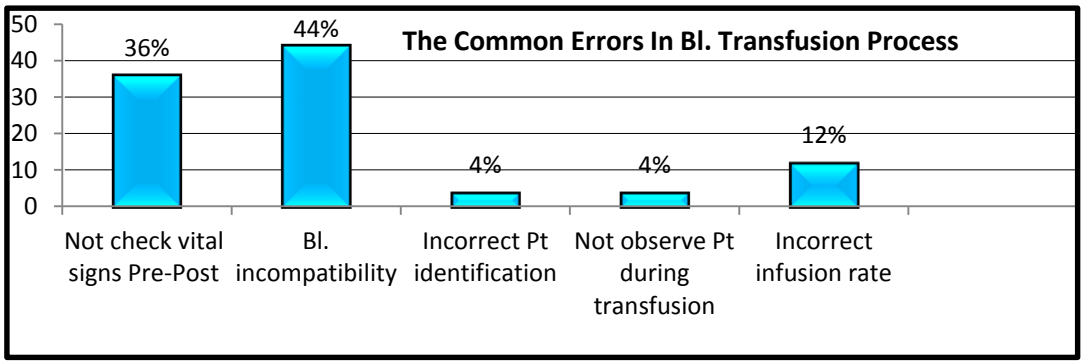

Figure 3: Distribution of common errors in blood transfusion process as reported by participants' nurses (n=50)

Figure 3 clarifies that the commonest errors in the blood transfusion process that lead to an adverse reaction as reported by participants' nurses included the blood incompatibility followed by not check vital signs pre, during and post-transfusion was (44%, & 36%) respectively. The other common errors that may occur were incorrect infusion rate, and incorrect patient identification, or not observing the patient during transfusion (12% & 4%) respectively.

Table 8: Relations between total satisfactory knowledge, practice, and demographic characteristics of participants' nurses in the pre-intervention phase (no=50)

Items	Age	Qualification	General experience years	Experience in blood transfusion	Sharing in blood transfusion	Attendance training courses	Total Knowledge pretest	Total practice pretest
Age: - Pearson Correlation	1	-.534**	.659**	.652**	.211	-.087-	-.268-	-.407**
- Sig. (2-tailed)	--	**.000**	**.000**	**.000**	.141	.547	.060	**.003**
Qualification: - Pearson Correlation	-.534**	1	-.655**	-.690**	-.286*	.117	.385**	.252
- Sig. (2-tailed)	**.000**	--	**.000**	**.000**	**.044**	.420	**.006**	.077
General experience years: - Pearson Correlation	.659**	-.655**	1	.738**	.279*	-.285*	-.413**	-.254-
- Sig. (2-tailed)	**.000**	**.000**	--	**.000**	**.050**	**.045**	**.003**	.075
Experience in bl. transfusion: - Pearson Correlation	.652**	-.690**	.738**	1	.374**	-.192-	-.369**	-.287*
- Sig. (2-tailed)	**.000**	**.000**	**.000**	--	**.007**	.180	**.008**	**.044**
No. of sharing in bl. transfusion: - Pearson Correlation	.211	-.286*	.279*	**.374****	1	-.126-	-.024-	.163
- Sig. (2-tailed)	.141	**.044**	**.050**	**.007**	--	.383	.870	.257
Attendance training courses: - Pearson Correlation	-.087-	.117	-.285*	-.192-	-.126-	1	.173	.040
- Sig. (2-tailed)	.547	.420	.045	.180	.383	--	.230	.782

**** Correlation is significant at the 0.01 level (2-tailed).** *** Correlation is significant at the 0.05 level (2-tailed).**

Table 8 clarifies that there was a statistically significant relation of total nurses' knowledge with their qualification, general experience years in nursing, and blood transfusion in the pre-intervention phase of the educational bundle, as well as there, was a statistically significant relation of participant nurses' practice with their age and experience years in blood transfusion. Furthermore, there was a statistically significant relation of various demographic characteristics with each other for participant nurses.

Table (9): Correlations between participants' total satisfactory knowledge and practice pre and post intervention (no=50).

Correlations		Pre total knowledge	Post total knowledge	Pre total practice	Post total practice
Pre total knowledge:	Pearson Correlation	1	.243	**.467****	.233
	Sig. (2-tailed)	--	.089	**.001**	.103
Post total knowledge:	Pearson Correlation	.243	1	.151	**.353***
	Sig. (2-tailed)	.089	--	.294	**.012**
Pre total practice:	Pearson Correlation	**.467****	.151	1	**.378****
	Sig. (2-tailed)	.001	.294	--	**.007**
Post total practice:	Pearson Correlation	.233	**.353***	**.378****	1
	Sig. (2-tailed)	.103	**.012**	**.007**	--

**** Correlation is significant at the 0.01 level (2-tailed).** *** Correlation is significant at the 0.05 level (2-tailed).**

Table 9 clarifies that there was a positive statistically significant correlation between total nurses' knowledge and practice regarding safe blood transfusion pre and post-intervention of the educational bundle as well as between their total pre/post practices.

Discussion:

Blood is a pivotal component of health care, utilized in a wide range of clinical servings, it most frequently applied for supportive care in heart, blood vessels, and transplant operations, massive injuries, and treatment for solid and hematological malignancies; also, it is more often used to handle pregnancy-related problems and severe infancy anemia. oncoming to enough, obtain supplies of blood and its products and safe transfusion services is the main part of any powerful health system and is a substantial component of efforts towards fulfilling the goal of comprehensive health covering **(WHO, 2017)**.

Millions of patients need blood and its products transfusions all around the world **(Hijji et al., 2013)**. So, making mistakes in transfusion and insufficient control of patients who receive blood during the transfusion can lead to death for such patients **(Soc Guidelines, 2012)**. Nursing staff plays a substantial role in the transfusion operation by referring patients before and after-transfusion, patients' assessment, blood sampling, and conducting the blood transfusion, and as accountable for the final bedside check before transfusion, have the last chance to prevent an unsafe transfusion. Lack of information about safe blood transfusion may cause nurses to perform unsafe blood transfusion practices or to give the incorrect blood components and lead to adverse results in the patients **(SHOT, 2019)**.

One of the most important medical procedures is the appropriate blood transfusion method, which is dangerous without adequate and specific skills **(Yousefian et al., 2015)**. According to Serious Hazards of Transfusion (SHOT) program about 70% of all reported adverse events are recognized to the improper transfused blood component. Developing blood transfusion policy and strategy, including appropriate guidelines as well as, providing training programs for nursing staff is an essential domain for a successful transfusion, improving the quality of health care, and acquiring new knowledge and skills **(Illingworth & Gray, 2013; Palmer, 2015)**. Training programs should be given in conjunction with a guided clinical practice, where nurses can apply blood transfusion and develop skills safely and competently **(Tavares et al., 2015)**. A discussion of the current results will cover the following main areas:

Regarding the Socio-demographic characteristics of studied nurses, the current study found that the highest percentage of

studied nurses was between 25-30 years old, and the majority of them were females. This may be attributed to that the majority of nursing force working in Zagazig university hospitals are females, this finding may due to that nursing education in the past was specialized only to females. These findings agree **Yesilbalkan et al., (2019)**, who reported in a study in Turkey, about "Assessing knowledge of nurses on blood transfusion" that the mean age of the participants was 27.36, and the majority of the nurses were female. Also, **Abd Elhy & Kasemy (2017)** showed that the majority of the studied sample was female. Moreover, **Kavaklioglu et al., (2017)** mentioned that 71% of nurses were aged ≤29 years, and 94% of them were female. While these findings disagree with **Abolwafa et al., (2018)**, who reported that 45% of nurses' age from 31: 40 years, but the agreement with him in the gender of nurses as 85.0% of nurses in his study were females.

The current study found that nearly two-thirds of nurses had attended previous training or workshops related to safe blood transfusion. This finding congruent with **Yesilbalkan et al., (2019)**, who reported that more than half of studied nurses were previously trained about transfusion, also agree with **Kavaklioglu et al., (2017)**, who mentioned that 79% of participants had received training about the transfusion of blood and blood products. Moreover, **Tavares et al., (2015)**, assert on that a coaching program should be given in incorporation with a guided clinical practice, where new nursing staff to apply blood transfusion can develop skills safely and competently. **Kabinda et al., (2014)** added that traineeship and teaching are paramount for all staff involved in the transfusion operation and as they diminish transfusion mistakes. Similarly, this gave support to the rationale of the present study result.

While this finding is not in agreement with **Abolwafa et al., (2018)**, who reported that all of the studied nurses didn't receive any training courses about blood transfusion, **Khalaf et al., (2017)**, who indicated that only about one-third of the studied nurses had received training courses related to transfusion, and **Tetteh Ebenezer (2015)** found that 72.1% of the nurses claimed not to have had any training session in issues concerning blood transfusion. Moreover, **Khalil et al., (2013)**, revealed that the majority of nurses did not join any preceding teaching program about blood transfusion. Additionally, **Hijji et al., (2012a)** in their study demonstrated that 85% of nurses reported that they had never received any in-service training in this field.

Related qualifications, the current results showed that two-third of studied nurses had a nursing technical institute diploma degree, while only 2% of them had a bachelor. This finding might be attributed to a shortage of high graduated nurses attached and working at Zagazig University Hospital who were always busy with administrative duties. These findings agree with **Abolwafa et al., (2018)**, who revealed that the highest percentage of studied nurses have technical institute education level. While this result not proportionate with **Yesilbalkan et al., (2019)**, who reported that the plurality of the nurses had a bachelor's degree and was not members of a professional association, and with **Abd Elhy & Kasemy (2017)**, who reported that plurality of studied subjects had bachelor's in nursing. Also, **Silva et al., (2016)** stated that more than two-thirds of the studied subjects were female that has a bachelor's degree in nursing.

Concerning to presence of written guidance about safe blood transfusion policy in the ward, the current results showed that more than three fourth of nurses reported that written guidance for safe blood transfusion in the ward was available and nearly two-thirds of them were read it. This finding disagreement with **Tetteh Ebenezer (2015)**, who revealed that the respondents were not too sure of having a unit protocol guide for administering blood transfusion, also, the nurses were not convinced that the available protocol was clear, concise, and simple to follow.

Regarding nurses' experiences in the nursing field, the current results showed that two-fifths of the studied nurses had general experience in the nursing field less than or equal 5 years, and one-third of them had >5-10 experience years. This might be due to, that the most common age group of the studied nurses is in the youngest age group ranging between 25-30 years. This finding consistent with

Yesilbalkan et al., (2019), who reported that 80 % of the participants' length of service in the profession varied between 0 and 4 years. Also, **Abolwafa et al., (2018)**, who found that 55% of nurses had from1:5 years of experience. Furthermore, **Kavaklioglu et al., (2017)** showed that 42% of participants had been working at the hospital for 2 to 5 years. Otherwise, **Shafik & Abd Allah (2015)** mentioned that most of the study sample was having experience from 5 - < 10 years in hematology units. Also, **Khalil et al., (2013)** revealed that the plurality of nurses had 5 -<10 years of experience in the medical department. **Elkattan, (2013)** found that more than two-thirds of the total sample under study had experienced less than 10 years. Moreover, **Hajji et al., (2012b)** mentioned that approximately, two-thirds of the nurses were those with five years of clinical experience or less.

Regarding nurses' experience years in blood transfusion practice, the current findings clarified that about two-thirds of nurses had less than or equal 5 experience years in transfusion, and only one-fifth of them had more than 10 experience years. This outcome correlates with **Yesilbalkan et al., (2019)**, who explored that 80 % of the participants' length of service in the clinic varied between 0 and 2 years. Meanwhile, **Tetteh Ebenezer (2015)** indicated that the highest percentage of studied nurses had between 1-5 years' experience, and only 10.7 of them reported that they had 11 years and more working experience in blood transfusion.

About sharing of participant nurses in blood transfusion, the present result illustrated that two-thirds of nurses were sharing in blood transfusion less than or equal 5 times weekly, while only 8% of them were sharing ≥10 times weekly. From the researchers' view that the longer duration of experience in blood transfusion; the number of transfusions per week, and training are effective factors for improving nurses' knowledge and practice levels. These findings agree with **Tetteh Ebenezer (2015)**, who found that half of the nurses, indicated that they had between 1 and 3 blood transfusions per week, whiles only 8.6% said 7-10 per week. Also, **Hijji et al., (2012b)**, clarified that 89% of nurses administered blood transfusions with a hesitancy that ranged from 1-4 times.

Regarding participant nurses' knowledge about nursing activities before initiation blood transfusion (patient preparation & blood package requisition) pre and post-intervention, the present result showed that only half of participants' nurses had total satisfactory knowledge about nursing activities before initiation of blood transfusion pre-intervention of the educational bundle, while most of them had a total satisfactory knowledge post-intervention of the educational bundle, with a highly statistically significant difference and improvement post-intervention in most knowledge items especially related to nurses' decision toward incomplete physicians' order for blood transfusion and their action when collecting A- unit of blood from the bank for a patient whose blood group is A^+. This may be attributed to, that the highest percentage of our participants had fewer experience years in blood transfusion and less sharing in blood transfusion weekly, in addition to that only 2% of them had a bachelor's degree in nursing.

This finding congruent with **Ddungu et al., (2018)**, who revealed that more than 60% of the studied sample acknowledged they lacked knowledge and needed training in transfusion medicine. Also, **Khalaf et al., (2017)** demonstrated that nurses' knowledge about preparation essentials and principles related to blood transfusion, was unsatisfactory in the pre-training phase, but it get better significantly in the post- training phase, this applied to whole associated fields of knowledge. Meanwhile, **Kabinda et al., (2014)** assured that coaching and health teaching are essential for all staff involved in the transfusion operation as it minimizes transfusion errors. Moreover, **Khalil et al., (2013)** revealed that the nurses' information before the health program was generally unsatisfactory. This supported by **Hijji et al., (2012b)**, who mentioned that the majority of nurses lacked awareness of the issue of patient preparation before leaving the ward for blood collection, also indicated that 87.5% of nurses would act on incomplete medical order and that 91% lack knowledge of basic ABO terminology.

Moreover, **Reza et al., (2009)** exhibited that the greater part of nurses their information was insufficient regarding blood and its components which in-turn prevents them from providing competent nursing care through transfusion procedure. While the present finding inconsistent with **Abd Elhy& Kasemy (2017)**, who demonstrated that the plurality of the studied nurses had adequate information related to the elaboration of the patient before blood transfusion, while more than half of them had fair and good information related to blood pack collection, (which include method used to transport blood from the blood bank, knowledge of basic ABO terminology, information to ensure collecting the right blood from the blood bank). Furthermore, **Lee et al., (2016)** stated that about half of the studied sample had adequate knowledge about blood pack collection. Also, **Tetteh Ebenezer (2015)** found that nurses' had excellent knowledge related to patient preparation about blood transfusion. **Yaghoobi et al., (2014)** reported that ≥50 of the studied subjects had a good knowledge before blood transfusion.

Regarding participant nurses' knowledge about nursing activities for initiate blood transfusion pre and post-intervention, the current results showed that that only two-fifths of studied nurses had a total satisfactory knowledge pre-intervention of the educational bundle about nursing activities for initiation blood transfusion, while the majority of them had satisfactory knowledge post-intervention, with a highly statistically significant difference and improvement post-intervention compared to pre-intervention in all knowledge items such as the suitable filter size of blood transfusion set, the best time to start transfusion, indications for blood warming, and steps of properly identify the right patient before initiating transfusion, etc.

These findings in the same line with **Abd Elhy & Kasemy (2017)**, who clarified that most of the studied nurses had pauper knowledge regarding pre-transfusion initiation nursing actions as (steps for patient identification, indications for blood warming, the suitable time to initiate the transfusion, appropriate filter size of transfusion set). Also, **Tetteh Ebenezer (2015)** found that the studied nurses were required further training in key areas like blood administration as 40.0% of them were required further training in the conducting of blood transfusions, 30.7% in sampling and 25.0% were needed training in the collection of blood bags. Moreover the current results consistent with **Hijji et al., (2012b)**, who pointed that the plurality of the nurses had inadequate information about nursing responsibilities before beginning the blood transfusion, and mentioned that only 2% of nurses were alert of all steps they must follow up to correctly identify a patient, 8% of them knew the most excellent practice of starting the transfusion without delay after bringing a unit of blood to the department, and 64% of nurses selected the incorrect filter size, while 10% stated "I do not know".

Also, **Khouri (2011)** mentioned that teaching may consolidate the capability of nurses to be efficient caring practitioners. Furthermore, **Aslani, et al., (2010)** explored that study nurses have good knowing and practical practice of using needles with appropriate diameters but don't have accurate scientific information of blood-heating instruction and methods, and have poor knowledge of the blood transfusion in terms of identification of patients. The researchers have explained that the prevention of mistakes and blood transfusion errors is based on patient identification; so insufficient knowledge is threatening the patient.

Regarding participant nurses' knowledge about nursing activities during and after blood transfusing pre and post-intervention, the current results indicated that slightly more than two-fifth of studied nurses had a total satisfactory knowledge pre-intervention of the educational bundle about nursing activities during and after blood transfusion, while the majority of them had total satisfactory knowledge post-intervention, with a highly statistically significant difference and improvement in most nurses' knowledge items post-intervention compared to pre-intervention especially was related to the maximum duration to use blood administration set in continuous multiple transfusions and administers a unit of blood completely to the patient, the solutions/agents can be safely mixed with the transfusion of blood, the time of measuring vital signs after starting a

transfusion., and routine nursing activities perform just after starting blood transfusion until complete.

This result was in agreement with **Abd Elhy& Kasemy (2017)**, who stated that two-thirds of the participant had pauper knowing related to nursing responsibilities during and after blood transfusion as (activities routinely performed by nurses after starting the blood transfusion, the maximum duration of using a blood administration set and for completing a unit of blood, agents compatible with blood, vital signs recording after starting a transfusion). Furthermore, **Kavaklioglu et al., (2017)** stated that most of the study participants advisable of persistent coaching-related the transfusion of blood and blood products. Also, **Lee et al., (2016)** clarified that about one-third of participants didn't distinguish the timing for measurement vital signs post initiate blood transfusion. Too, **Tavares et al., (2015)** mentioned that the lowest score was recorded for the nursing activities during the transfusion process. In addition, **Khalil et al., (2013)** revealed that an insufficient level of knowledge about blood, blood transfusion, and transfusion complications, which uncover the lack in their training. Additionally, **Asadi-Fakhr et al., (2012)** determined that only half of the employees recorded patients' vital signs during blood transfusion.

Regarding participant nurses' knowledge about adverse reactions of blood transfusion pre and post-intervention, the current results showed that there were a highly statistically significant difference and improvement in most nurses' knowledge items about adverse reactions of blood transfusion as well as in total knowledge score about adverse reactions of blood transfusion post-intervention of educational bundle compared to their knowledge pre-intervention. This improvement may be due to many reasons, knowledge refreshment through the educational bundle, relevance of the booklet content items and easy language of it, and clarity of educational bundle materials.

These findings agree with **Abolwafa et al., (2018)**, who showed a significant improvement in all items of knowledge and practice among the studied nurses after the educational program implementation and this led to an improvement of patients' outcomes. Also, this goes in the same line with **Abd Elhy& Kasemy (2017)**, who clarified that the larger number of the study had indigent knowledge about the complications related to blood transfusion and stated that inadequate teaching, coaching, and inadequate refreshment of knowing continuously lead to bad nurse' knowledge which put patients at threat through and after transfusion. Also, **Saad et al., (2016)** mentioned that overall, the nurses had significant knowledge deficits of complications related to blood transfusion. Since good awareness of transfusion reaction by nurses enables rapid intervention and management, there was a need for a compulsory on-going educational program to improve their knowledge.

Regarding participant nurses' knowledge about nursing management for blood transfusion adverse reactions pre and post-intervention, the current results illustrated that less than half of nurses had total satisfactory knowledge pre-intervention of the educational bundle about it, while post-intervention, the majority of them had total satisfactory knowledge, with a highly statistically significant difference and improvement post-intervention in most nurses' knowledge items especially was related to the first nursing intervention should take to handle the patients' allergic transfusion reactions. Concerning overall satisfactory nurses' knowledge about safe blood transfusion pre-intervention of the educational bundle was 56% that improved to 96% in post-intervention. From the researchers' view, the unsatisfactory knowledge of the studied nurses in the present study before program intervention may be attributed to lack of preparation during the basic education or lack of desire of nurses to acquire new knowledge, overload in the working situation, and lack of persistent training courses related to safe blood transfusion.

The current findings in the same line with **Encan & Akin (2019)**, who found that nurses didn't have sufficient knowledge regarding the causes of blood transfusion reactions or the appropriate precautions and interventions required to prevent or manage blood

transfusion reactions. Meanwhile, **Khalaf et al., (2017)** demonstrated that there were very low levels of knowledge among studied nurses before the enforcement of the program; this was expressly apparent in critical duties such as preparation skills before blood transfusion, cannulation, or central venous access, and nursing actions for all suspected adverse reactions during a blood transfusion. Furthermore, **Lim et al., (2016)** stated that the lowest knowledge score was recorded for "during and post-transfusion nursing responsibilities and management of adverse reactions areas". Moreover, **Javadzadeh Shahshahani (2016)** reported that personnel who participate in the administration of blood components must be trained in transfusion procedures and in the recognition and management of adverse reactions. Too, **Saad et al., (2016)** mentioned that the majority of the nurses were aware of the usual presenting complaint of a mild allergic reaction but very few nurses knew the first action in handling this case and only 49.5% of them knew the nursing intervention to minimize the risk of acute transfusion reactions.

Regarding participant nurses' practice of safe blood transfusion pre and post-intervention of the educational bundle, the current results showed that there were a highly statistically significant difference and improvement of nurses' practices in all phases of blood transfusion procedure post-intervention compared to pre-intervention. Concerning overall competent nurses' practice of safe blood transfusion, pre-intervention was 66% that improved to 90% in post-intervention of the educational bundle. This finding goes in line with **Encan, & Akin (2019)**, who stated that nurses require evidence-based professional knowledge and skills to improving their competency, and need adequate practice to, improves therapeutic effects of blood transfusion and decreases transfusion-related adverse reactions. So, in the process of ensuring safe blood transfusion, monitoring and safe practices have huge importance. Moreover, **Sapkota et al., (2018)** noticed that the plurality of the sample had scanty information related to blood transfusion and clarified that lacking education, traineeship programs lead to weak nurses' knowledge regarding transfusion.

Meanwhile, **Islami (2018)** reported that most of the nurses in his study had insufficient knowledge and intermediate performance, and concluded that there was necessary to improve nurses' level of knowledge and performance to ensure the safety of blood transfusion and suggested that an intervention can be improved; update nurses' knowledge and acquisition competent practices related to such topic. Moreover, this finding congruent with **Khalaf et al., (2017)**, who exhibited that 88.8% of the studied nurses, had inefficient practices before the enforcement of the program as a contrast to after enforcement of the program, where 87.5% of them had efficient practices. These findings may reflect the positive effect of the educational bundle to achieve the main goal of this study and may help increase the self-confidence of studied nurses to make the right decisions during urgent situations such as blood transfusion reaction.

Regarding the common signs and symptoms of blood transfusion adverse reactions as reported by participants' nurses, the current results demonstrated that tachycardia, nausea, and vomiting followed by bradycardia and chest pain was the commonest signs and symptoms of blood transfusion adverse reactions as reported by participants' nurses, while the less common signs and symptoms were shallow breathing followed by hypotension. The decrease in an enumeration of common signs and symptoms of bl. transfusion adverse reactions may be attributed to, that two-thirds of our participants had a fewer experience years in blood transfusion or less sharing weekly in it as clarified in figure1. This result compatible with **Dubey et al., (2013)**, who declared that majority of nurses, had good knowledge about signs and symptoms of blood transfusion reactions. Also, **Thomas & Hannon (2010)** added that many transfusion reactions are unrecognized and unreported by both nurses and physicians, so the experience and training of the nurses in recognizing and responding to the signs and symptoms of transfusion reactions were important.

Regarding the common errors in the blood transfusion process, the current results clarified that the commonest errors in the blood transfusion process that lead to an adverse reaction as reported by participants' nurses included blood incompatibility followed by not check vital signs pre, during, and post-transfusion. The other common errors that may occur were incorrect infusion rate, incorrect patient identification, or not observing the patient during transfusion. This result is agreeable with **Ddungu et al., (2018)**, who revealed that almost the entire studied sample indicated identification error as the most common cause of fatal transfusion reactions. Meanwhile, **Kavaklioglu et al., (2017)** stated that the need to confirm the patient's identity and the type of blood products was corroborated by 91% of nurses.

This result supported by **Tetteh Ebenezer (2015)**, who found that the commonest errors committed by the nurses in the blood transfusion process included the non-checking of vital signs before, during, and after transfusion, blood incompatibility, and wrong identification of patients, followed by non-monitoring of patients given a blood transfusion, non-reporting of complications and adverse reactions, and high rate of blood transfusion. Also, **Kabinda et al., (2014)** reported that coaching and teaching are essential for all staff involved in the transfusion procedure and as they depreciate transfusion errors. While this finding inconsistent with **Saad et al., (2016)**, who mentioned that only 33.5% were aware that patient identification error from the common cause of fatal transfusion reaction. Furthermore, **Dubey et al., (2013)** mentioned that majority of nurses had monitoring patient vital signs before, during, and after blood transfusion.

Regarding the relation between total satisfactory knowledge, practice, and demographic characteristics of participants' nurses in the pre-intervention phase of the educational bundle, the current result clarified that there was a statistically significant relation of total nurses' knowledge with their qualification, general experience years in nursing and blood transfusion, as well as there was a statistically significant relation of participant nurses' practice with their age and experience years in blood transfusion. Furthermore, there was a statistically significant relation of various demographic characteristics with each other for participant nurses. This result consistent with **Abolwafa et al., (2018)**, who revealed that there was a statistically significant correlation between the total score of nurses' knowledge, practice pre-program implementation and age, years of experience, and educational level. Moreover, **Lee et al., (2016)** found significant relations between socio-demographic characters as age, years of service with total knowledge scores. Also, this result is supported by **Shafik & AbdAllah (2015)**, who stated that the greater experience years of the nurses, the greater their knowledge and practices. The present study showed that those with a high level of qualification had adequate knowledge, also a significant difference from other levels of qualification. This may attribute to, that nurses with high qualifications have the opportunity to gain more knowledge, skills, and have a good chance to deal with highly qualified experts.

Regarding the correlation between total satisfactory knowledge and practice pre and post-intervention, the current finding clarified that there was a positive statistically significant correlation between total nurses' knowledge and practice regarding safe blood transfusion pre and post-intervention of the educational bundle as well as between their total pre and post practices. This result refers to that the level of practice influenced by the level of knowledge, so without proper knowledge, no presence of proper practice, which will be affecting on quality of nursing care. This current finding constant with the previous study of **Khalaf et al., (2017)**, who reported that there was a statistically significant correlation between total scores of nurses' knowledge and practices about blood transfusion pre/post-program implementation.

Conclusion:

In the light of the current study results, it can be concluded that the implementation of the educational bundle had a positive effect on improving the nurses' knowledge and their practice competency toward safe blood transfusion, with a highly statistically significant difference and difference and improvement in nurses' knowledge level and

their practice competency toward safe blood transfusion pre and post-implementation phase of the educational bundle. Furthermore, this study explored that blood incompatibility, not-checking of vital signs before, during, and after transfusion, the incorrect infusion rate, incorrect patients' identification, and not observing patients during transfusion were among the commonest errors made in the blood transfusion process. As well, there was a statistically significant relation between total nurses' Knowledge and practice scores with their age, qualification, general experience years in nursing, and blood transfusion.

Recommendations:

Based upon the results of the current study, the following recommendations are suggested:

- Continually perform regular in-service training and follow-up to nurses' performance and motivating to updating their knowledge and practices.
- Clinical nursing practice must emphasize on strict adherence to facility protocols to minimize the chance of error occurrence.
- Blood transfusion as invasive procedures should conduct only by highly qualified and experienced nurses.
- Further studies should be carried out on a large number of nurses on different departments and hospitals for evidence of the results.

References:

Abd Elhy A.H & Kasemy Z.A, (2017): Nurses' knowledge assessment regarding blood transfusion to ensure patient safety. Journal of Nursing and Health Science; 6(2): pp.104-111. ISSN: 2320–1940.

Abolwafa N F, Mohamed H A, & Hossein E Y, (2018): Improving quality of nursing care among school age children with thalassemia major as regards blood transfusion. IOSR Journal of Nursing and Health Science (IOSR-JNHS); 7(5):pp.79-89. ISSN: 2320–1940. Available at: www.iosrjournals.org

Al Nasr M, (2016): Assessment of nurses' performance regarding nursing care of patients undergoing blood transfusion. Published Master Thesis, Faculty of Nursing, Port Said-University. Port Said Scientific Journal of Nursing; 3(2):pp.166-182.

Annual Serious Hazards of Transfusion Report (SHOT) (2019): Enquiries. Available at: shot@nhsbt.nhs.uk www.shotuk.org

Asadi Fakhr A, Bikmoradi A, Zandiyh M, Mozafari H, (2012): The assessment standards related to blood transportation, storage, preparation, and administration in operating rooms of Hamedan educational treatment centers. Sci J Iran Blood Transfus Organ; 9(1): pp.63 – 71.

Aslani Y, Etemadyfar S, & Noryan K, (2010): Nurses' knowledge of blood transfusion in medical training centers of Shahrekord University of Medical Science, IJNMR; 15(3): pp.141-144.

Bellamy M, (2018): Serious Hazards of Transfusion (SHOT): Annual Report. Published July 2019, ISBN 978-1-9995968-1-1. Available at: www.shotuk.org.

Belousov A, (2018): Current faults and recommendations for transfusion of red blood cell assessment and clinical evaluation of changes in hematocrit. Am J Anesth Clin Res; 4(1): pp.001-007.

Bielby L, Stevenson & Wood E, (2011): The Role of the transfusion nurse in the hospital and blood center. International Society of Blood Transfusion, ISBT Science Series; 6: pp. 270–6.

Burhans L.M, & Alligood M.R, (2010): Quality nursing care in the words of nurses. Journal of Advanced Nursing; 66(8):pp.1689–1697. Doi: 10.1111/j.1365-2648.2010.05344.x

Connelly LM, & Powers JL, (2013): Online Patient Safety Climate Survey: Tool Development and Lessons Learned. Advances in Patient Safety; Volume 4. Available from: https://www.ncbi.nlm.nih.gov/books/NBK20585/

Davis RE, Vincent CA, & Murphy MF, (2011): Blood transfusion safety: the potential role of the patient. Transfus Med Rev. 25(1):pp.12-23. Doi: 10.1016/j.tmrv.2010.08.003. PMID: 21134623.

Ddungu H , Krantz E. M , Phipps W , Naluzze S , Orem J , Kiwanuka N , Wald A ,& Kajja I, (2018): Survey to assess knowledge and reported practices regarding blood transfusion among cancer physicians in Uganda. Journal of Global Oncology; pp. 105,199,113,232. DOI: https://doi.org/10.1200/JGO.18.00143

de Mattia D, & de Andrade S.R, (2016): Nursing care in blood transfusion: A tool for patient monitoring, Texto Contexto Enferm; 25(2): e2600015.

Dubey A, Sonker A, Chaudhary RK, (2013): Evaluation of health care workers' knowledge and functioning of blood centres in north India: a questionnaire based survey. Transfusion and aphaeresis science: official journal of the World Aphaeresis Association: official journal of the European Society for Haemaphaeresis; 49(3):pp.565-70. Doi: 10.1016/j.transci.2013.09.007. PMID: 24126014.

Elkattan B, (2013): Impact of training program regarding for neurological patients in coma upon nurses' performance. Doctoral Thesis in Nursing Science, faculty of Nursing, Ain Shams University; p.120.

EnCana B, & Akin S, (2019): Knowledge of blood transfusion among nurses. The Journal of Continuing Education in Nursing; 50(4):pp.176-182. DOI: 10.3928/00220124-20190319-08

Flood L, & Higbie J, (2016): A Comparative Assessment of nursing students' cognitive knowledge of blood transfusion using lecture and simulation. Nurse Educationinpractice; 16(8): e13. Available at: www.Elsevier.Com/Nepr22-11-2016

Hijji B, Oweis A, Dabbour R, (2012a): Measuring knowledge of blood transfusion: a survey of Jordanian nurses. American International Journal of Contemporary Research; 2(10). Available at: www.Aijcrnet.Com /.

Hijji B, Parahoo K, Hossani M.M, Barr O, & Murray S, (2012b): Nurses' practices of blood transfusion in the United Arab Emirates: An observational study. Journal of Clinical Nursing; 19(23-24):pp.3347-3357.

Hijji B, Parahoo K, Hussein MM, Barr O, (2013): Knowledge of blood transfusion among nurses. J Clin Nus; 22(17–18):pp.2536-50. Available at: https://doi.org/10.1111/j.1365-2702.

Illingworth J, & Gray A, (2013): Right blood, right patient, right time: RCN guidance for improving transfusion practice. Royal College of Nursing, London W1G 0RN; pp.3-16. ISBN: 978-1-908782-41-0.

Islami M, (2018): The impact of an educational program on blood and blood products transfusion on nurses' level of knowledge and performance. Journal of Medicine and Life; 11(3):pp.238–242.

Javadzadeh Shahshahani H, (2016): Status of Transfusion Medicine Education in Iran. Arch Iran Med; 19(6): pp.439 – 445.

Kabinda J.M, Miyanga S.A, Donnen P, den Ende J.V, & Dramaix M.W, (2014): Knowledge, attitudes and practices of medical and paramedical staff in blood transfusion in the Democratic Republic of Congo. Open Journal of Preventive Medicine; 4(3): pp.672-680.

Kafando E, Koumaré AR, Sawadogo S, et al., (2017): Improving blood transfusion safety: a survey on the knowledge and attitudes of health professionals in blood transfusion at the Yalgado Ouedraogo University Hospital Center, Burkina Faso. Hematol Transfus Int J; 4(1): pp.1–4. DOI: 10.15406/htij.2017.04.00070

Kavaklioglu A B, Dagci S, Oren B, (2017): Determination of health workers' level of knowledge about blood transfusion. North Clin Istanbul; 4(2):pp.165–172. DOI:10.14744/nci.2017.41275

Kavaklioglu A.B, Dagci S, & Oren B, (2017): Determination of health workers' level of knowledge about blood transfusion, Istanbul Northern Anatolian Association of Public Hospitals. North Clin Istanbul; 4(2):pp.165–172. DOI: 10.14744/nci.2017.41275.

Kebadnew Mulatu, Tamiru Hailu, Addisu Yegezu and Bezuayehu Tena, (2017): Assesment of knowledge, attitude and practice on blood donation in Aman Sub City Residents, South West, Ethiopia. Health Sciences Journal; 11 (1):p.485.

Khalaf S.M, Abd El Sadik B.R, & Bayoumi M.H, (2017): Effect of training program on nurses' competent practices towards children receiving blood transfusion. Journal of Nursing and Health Science; 6(2): pp.54-66. DOI: 10.9790/1959-0602055466. Available at: www.iosrjournals.org.

Khalil S.S, Mohammad Z.A, Ez el-deen M.E, & Ahmed N.M, (2013): Impact of implementing a designed nursing intervention protocol on nurses' knowledge and practice regarding patients undergoing blood transfusion. Med. J. Cairo University; 81(2):pp. 163-171.

Khouri R, (2011): Impact of an educational program on nursing students' caring and self–perception in intensive clinical training in Jordan. Depress Browse Journal; Advances in Medical Education and Practice. 2: pp.173-185.

Kluwer W, (2016): Lippincott nursing procedures. 7th edition. Williams & Wilkins, publisher, London; pp. 4458-4473.

Kozier B, Erb G, & Berman A, (2018): Fundamentals of Canadian Nursing: Concepts, Process, and Practice. 4th edition. Pearson Canada Inc. pp.1380–1386.

Kumarage S, Fernando R, & Gunasekara L, (2017): A survey of knowledge and practices of transfusion medicine among post intern doctors in specialized hospital in Sri Lanka. Lab Med; 48(1): pp. 46-50.

Lahlimi F.Z, Tazi I, Sifsalam M, Bouchtia M, & Mahmal L, (2015): Assessment of transfusion practice: Assessing nurses' knowledge in transfusion medicine at Mohamed VI Hematology and Oncology Center of Marrakesh, Morocco. Transfusion Clinique et Biologique; 22: pp.12-16. DOI: 10.1016/j.tracli.2014.05.006.

Lee E, Rahim N, &Tuan Din S, (2016): Knowledge of blood transfusion among nurses at hospital pulau pinang: nursing responsibilities and patient management related to transfusion reactions. Education in Medicine Journal; 8(4): pp.47–56.

Lim SL Elaine, Abdul Rahim NA, & Tuan Din SA, (2016): Knowledge of blood transfusion among nurses at Hospital Pulau Pinang: Nursing responsibilities and patient management related to transfusion reactions. Education in Medicine Journal; 8(4):pp.47–56. DOI: 10.5959/eimj.v8i4.473

Ndambuki J, (2013): The level of patients' satisfaction and perception on quality of nursing services in the Renal Unit, Kenyatta National Hospital Nairobi, Kenya. Open Journal of Nursing; 3: pp.186-194.

Palmer A, (2015): Blood Transfusion error prevention: Nurses' role. American Society of Registered Nurses. Journal of Nursing; 2(3):pp.123-129.

Reza P, Aziz S, Ali M, Marjan M, & Reza T, (2009): Evaluation of knowledge of healthcare workers in hospitals of Zabol city on proper methods of blood and components transfusion. Asian Journal of Transfusion Science; 3(2): pp.78–81.

Saad NH, Mohd NH, Ramli M, & Hasan M N, (2016): Knowledge on the complications related to blood transfusion among nurses in HUSM, 15th Annual Scientific Meeting, College of Pathologists, Academy of Medicine Malaysia, Hotel Pullman, Putrajaya.

Sapkota A, Poudel S, Sedhain A, & Khatiwada N, (2018): Blood transfusion practice among healthcare personnel in

Nepal: an observational study. Journal of Blood Transfusion; p.7. Available at: https://doi.org/10.1155/2018/6190859

Shafik S, & Abd Allah E, (2015): Improving the quality of nursing care for patients with leukemia in day care units through nursing education. American Journal of Nursing Science; 4(3): pp.63-72.

Silva MA, Torres GV, Melo GSM, Costa IKF, Tiburcio MP, Farias TYA, (2016): Knowledge about the transfusion process of the ICU nursing team at a university hospital. Cienc Cuid Saúde; 8(4): pp. 571 – 578. Available from: http:// periodicos. uem.br/ojs/index.php/CiencCuidSaude/ article/view/9676/5389

Soc Guidelines (2012): Standards of care guidelines for thalassemia, Children's Hospital & Research Center Oakland Hematology/Oncology Department. Available at: www. children shospitaloak land.org

Taher A, Vichinsky E, Musallam K, Cappellini M, & Viprakasit V, (2013): Guidelines for the management of non transfusion dependent thalassaemia (NTDT). Nicosia (Cyprus): Thalassaemia International Federation. Available at: https://www. ncbi. nlm.nih.gov/books/NBK190453/

Tavares J.L, Barichello E, De Mattia A.L, & Barbosa M.H, (2015): Factors associated with knowledge of the nursing staff at a teaching hospital on blood transfusion. Rev. Latino-Am. Enfermagem; 23(4): pp.595-602, DOI: 10.1590/0104-1169.0024.2593.

Tetteh Ebenezer, (2015): knowledge and practice of blood Transfusion among nurses in Ghana: Experiences from the Cape Coast teaching hospital. Master thesis, School of Nursing and Midwifery of College of Health and Allied Sciences, University of Cape Coast.pp.21-52.

Thomas J.J, & Hannon T, (2010): Under recognition and underreporting of transfusion related adverse events [abstract]. Transfusion; 50(s2): pp.50-63.

World Health Organization (2017): Blood Safety and Availability Fact Sheet. Available at: http:// www. who. int/ mediacentre/factsheets/fs279/ en/.

World Health Organization (2017): Global Status Report on Blood Safety and Availability. Available at: http:// apps. who. int/ iris/ bitstream/ 10665/ 254987/ 1/ 97.pdf

Yaghoobi M, Shirzaie, Kianoosh, Sotvaan, Homa, Yaghoobi Pheyzabad, Esmat, Yoosefian Miandoab, Nazanin, (2014): Knowledge level of the staff's about blood transfusions in hospitals in East of Iran. Science Road Journal; 02 (01):pp. 91-96.

Yesilbalkan OU, Akyol A, Ozel F, Kankaya H, Doğru B, & Argon, (2019): Assessing knowledge of nurses on blood transfusion in turkey. International Journal of Caring Sciences; 12(1): p.521.

Yousefian N R, Nikbakht Kh, Fazeli A, Nootizehi H, Salehinia M, Yaghoobi, Khosravi S, Sanei Moghaddam E, & Hasanzadeh Sooreh B,(2015): Awareness of health care staff in hospitals of Zahedan about blood transfusion. The Scientific Journal of Iranian Blood Transfusion Organization; 11(1):pp.71-76.