Effect of a Computer-Based Learning Module on Nurses' Performance Regarding Safety Arterial Blood Gases Sampling for High Risk Neonates

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Abstract

Arterial blood gases analysis considered a method for monitoring high-risk neonate's condition as it provides the basic information for determining the adequacy of alveolar ventilation, acid-base status and oxygenation. Nurses' attention should be given to the following factors; infection control or universal precautions as the neonates are at high risk of infection. **Aim:** The study aimed to evaluate the effect of a computer-based learning module on nurses' performance regarding safety arterial blood gases sampling for high risk neonates. **Methods:** A quasi-experimental research design conducted at Neonatal Intensive Care Units (NICUs) and Surgical Neonatal Intensive Care Unit "SNICU" of Benha Specialized Pediatric Hospital. A purposive sample of available nurses (62) and high-risk neonates (74). Researchers used three tools as Online nurses' self-administered questionnaire designed to assess nurses' personal characteristics and nurses' knowledge regarding safe blood sampling for high-risk neonates. The second tool was nursing practice observation checklists. The third tool was High-risk Neonates' Medical Assessment Record. **Results:** Findings of the current study revealed a statistically significant difference pre and post computerized-based learning module implementation regarding safety arterial blood gases for high-risk neonates. The results also revealed a highly statistically significant difference in nursing knowledge and practices ($p<0.001$). **Conclusion:** It can be concluded that the research hypothesis is accepted, the implemented computerized-based learning module improved nurses' knowledge and practices towards safety arterial blood gases sampling for high-risk neonates. The study recommended conducting periodical online programs for nurses in NICUs with continuous regular updating of knowledge and practice regarding safe arterial blood gases sampling for high-risk neonates.

Keywords: Arterial Blood Gases, Computer-Based Learning Module, Nurses' Performance, High Risk Neonates

Introduction:

Arterial blood gases (ABG) considered a vital step of assessment of respiratory status in critically ill neonates and its analysis is considered one of the most common laboratory investigations. Therefore, ABG sampling is a regularly-performed invasive procedure in clinical settings. The puncture of the artery is always styled as a very painful and interesting invasive procedure that is not accepted of hazards ***(Bijapur et al., 2019***). There are many errors occurs during withdrawing of ABG sample which could cause serious complications as nerve injuries, bleeding, acute compartment syndrome, thrombosis and pseudo aneurysm. Therefore, it is important that those health care professionals who responsible for withdrawing arterial blood samples are sufficiently trained (***Hernández-Padilla et al., 2016).***

Arterial blood gases sampling (ABGs) is a simple blood test which is performed through puncturing an artery with a thin needle and heparinized syringe. Those who performed this test usually draw a small amount of blood (approximately, 1ml) from the radial artery at the wrist, or the femoral artery in the groin or other sites can be used as well. Moreover, the blood can also be drawn from an arterial catheter. The reasons behind performing this test are to identify the pH of the blood, the partial pressure of carbon dioxide, oxygen, and the level of bicarbonate Prematurity accounts for the largest number of admissions to NICUs **(Haldar & Dwari, 2019).**

Nurses are responsible for drawing blood samples for ABG analysis while, training for this invasive procedure is not always presented as a part of nursing programmers or as a continuous educational resource. Furthermore, the pediatric population have need more skillful professionals to carry out the procedure, which may indicate a need for evaluation of nurses and nursing students' competence to perform arterial puncture before attempting the procedure in real patients without supervision **(Simundic et al., 2013).**

Online learning is known as an effective learning approach for improving nurses' knowledge and skills. It has widely used for professional development and training of nurses in clinical settings. The online education should empower nurses to balance their workloads and learning at the same time. Additionally, the flexibility of time and space, self-regulated learning, cost-effectiveness, and less impact on nurses' families and personal life styles **(Wu et al., 2018).**

Computer-based learning refers to self-paced learning activities provided on a computer or mobile device. It can be learned in a computer or mobile phone at home, or in any location in which nurses can use the device at any time convenient for them. Computer-based multimedia learning environments – consisting of pictures (such as animation) and sentences (such as narration), that offer an actually powerful place for improving nurses' understanding. Nursing education has evolved from traditional methods of teaching to modern methods using technology for knowledge acquisition. Computer-based technology has been utilized for a variety of educational purposes in nursing education, either to increase or to replace conventional teaching methods **(Shimura, 2014).**

Nurses are required to have specialized skills and knowledge to enable them to critically think rapidly in life-threatening conditions. One of the specific skill sets that is foundational for NICUs nurses is to be able to proficiently analyze arterial blood gases, which can be a difficult and frightening concept for NICUs nurses to grasp. Furthermore, nurses have other obligations, such as mandatory regulatory agency requirements, and family obligations to fulfill. These factors contribute to the challenges staff nurses encounter in accessing continuing E- learning and educational programs **(Hart et al., 2019).**

Online-learning is a decision for nurses who want to continue their education to improve care provided for high-risk neonates on NICUs, advance their careers, and contribute to a more effective and efficient health care system. Even though, online learning is increasingly used in these days, there is nominal evidence regarding its effectiveness in nursing field. Therefore, this study was carried to evaluate the effect of a computer-based learning on nurses' performance regarding safety arterial blood gases sampling for high risk neonates **(Wu et al., 2018).**

Significance of the study:

Nurses in NICUs are required to have specialized knowledge and skills to permit them to judgmentally think rapidly in life-threatening situations. Safe arterial blood gases withdrawal is one of the most specific skills which are foundational for neonatal intensive care nurses, which can be a difficult and daunting concept for neonatal care nurses to grasp. Though the nurses take an active role in assembling of ABGs and this requires puncture by competent nurses which can prevent further complications for high-risk neonates. Hence, this study was conducted to evaluate the effect of a computer-based learning on nurses' performance regarding safety arterial blood gases sampling for high risk neonates.

Aim of the study:

The current study aimed to evaluate the effect of a computer-based learning on nurses' performance regarding safety arterial blood gases sampling for high risk neonates, through:

- Assessing nurses' knowledge and practice regarding safe blood sampling for high-risk neonates.
- Designing and implementing a computer-based learning module based on nurses' actual needs assessment regarding safety arterial blood gases sampling for high-risk neonates.
- Evaluating the effect of a computer-based learning on nurses' performance regarding safety arterial blood gases sampling for high-risk neonates.

Research hypotheses:

Nurses who exposed to a computer-based learning will display satisfactory knowledge and

competent practice regarding safety arterial blood gases sampling for high-risk neonates compared to their pre-intervention level.

Subjects & Methods

Research design:

A quasi-experimental research design (pre/post-test) used to conduct the current study at January 2019 to the end of June 2019.

Research Settings:

The current study carried out at Neonatal Intensive Care Units (NICUs) and Surgical Neonatal Intensive Care Unit "SNICU" of Benha Specialized Pediatric Hospital affiliated to Specialized Medical Centers and the Egyptian Ministry of Health and Population at Benha City, Egypt where this hospital being of highest capacity of high-risk neonates. This hospital included one NICU on the third floor in building "A" and Surgical Neonatal Intensive Care Unit "SNICU" on the third floor in building "B." NICU on the third floor contains two rooms, the 1st room had 31 incubators, and the 2nd room had three incubators. The building "B" contains two rooms on the third floor with 12 incubators.

Subjects:

A purposive sample of nurses (62) who are working at the previously mentioned study settings was taken. Nurses were selected depending on their availability during the time of data collection as well as, their readiness to contribute in the current study. They were selected under the following inclusion criteria:

- Have android mobile with whatsApp and internet access.
- Have the ability to use the internet.
- Have the ability to communicate with the researchers during data collection.

A purposive sample of high-risk neonates (74) included in the current study from the previously mentioned study settings was included under the following inclusion criteria:

- Males and females high-risk neonates undergoing arterial blood gases.
- Free from blood disorders.
- Free from congenital anomalies.

Tools of data collection:

The following three tools were used to collect data relevant to the current study. These tools consisted of the following:

Tool I:

Online nurses' self-administered questionnaire:

It designed by the researchers in light of related studies and researches (***Gattinoni et al., 2018***). It was prepared in an Arabic language and available online. It used to assess the nurses' knowledge regarding safe blood sampling for high-risk neonates. It was included two parts.

1st part: concerned with characteristics of studied nurses such as age, gender, academic qualifications, years of experiences, and attendance of previous training courses regarding safe arterial blood gases sampling.

2nd part: concerned with knowledge regarding arterial blood gases sampling such as; identification of anatomy and physiology of arteries, definition of arterial blood gases sample, indications, sites of withdrawal (arteries names), types of blood sampling, devices used for blood withdrawal, contraindications for arterial sampling, complications of arterial sampling, infection prevention and control, devices used for blood withdrawal and safety precautions that must be considered during withdrawal of arterial blood gases sample for high-risk neonates. It includes 20 multiple-choice questions.

Scoring system:

The studied nurses' knowledge checked with an electronic model key answer. Accordingly, the correct answer scored (1) and (0) for incorrect or do not know answers. The total score ranged from 0-20 (20 questions ×1). Then, total knowledge categorized as a score of 85%, and more considered satisfactory knowledge, while less than 85% considered unsatisfactory knowledge.

Tool II: Nursing Practice Observation Checklists:

It was adapted from ***WHO, (2016)*** and modified by the researchers. It used to assess the actual nurses' practices regarding safe arterial blood gases sampling for high-risk

neonates. It included hand hygiene (8 steps), immobilization of high-risk neonates (10 steps), withdrawal of arterial blood gases sample (21 steps), blood spillage (10 steps) infection prevention and control (17 steps), disassembly of needle from syringe or other devices (3 steps).

Scoring system:

Total scores for practice were (69 items). Each nurse observed during each procedure using nurses' observational checklists. Each correctly done step gave the score of (1) and (0) for each incorrectly done step or not done. Total practice categorized as a score of 85%, and more considered, competent practice while less than 85% considered incompetent practice

Tool III: High-risk Neonates' Medical Assessment Record:

It was included two parts as follow:

1st part: included the characteristics of high-risk neonates such as age, gestational age, gender, birth weight, and current weight.

2nd part: included the medical data of high-risk neonates such as medical/surgical diagnosis, causes for withdrawing arterial blood gases sampling, complications regarding arterial blood gases sampling, and results of arterial blood gases.

Validity & reliability:

Jury of three experts including; two assistant professors of the pediatric nursing from the Faculty of Nursing Ain Shams and Benha Universities, and one professor of pediatrics faculty of medicine, Benha University to test the data collection tools for clarity, comprehensiveness, relevance, simplicity, and applicability. All modifications of the data collection tools made according to the experts' judgment on the clarity of sentences, relevance of the content, and sequence of items. The experts agreed on the data collection tools contents. The reliability of the data collection tools was done by using Cronbach's alpha test. The reliability score was 0.86 for structured interviewed questionnaires and was 0.84 for nurses' practices observational checklists.

Ethical considerations:

Official permissions to conduct the current study were obtained from the hospital manager and head of NICU and SNICU at the previously mentioned study setting through submission of official letter issued from the dean of faculty of nursing Benha University. The title, aim, and outcomes of the study clarified as well as the main data items to be covered, and the study carried out after gaining the necessary permission.

The participation of nurses in current study was voluntary; each nurse well-versed about the nature of the study, the purpose, procedures, and all the information has taken was confidential. Each nurse had the right to withdraw from the study at any time without any rationale, and then oral consent obtained from them. Nurses informed that all obtained data would not be included in any job evaluation.

Pilot study:

A pilot study carried out for 10% of studied subjects (7 high-risk neonates and six nurses) to assess the viability of the research process, clarity, objectivity, applicability, and time needed for collecting data. Accordingly, the necessary modifications made in the form of addition or omission of some items. The pilot study subjects excluded from the actual study sample.

Field work:

The current study was carried out through the following phases:

Assessment and planning phase:

The actual field work was conducted from the beginning of January 2019 to the end of June 2019. Official permissions to conduct the current study were obtained from the hospital manager and head of NICU and SNICU at the previously mentioned study setting. In the beginning, the researchers interviewed nurses in the study settings at morning and afternoon shifts to give them a brief idea about the current study and its purpose and an oral consent was obtained. Then, the website link of the pre-test online nurses' self-administered questionnaire was given for studied nurses through their whatsApp mobile phone to collect their personal characteristics and to assess their knowledge regarding safe arterial

blood gases sampling for high-risk neonates (Tool I). The researchers were observing the nurses' practice to fill out the observational checklists (Tool II). The time required for complete the observational checklists ranged between 20- 30 minutes.

Steps of computer-based learning module construction:

A. General Objectives

The aim of this computer-based learning module was to update studied nurses' knowledge and improving their practice regarding safe arterial blood gases for high-risk neonates.

B. Specific Objectives;

By the end of the computer-based learning module, each studied nurse should be able to:

- Identify anatomy and physiology of the arteries.
- Define arterial blood gases sampling.
- Enumerate indications of arterial blood gases sampling.
- Determine site for every artery.
- List types of blood sampling.
- Identify devices used for blood withdrawal.
- Determine contraindications for arterial sampling
- Identify complications of arterial sampling
- Determine the infection prevention and control
  a. Elements of standard precautions
  b. Use of antiseptics – skin disinfection
  c. Disposal of used equipment
- Identify safety of the high-risk neonates
  a. Neonates' identification
  b. Parent informed consent and neonates rights;
  c. Managing supplies for neonates in isolation
- Protection of the health worker.
- Identify the importance of post exposure prophylaxis.
- Determine safety measures for needle removal.
- Identify the appropriate use of personal protective equipment, including gloves.
- Identify different types of equipment available for blood sampling.
- Practice taking arterial blood samples.
- Demonstrate waste management, including disposal of waste and sharps, and procedures for spillage and breakage.

Implementing phase:

The computerized-based learning module was carried out at the previously mentioned study settings in a period of three weeks in addition to one week for pre and post-test. It was implemented through 9 sessions (3sessions for online theoretical part and 6 sessions for practical part), in addition to one session for pre-test and another one for post-test for six months. Nurses were distributed into 10 groups, 6 nurses in each group. These sessions have lasted for 15 hours (3 hours for theory & 12 hours for practice). Theoretical part of the computerized-based learning module was given for nurses through online sessions, and practical part was given through direct face to face learning. The researchers started each session with a summary for the previous one.

At the beginning of the first online session, the researchers provide an overview of the computerized-based learning module. Also, the objectives of the new topic explained. Simple Arabic words used to suite the nurses' level of education. At the end of each session, nurses' questions discussed to correct any misunderstanding in addition to re-demonstration for practical procedures.

Different teaching strategies used for the application of the computerized-based learning module were lectures, brain storming, small group discussions, role play, demonstration, and re-demonstration using real objects for practice. Proper audio-visual supplies were used in order to help appropriate understanding of the contents of the computerized-based learning module. Nurses were motivated to collaborate and participate actively in all stages of the current study.

Evaluation phase:

After implementation of the computerized-based learning module, the post-test was done for the studied nurses in NICU to evaluate the effect of a computer-based learning on nurses' performance regarding safety arterial blood gases sampling for high risk neonates.

Statistical analysis

The collected data were reviewed, organized, tabulated, and analyzed by using SPSS (Statistical Package for the Social Science Software) statistical package version 22 on IBM compatible computer. Mean and Standard deviation ($\overline{X}$ ± SD) were used for numerical data (Quantitative data) and analyzed by applying t-test for normally distributed variables, while qualitative data stated as frequency and percentage and chi-square, and t-test was used as a parametric test of significance for comparing between two samples means. Pearson correlation test (r) used to measure the correlation between quantitative variables. *P-value* at 0.05 used to determine significance regarding:

- P-value > 0.05 to be statistically insignificant.
- P-value < 0.05 to be statistically significant
- P-value < 0.01 to be highly statistically significant.

Results:

Table (1) revealed that mean age of them is 31 ± 2.9 years. The majority of nurses were females (88.7%). Regarding years of experience, about half of them (51.6 %) their years of experience ranged from 1 to less than 10 years. Regarding nurses' academic qualification, more than three-quarters of them (79.0%) had a technical institute of nursing in nursing, while 11.3% of them had a bachelor's degree in nursing, and 4.8% of them working as a head nurse. Also, 90.3% of them not attended any previous training courses regarding arterial blood gases sampling.

Table (2) displayed a highly statistically significant difference between the studied nurses' knowledge pre and post implementation of the computerized-based learning module.

Figure (1) described that 87.1% of the studied nurses have satisfactory knowledge regarding safe arterial blood gases sampling post implementation of the computerized-based learning module compared to 11.3% of them pre implementation.

Table (3) detected that, all studies nurses having competent practice post-intervention regarding hand hygiene, immobilization of high-risk neonates, withdrawal of arterial blood gases sample, blood spillage, infection prevention and control and disassembly of needle from syringe or other devices. This table also explains that, there is a highly statistically significant difference between studied nurses' practice scores regarding all items pre and post-intervention (P<0.001).

Table (4) displayed that the total nurses' knowledge were unsatisfactory with percentage 88.7% pre-intervention. However, post-intervention was satisfactory with percentage 87.1%. Regarding their total practices, there were 83.9% were competent post- intervention compared with 8.0% pre- intervention.

Table (5) exposed that there were a highly statistically significant positive correlation between total nurses' knowledge and total practices post-intervention (r=0.868, p<0.000).

Table (6) found that the mean age of high risk neonates was 13.85±1.56 days, while mean gestational age was 33.28±2.46 weeks. Regarding gender, 59.5% were males, and 44.6% and 50.0% their weight ranged from 2000 to less than 2500 grams regarding birth and current weight respectively. The mean birth weight was 2230±187.42 grams, while current weight was 2190±362.76 grams.

Table (7) found that 64.9% of had respiratory distress syndrome. 46.0% withdrawing arterial blood gases sampling for changing of ventilator settings, while 77.0% having complications of arterial sampling and the majority of them having hypoxia.

Table (1): Number and percentage distribution of the studied nurses regarding their personal characteristics (N= 62).

Characteristics	Study group (N= 62)	
	No	%
Age/ years		
< 20	0	0.0
20 – < 25	21	33.9
25 - <30	37	59.7
≥ 30	4	6.4
Mean ±SD 31 ± 2.9 years		
Gender		
Male	7	11.3
Female	55	88.7
Years of experience:		
<1	9	14.5
1 - < 10	32	51.6
≥ 10	21	33.9
Academic Qualifications		
Diploma (Secondary School)	6	9.7
Technical Institute of Nursing	49	79.0
Bachelor of Nursing	7	11.3
Job position		
Nurse	59	95.2
Head nurse	3	4.8
Attendance of previous training courses		
Yes	6	9.7
No	56	90.3

Table (2): Comparison of studied nurses' knowledge regarding safe arterial blood gases sampling for high-risk neonates before and after the computer-based learning module (no. 62).

Items of Knowledge	Pre-intervention				Post-intervention				x^2	P-value
	Satisfactory		Unsatisfactory		Satisfactory		Unsatisfactory			
	No	%	No	%	No	%	No	%		
Anatomy of arteries	4	6.4	58	93.6	60	96.8	2	3.2	32.41	0.001
Physiology of arteries	3	4.8	59	95.2	56	90.3	6	9.7	42.18	0.001
Definition of arterial blood gases sample	5	8.0	57	92.0	57	91.9	5	8.1	37.04	0.001
Indications	8	12.9	54	87.1	62	100.0	0	0.0	38.49	0.000
Sites of withdrawal	17	27.4	45	72.6	59	95.2	3	4.8	35.22	0.001
Types of blood sampling	21	33.9	41	66.1	58	93.6	4	6.4	31.74	0.001
Devices used for blood withdrawal	13	21.0	49	79.0	54	87.1	8	12.9	40.16	0.00
Contraindications for arterial sampling	7	11.3	55	88.7	60	96.8	2	3.2	33.55	0.001
Complications of arterial sampling	5	8.0	57	92.0	58	93.6	4	6.4	36.44	0.001
Infection prevention and control										
a. Elements of standard precautions	10	4.8	59	95.2	58	93.6	4	6.4	40.11	0.001
b. Use of antiseptics and skin disinfection	22	35.5	40	64.5	55	88.7	7	11.3	28.64	0.001
c. Disposal of used equipment	30	48.4	32	51.6	56	90.3	6	9.7	36.44	0.001
Safety precautions										
a. Neonates' identification	5	8.0	57	92.0	58	93.6	4	6.4	33.41	0.001
b. Parent informed consent and neonates rights	1	1.6	61	98.4	54	87.1	8	12.9	32.44	0.001
c. Managing supplies in isolation	7	11.3	55	88.7	62	100.0	0	0.0	32.12	0.001
Protection of the health worker.	18	29.0	44	71.0	56	90.3	6	9.7	28.7	0.000
Identify the importance of post exposure prophylaxis.	1	1.6	61	98.4	60	96.8	2	3.2	38.19	0.000
Determine safety measures for needle removal.	20	32.3	42	67.6	58	93.6	4	6.4	31.17	0.001
Identify the appropriate use of personal protective equipment.	43	69.4	19	30.6	60	96.8	2	3.2	29.07	0.005
Identify different types of equipment available for blood sampling.	39	62.9	23	37.1	62	100.0	0	0.0	30.02	0.001
Total	**7**	**11.3**	**55**	**88.7**	**54**	**87.1**	**8**	**12.9**	**27.38**	**0.001**

A statistically significant difference ($P \leq 0.05$) A highly statistically significant difference ($P \leq 0.001$).

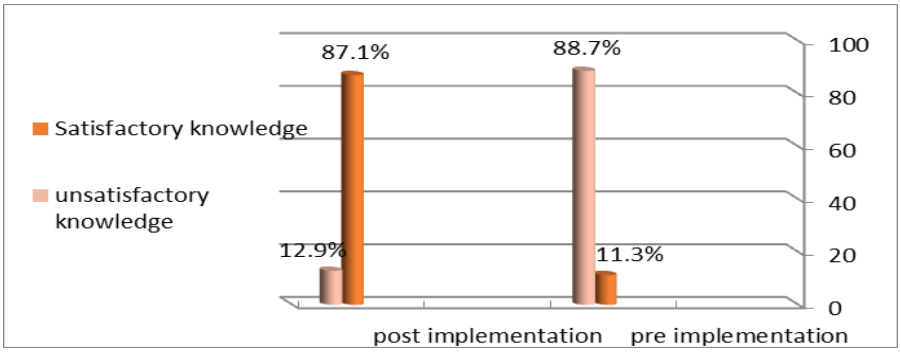

Figure (1): Percentage distribution of the studied nurses' total knowledge regarding safe arterial blood gases sampling pre and post computer-based learning module (no. 62)

Table (3): Comparison of studied nurses' practices regarding safe arterial blood gases sampling for high-risk neonates before and after the computer-based learning module (no. 62).

Items of practice	Pre-intervention (62)				Post-intervention (62)				x^2	P value
	Competent		Incompetent		Competent		Incompetent			
	No	%	No	%	No	%	No	%		
Hand hygiene	22	35.5	40	64.5	60	96.8	2	3.2	26.07	0.001**
Immobilization of high-risk neonates	7	11.3	55	88.7	54	87.1	8	12.9	31.48	0.001**
Withdrawal of arterial blood gases sample	18	29.0	44	71.0	55	88.7	7	11.3	30.14	0.001**
Blood spillage	13	21.0	49	79.0	50	80.6	12	19.4	31.16	0.000**
Infection prevention and control	7	11.3	55	88.7	55	88.7	7	11.3	32.45	0.001**
Disassembly of needle from syringe or other devices	22	35.5	40	64.5	58	93.6	4	6.4	28.35	0.000**
Total	**5**	**8.0**	**57**	**92.0**	**52**	**83.9**	**10**	**16.1**	**34.18**	**0.001****

P Value ≤ 0.05 Statistical significant differences (S); P value ≤ 0.01 high Statistical significant differences (HS).

Table (4): Number and percentage distribution of the studied nurses' total knowledge and total practices regarding safe arterial blood gases sampling for high-risk neonates before and after the computer-based learning module (no. 62).

Items		Pre-intervention (62)		Post- intervention (62)		x^2	P value
		No	%	No	%		
Knowledge	**Satisfactory**	**7**	**11.3**	**54**	**87.1**	27.38	0.001**
	Unsatisfactory	**55**	**88.7**	**8**	**12.9**		
Practice	**Competent**	**5**	**8.0**	**52**	**83.9**	34.18	0.001**
	Incompetent	**57**	**92.0**	**10**	**16.1**		

P Value ≤ 0.05 Statistical significant differences (S); P value ≤ 0.01 high Statistical significant differences (HS).

Table (5): Correlation between total nurses' knowledge and total practices regarding safe arterial blood gases sampling for high-risk neonates after the computer-based learning module (no. 62).

Items	r	p-value
Knowledge	0.758	0.000**
Practice		

Table (6): Frequency and percentage distribution of high-risk neonates according to their characteristics (no. 74).

High-risk neonates' characteristics	No (n=74)	% 100%
Age/days		
Less than 1 day	10	13.5
2->5	12	16.2
5->10	14	18.9
≥10	38	51.4
Mean ±SD	**13.85±1.56**	
Gestational age / weeks		
28->30	8	10.8
30->32	11	14.9
32->34	9	12.2
34->37	40	54.0
≥37	6	8.1
Mean ±SD	**33.28±2.46**	
Gender		
Male	44	59.5
Female	30	40.5
Birth weight/ grams		
Less than 1500	9	12.2
1500>2000	21	28.4
2000>2500	33	44.6
≥2500	11	14.8
Mean ±SD	**2230±187.42**	
Current weight/ grams		
Less than 1500	7	9.5
1500>2000	23	31.0
2000>2500	37	50.0
≥2500	7	9.5
Mean ±SD	**2190±362.76**	

Table (7): Frequency and percentage distribution of high-risk neonates according to their medical data (no. 74).

Medical data of High-risk neonates'	No	%
Medical/ surgical diagnosis		
Respiratory distress syndrome	48	64.9
Pneumonia	14	18.9
Hypoxic Ischemic Encephalopathy	2	2.7
Meconium aspiration	5	6.7
Tracheo-esoghageal fistula	2	2.7
GIT anomalies	3	4.1
Causes for withdrawing arterial blood sample:		
Change ventilator settings	34	46.0
For diagnosis	30	40.5
For follow-up	10	13.5
Complication of arterial blood sample		
Yes	57	77.0
No	17	23.0
Results of blood gases sample		
Hypoxia	62	83.8
Respiratory acidosis	38	51.4
Respiratory alkalosis	36	48.6
Metabolic acidosis	35	47.9
Metabolic alkalosis	39	52.7

A statistically significant at P value ≤0.05, Highly statistically significant at P value >0.001.

Discussion:

The current study was quasi-experimental study involved 74 high-risk neonates, and 62 nurses from Benha Specialized Pediatric Hospital worked at Neonatal Intensive Care Units (NICUs) and Surgical Neonatal Intensive Care Unit (SNICUs). The current study aimed to evaluate the effect of a computer-based learning module on nurses' performance regarding safety arterial blood gases sampling for high risk neonates.

Regarding the personal characteristics of the studied nurses, the results of the current study shown that the mean age of the studied nurses was **31 ± 2.9** years. This finding supported by **Said *et al., 2019*** in a study about "The Effect of Designed Practice Guidelines on Nurses' Performance and Outcome of Children with Head Injuries" which they found that the mean age of the studied nurses was 32 ± 2.7 years. This result also supported with ***Mohammed et al., 2018*** in a study about "Effect of preterm neonates' developmental supportive care program on nurses' performance regarding nurses' age" who stated that less than half of studied nurses their age range from 30 to less than 40 years.

Regarding gender of studied nurses, the present study demonstrated that the majority of the studied nurses were females, this may be due to the study of nursing was special for females only till a few years ago at Egypt, thus the career of nursing in Egypt was mostly feminine. This result reinforced by ***Sabaq & Said (2015)*** in a study about "Effect of educational program on nurses' performance regarding safe medications administration through nasogastric tube among critically ill children," who found that 95.2% were females. This also agreed with ***Said et al., 2019*** in a study about "Effect of Nursing Protocol Regarding Nasal Skin Breakdown for Preterm Infants Receiving Continuous Positive Airway Pressure". Who founded that 91.4% of nurses were females. From the researchers' point of view, this might be due to the trend of the hospital administration to employ the bachelor degree in critical areas in the step of change to make all the staff nurses in the NICU bachelor degree.

As regard years of experiences for studied nurses, the current study revealed that slightly more than half of the studied nurses had one to less than ten years of experience. The reductions in years of nurses' experience have a negative effect on their performance regarding care provided for high-risk neonates. This finding was supported with ***Mohammed et al., (2019) and Aziz & Mansi, (2018)*** in a study about "Assessment quality of nursing care provided to neonates with respiratory distress syndrome at intensive care unit in Al- Nasiriyah City Hospitals," who displayed that half of the studied nurses had less than two years of experience in pediatric nursing filed and neonatal care unit.

As regard studied nurses' academic qualifications, the current study clarified that more than three quarters of them had technical institute of nursing ***Buraihi & Mohammed (2017)*** in a study about "Effectiveness of an educational program on nurses' knowledge concerning prevent of post-thoracic surgery complications at AL-Najaf Teaching Hospitals," who confirmed that the highest percentage of the study sample were technical nursing institute. This also supported with ***Safwat and Khorais, (2018)*** in a study about "Effectiveness of a computer-based learning module on arterial blood gas interpretation among staff nurses in critical care units", who found that 66.7% of the nurses had bachelor degree in nursing science.

The current study displayed that the majority of the studied nurses did not attained training programs regarding safe arterial blood gases sampling. This result supported with ***Mohammed et al., (2019); Elsobkey & Amer, (2018)*** in a study entitled "Effect of educational guidelines program about nursing care of neonates receiving Continues Positive Airway Pressure," and shown that more than two-thirds of the studied nurses did not have training courses. This result also agreed with ***Safwat and Khorais, (2018),*** who found that 80% of nurses not attend training courses regarding arterial blood gases interpretation.

Regarding the total nurses' knowledge regarding safe arterial blood gases sampling for high-risk neonates before and after the computer-based learning module, this result displays a highly statistically significant difference between the studied nurses' knowledge pre and post implementation of the computerized-based learning module. This result agreed with ***Schneiderman et al., 2009*** in a study about

"Demonstrating the effectiveness of an online, computer-based learning module for arterial blood gas analysis" who found that the computer-based learning module was considered an effective method for teaching for intensive care nurses. The present finding also is constant with ***Youssef et al., 2013*** in a study about "Factors Affecting Validity of Arterial Blood Gases Results among Critically Ill Patients: Nursing Perspectives", who stated that all studied nurses demonstrated satisfactory knowledge and practice regarding ABG sampling, after using Web-based resources to teach nurses.

The result of the current study has emphasized the unsatisfactory nurses' knowledge regarding safe arterial blood gases sampling for high-risk neonates before the computer-based learning module. This might be due to the fact that the nurses didn't received any training courses regarding ABGs and burden by increased number of high-risk neonates for each nurse as well as this topic was not included in the curricula of nursing education for nursing students. This finding was agreed with ***Subin, (2017)*** in a study about "Assessing the effect of video-assisted teaching on knowledge regarding arterial blood gases sampling among staff nurses of Bhopal in India" who found that the majority of studied staff nurses had inadequate knowledge regarding ABGs at the pre -test phase. Additionally, this result was congruent with ***Hemavathy et al., (2016)*** in a study about " A study to assess the effectiveness of structured teaching program on knowledge regarding arterial blood gases sampling among the staff nurses at selected hospital in India" who reported that, the majority of studied nurses had adequate knowledge at the post test phase.

Correspondingly, this finding was in the same context with ***Schneiderman et al., (2012)*** in a study about "Demonstrating the effectiveness of an online, computer-based learning module for arterial blood gases sampling in Northern Illinois in USA. Clinical nurse specialist" who found that the online educational program and computer-based learning module were significantly effective for increasing nurses' knowledge regarding ABGs and stressed that continues nursing education is the key to update the nurses' knowledge which will help them to provide inclusive nursing care.

Regarding nurses' practices toward safe arterial blood gases for high-risk neonates, the current study shown that, the majority of studied nurses had incompetent practices pre-intervention of the computer-based learning module. This might be attributed to that the studied nurses manipulated that ABGs is not nurses' responsibility and is considered doctor responsibility. For this reason, the nurses didn't feel experienced enough to perform ABGs and majority of them try to withdraw arterial sampling depend on random repetition. The result of the current study was well-matched with ***Youssef et al., (2013)*** who found that majority of the studied nurses demonstrated incompetent practical level in relation to arterial blood gases sampling. Post-intervention there was a highly statistical significant improvement with studied nurses. From researchers' point of view, this may be the computerized-based learning module enhances studied nurses' knowledge which in turn leads to upgrading of their practices. This result agreed with ***Kaur and Charan, (2018)*** in a study about" A study to assess the effectiveness of structure teaching program on knowledge and practice regarding arterial blood gases sampling among ICU nurses in selected hospitals at Jalandhar, Punjab in India" who found that the majority of studied nurses had competent level of practice in the post –test phase.

Also, the current finding was in the same context with ***Barnett and Kautz, (2013)*** in a study about "Creative ways to teach arterial blood gases sampling. Dimensions of critical care nursing" who found that the using of teaching approach to evaluate ABGs could improve the nurses' ability to achieve ABGs perfectly. Additionally, the current study was congruent with ***Aygencel, (2014)*** in a study about "Arterial blood gases sampling" who reported that, training has positive impact toward enhancing nurses' practice.

On concerning correlation between total nurses' knowledge and total practices regarding safe arterial blood gases sampling for high-risk neonates before and after the computer-based learning module, there was a significant positive statistical correlation between total nurses' knowledge and total practices post-intervention. This result might be qualified to the more time of education could help the studied nurses to

improve their knowledge and enhance their practice. This finding was on the same line with ***Safwat and khorais, (2018) and Sebaq et al., (2019),*** they found that there was a significant positive correlation between nurses' knowledge and practices at the post program phases ($p<0.001$).

Regarding gestational age of the studied high-risk neonates, the present study showed that more than half had a gestational age between 34->37 weeks with the mean 33.28±2.46 weeks. This result approved by ***Mohammed et al., (2019)***, who reflected that 81.8% of the studied preterm infants were between 32-≤36 weeks. This finding also supported by ***Mahmoud et al., (2016),*** in a study about "The effect of endotracheal suction intervention on oxygen saturation level in preterm infants" who founds that more than two-thirds of studied preterm infants had the gestational age 32-≤36 weeks. These findings may reveal that the preterm infants with gestational age 32-≤ 36 are at high risk of being ventilated and requiring arterial blood gases sampling.

The result of the current study revealed that about three-fifths of the studied high-risk neonates were males. This finding was agreed with ***Mohammed et al., (2019)*** who found that, more than three-quarters of the studied preterm infants were males. This finding also supported by ***Zhu et al., (2017)***, in a study about "Noninvasive high frequency oscillatory ventilation versus nasal continuous positive airway pressure in preterm infants with moderate-severe respiratory distress syndrome" who observed that about two-thirds of the studied preterm infants were males. Furthermore, this finding disagreed with ***Sivanandan et al., (2018)*** in a study about "Target oxygen saturation among preterm neonates on supplemental oxygen therapy: A quality improvement study," who confirmed that more than two-thirds of preterm neonates were females.

Regarding the medical diagnosis of the studied high-risk neonates, the current study reflected that about two thirds had respiratory distress syndrome. This finding supported by ***Mahmoud et al., (2016)***, who founded that nearly half of studied preterm infants had respiratory distress syndrome. Moreover, this result agreed with ***Elsobkey & Amer (2018),*** who presented that the majority of preterm infants had respiratory distress syndrome. From the researchers' point of view, arterial blood gases sampling is required for these ventilated high-risk neonates.

Regarding complications of arterial blood gases sample, the result of the present study revealed that more than three quarters have complications; this was agreed with ***Haldar & Dwari (2019),*** who found that there was risks for arterial blood sampling. From the researchers' points of view, this may be due to incompetent nurses' practices regarding safe arterial blood gases sampling for these high-risk neonates.

Conclusion

Based on the results of the current study, it can be concluded that the research hypotheses were accepted. The majority of studied nurses had a good level of knowledge and competent level of practice after implementation of the computer-based learning module as compared to before intervention with highly statistically significant improvement.

Recommendations

Based on the results of the current study, the following recommendations can be suggested:

- Conducting periodical online programs for nurses in NICUs with continuous regular updating of knowledge and practice regarding safe arterial blood gases sampling for high-risk neonates.
- Highlighting the importance of implementation of online nurses' program and webinar regarding caring of high-risk neonates.
- Further studies are recommended regarding implementation of online programs for different health statuses for high-risk infants in different health care settings.

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