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Effectiveness of a computer-based learning module on arterial blood gas interpretation among staff nurses in critical care units

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1. ABSTRACT

Continuous education and updating knowledge and skills for nurses is very important, because they working in different shifts, do not have the opportunity to participate in face-to-face teaching sessions; self-educating methods are is very useful for them. Online, computer-based learning has emerged as an alternative means of providing continuing education to nurses. **The aim** of this study was to assess the effect of online-learning module on nurses' knowledge and practice regarding Arterial Blood Gas (ABG) interpretation in critical care units. **Design:** A quasi-experimental design was utilized in the conduction of this study. **Setting:** the study was carried out in the respiratory ICU and coronary care unit affiliated to Ain Shams University Hospitals. **Sample:** a purposive sample of (60) staff nurses. **Tools:** data were collected through three tools; **1.** Nurses' self- administered questionnaire**;** it included two parts: A. characteristics of the studied Nurses, B. Nurses' knowledge assessment tool to assess the level of nurses' knowledge regarding ABG interpretation. **2.** Nurses' practice checklist to assess nurses' level of practice regarding ABG interpretation; both tools used pre and post implementation of the online-learning module **3.** Nurses' satisfaction questionnaire to assess the level of nurses' satisfaction regarding Arterial Blood Gas (ABG) interpretation post implementing online learning module. **Results** howed that there were a highly statistically significant difference of nurses' level of knowledge and nurses' level of practice before and after implementation of online-learning module (X^2 = 53.333; 58.800) respectively at p. <0.001. The results also revealed that there was a positive correlation association between nurses' total satisfactory level of knowledge and total satisfactory level of practice pre and post implementation of online-learning module (**r** = 0.566, 0.809) respectively. **Conclusions:** The level of nurses' knowledge and level of nurses' practice regarding Arterial Blood Gas (ABG) interpretation increased significantly after implementing the online-learning module. **Recommendations:** The study can be replicated on a large sample to generalize findings. Incorporating online-learning module related to ABG interpretation into the continuing professional development courses for critical care nurses is recommended.

2. Introduction

The process of analysis and monitoring of arterial blood gas (ABG) is an essential part of diagnosing and managing the oxygenation status and acid–base balance of the high-risk patients, as well as in the care of critically ill patients in the Intensive Care Unit. Arterial blood gas interpretation is just one example of the many activities in which nurses must demonstrate competency to provide safe patient care ***(Sood, Paul & Puri, 2010)***.

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In the health care area, scientific and technological advances lead to the obsolescence of knowledge and professional skills in a remarkably short period of time. Thus, a comprehensive basic professional preparation is no longer sufficient for a whole life of practice. Moreover, given the emphasis on evidence-based practice, nursing staff members constantly need to update their knowledge and professional abilities. Therefore, continuing education has increasingly become essential to guarantee high-quality nursing practice *(**Goldsworthy, 2016**)*.

Education offered in traditional classroom settings has its own barriers, including the challenges associated with travel, limited budgets for education and training, and inflexibilities of scheduling inherent in shift work. For this reason, online learning has emerged as an alternative means for providing information and sharing knowledge. Computers are more readily available and accessible in both work and home settings than ever before, and using such technology is one way to accommodate nurses' learning needs *(**Atack & Rankin, 2002; Smith, 2005**)*.

The education and training of healthcare professionals has been apprised by advancements in information and communication technologies for several decades. Access to these technologies has meant that adult learners now have instant access to information flow *(**Billings, 2005**)*. Hence, a nurse as a lifelong learner now has access to instant evidence-based information on patient care processes and standards.

Online learning is recognized as an effective learning approach for enhancing nursing knowledge and skills. It has been widely utilized for professional development and training nursing skills in clinical setting. ***Cook (2012)*** suggested that online education should empower nurses to balance their own learning and workloads at the same time. Other reasons for nurses to adopt online continuing education are the flexibility of both time and space, self-regulated learning, cost-effectiveness, and less impact on their families and personal lives *(**Wu, Chan, Tan & Wang, 2017**)*.

The Internet and the development of information technologies have revitalized the exchange of information and training worldwide. Consequently, eLearning is used increasingly in medical and health professional education, to tackle the global shortage of health workers. E-Learning is "an approach to teaching and learning, representing all or part of the educational model applied, that is based on the use of electronic media and devices (computer, tablet, smartphone) as tools for improving access to training, communication and interaction and that facilitates the adoption of new ways of understanding and developing learning" *(**Sangrr ˇ, Vlachopoulos & Cabrera, 2012**)*.

E-Learning does not only differ from traditional learning (i.e., face–to–face learning that takes place in a classroom environment) in the medium by which learning is delivered *(**Masters & Ellaway, 2014**)*, but also affects the teaching and learning approaches used. E-Learning can take the form of a full eLearning approach, which is entirely driven by technology, or be a mix of the traditional and fully computer–based methodologies (blended learning). Blended learning might be more suitable for health care training because of the need to combine hands–on skills– based training at a practical level as well as self–directed learning *(**Duque, Demontiero, Whereat, Gunawardene, Leung & Webster, 2013**)*.

3. Significance of the Study

Critical care nurses are required to have specialized skills and knowledge to enable them to critically think rapidly in life-threatening situations. One of the specific skill sets that is foundational for critical care nurses is to be able to competently analyze arterial blood gas, which can be a difficult and daunting concept for critical care nurses to grasp. In addition to shift responsibilities, nurses have other commitments, such as mandatory regulatory agency requirements, committee work, and family obligations to fulfill. These factors contribute to the challenges staff nurses encounter in accessing continuing education programs.

Online-learning is growing as an option for

nurses who want to continue their education to improve patient care outcomes, advance their careers, and contribute to a more effective and efficient health care system. Although online-learning is becoming increasingly used, there is minimal information regarding its effectiveness. Therefore, this study was conducted to assess the effect of utilizing online-learning module as a method of an educational delivery system.

4. Aim of the study

This study aimed to assess the effect of online-learning module on nurses' knowledge and practice regarding Arterial Blood Gas (ABG) interpretation in critical care units. This aim was achieved through the followings:

- Assessing
- Developing and implementing an
- Evaluating the effect of an online learning module on nurses' knowledge and practice regarding Arterial Blood Gas (ABG) interpretation.

5. Hypothesis of the study

The level of nurses' knowledge and practice regarding Arterial Blood Gas (ABG) interpretation will significantly increase after implementing the online-learning module.

6. Subjects and method

Research Design:

A quasi-experimental design was utilized in the conduction of this study.

Setting:

The study was carried out in the respiratory intensive care unit (ICU) and coronary care unit (CCU) that affiliated to Ain Shams University Hospitals.

Subjects:

A purposive sample of staff nurses working in the pre mentioned settings, (60) nurses were selected depending on their availability during the data collection time as well as their willingness to participate in the study. They were attended first-time online-learning module, and has the ability to use the internet to communicate with the researchers in applying the tools of the study.

7. Tools for data collection:

The following tools were used for data collection:

I. Nurses' self- administered questionnaire: it was available online and included two parts:

- Characteristics of the studied Nurses:

1. Nurses' knowledge assessment tool:

Scoring system:

The correct response was scored one grade, while the incorrect response scored zero. The total satisfactory level of knowledge was $\geq$85%; while the unsatisfactory level was $<$85%.

II. Nurses' practice checklist:

It was adapted from ***(Blair & Jansen, 2015; Larkin & Zimmanck, 2015)*** to assess the level of nurses' practice regarding ABG interpretation. The researchers used four standardized ABG Strips of real patients had the following problems (Respiratory Acidosis, Respiratory Alkalosis, Metabolic Acidosis and Metabolic Alkalosis).

Scoring system:

One grade for each step that done correctly, and zero for step that done incorrectly or not done. The total maximum score was twenty and categorized as competent (100%) and incompetent ($<$100%).

III. Nurses' satisfaction questionnaire:

It was used to assess the level of nurses' satisfaction regarding Arterial Blood Gas (ABG) interpretation post implementing online learning module. This questionnaire adapted from ***Cervera-Gascha, Ganzalez-Chorda, Mena-Tuela, Salas-Medina, Masia-Solar & Orts-Corts (2014)*** and modified by the researchers in order to suite the study aim. It included 11 items as follows, relevant of the course to their work, quality

of the course content, organization and structure of content, clear, appropriateness of the materials used, stimulating participation / reflection, acquisition of new skills and knowledge through online learning module, possibility of practical application and relevance to the aim of the program.

Scoring system:

The nurses' questionnaire is based on Likert scale with 5 levels of response (1 = very low, 2 = low, 3 = Average, 4 = high, 5= very high). A total score was given to each participant (11 being the lowest and 55 being the highest possible score). Level of nurses' satisfaction was distributed as (11-21) = very dissatisfied, (22-32) = dissatisfied, (33-44) = satisfied and (45-55) = very satisfied.

Validity and reliability:

Validity was ascertained by a group of experts (9) from Medical Surgical Nursing specialty. Their opinions were elicited regarding the tools format layout, consistency and scoring system. The contents of the tools were tested regarding the knowledge accuracy, relevance and competence. The questionnaire and checklists *reliability* were confirmed by Cronbach's alpha coefficient (alpha = 0.88 for nurses' knowledge questionnaire & alpha = 0.85 for observation checklist.

Ethical considerations and human rights:

In the planning stage, approval was obtained from the director of the Medical ICUs at Ain Shams University, after explaining the purpose of the study. The participant's approval was taken after informing them that their participation is voluntary, and that they have the right to withdraw at any time without any consequences. As well, confidentiality was insured for the nurses. There are no risks for the participant in this study. There is no cost to be upon the study subjects. There are direct benefits for the participants.

Pilot study:

A pilot study was carried out on 10% of the total study sample to test the study process's clarity, feasibility and practicability of the tools in addition to the subjects and settings. Pilot subjects were later included in the study as there was no radical modifications in the study tools.

Field work:

1. The study were conducted within

- The development of tools and designing the online learning module

The current study was conducted through the following phases:

Assessment and Planning phase

- The researcher visited the selected coronary care and respiratory intensive care units before implementation of the online-learning module.

1. Nurses' knowledge and practice were assessed before implementing the
2. Online-learning module for ABG interpretation

Implementation phase:

The online-learning module for ABG interpretation was presented for theoretical session via fliers on e-mail box, and in the practical sessions the nurses were observed on spot.

- Theoretical session:

1. 'Practical sessions:

Evaluation phase:

Immediately after implementing the online training module the researcher conducted the post-test using the same knowledge assessment tool of pre-test. For practical evaluation the researchers observed the nurses individually at bedside using the same four strips that previously used. The researchers also used nurses' satisfaction questionnaire to assess the level of nurses' satisfaction regarding Arterial Blood Gas (ABG) interpretation post implementing online learning module.

8. Statistical analysis

Data were presented using number and percentage, means, standard deviations and qui-square test. Level of significance was threshold at 0.05.

Table 1: **Demographic characteristics of nurses under study (n=60)**

Demographic characteristics		%
Age;		
< 30	34	56.7
≥ 30	26	43.3
Mean ±SD	28.67±4.23	
Sex		
Male	23	38.3
Female	37	61.7
Level of education:		
Diploma	20	33.3
Bachelor	40	66.7
Years of experience:		
< 10	35	58.3
≥ 10	25	41.7
Mean ±SD	11.09±3.5	
Exposure to In-service education program;		
Yes	12	20.0
No	48	80.0

Table 2: Frequency and percentage distribution of nurses' satisfactory level of knowledge regarding ABG analysis, pre and post implementation of online-learning module (n=60)

Nurses	Pre		Post		Chi-square	
knowledge		%		%	X2	P value
Definition of ABG	9	15.00	51	85.00	58.800	<0.001**
Oxygenation	8	13.33	52	86.67	64.533	<0.001**
Respiratory acidosis	12	20.00	48	80.00	43.200	<0.001**
Respiratory alkalosis	10	16.67	50	83.33	53.333	<0.001**
Metabolic acidosis	15	25.00	45	75.00	30.000	<0.001**
Metabolic alkalosis	7	11.67	53	88.33	70.533	<0.001**
Total	10	16.67	50	83.33	53.333	<0.001**

Table 3: Frequency and percentage distribution of nurses' satisfactory level of knowledge regarding ABG analysis, pre and post implementation of online-learning module (n=60)

Nurses	Pre		post		Chi-square	
knowledge		%		%	X2	P-value
Strip I	7	11.67	53	88.33	70.533	<0.001**
Strip II	10	16.67	50	83.33	53.333	<0.001**
Strip III	11	18.33	49	81.67	48.133	<0.001**
Strip IV	8	13.33	52	86.67	64.533	<0.001**
Total	9	15.00	51	85.00	58.800	<0.001**

Table 4: Relation association between nurses' total satisfactory level of knowledge and demographic characteristics (n=60)

Demographic characteristics	Knowledge post		Chi-square	
		%	X2	P-value
Age				
<30	26	76.47	2.561	0.103
≥ 30	24	92.31		
Sex				
Male	16	69.57	5.090	0.024*
Female	34	91.89		
Level of education:				
Diploma	11	55.00	17.340	<0.001**
Bachelor	39	97.50		
Years of experience:				
< 10	26	74.29	4.951	0.026*
≥ 10	24	96.00		
Exposure to In-service education program				
Yes	5	41.67	18.750	<0.001**
No	45	93.75		

Table 5: Relation association between nurses' total satisfactory level of knowledge and demographic characteristics (n=60)

Demographic characteristics	Practice post		Chi-square	
		%	X2	P-value
Age				
<30	28	82.35	0.431	0.511
≥ 30	23	88.46		
Sex				
Male	16	69.57	6.969	0.008*
Female	35	94.59		
Level of education:				
Diploma	13	65.00	9.412	0.002*
Bachelor	38	95.00		
Years of experience:				
< 10	27	77.14	4.067	0.044*
≥ 10	24	96.00		
Exposure to In-service education program				
Yes	8	66.67	3.954	0.047*
No	43	89.58		

Table 6: Relation association between nurses' total satisfactory level of knowledge and total satisfactory level of practice regarding ABG analysis (n=60)

Practice	Knowledge	
	r	P-value
Pre	0.566	<0.001*
Post	0.809	<0.001*

Table 7: Level of nurses' satisfaction as regards online-learning module of arterial blood gas (ABG) interpretation (n=60)

Items	Nurses' response	
		%
Very satisfied	40	66.6
Satisfied	10	16.7
Dissatisfied	10	16.7
Very Dissatisfied	0	0

9. Results

Table (1):*Frequency and percentage distribution of demographic characteristics of the nurses under study*, this table illustrates that 56.7 % of the nurses were below 30 years with the mean age 28.67±4.23 years, and 61.7 % were female. Regarding educational level, it was found that 66.7 % of the nurses had bachelor degree in nursing science. As regards to years of experience, it was found that 58.3 % of the nurses had less than 10 years and the mean years of their experience was 11.09±3.5 years. Concerning attending training courses, 80 % of nurses didn't attend any training course related to ABG interpretation.

Table (2):*Frequency and percentage distribution of nurses' satisfactory level of knowledge regarding ABG analysis, pre and post implementation of online-learning module*, this table reveals that there was a highly statistically significant difference of nurses' level of knowledge pre and post implementation of online-learning module regarding definition of ABG, oxygenation, respiratory acidosis, respiratory alkalosis, metabolic acidosis and metabolic alkalosis at p <0.001.

Table (3):*Frequency and percentage distribution of nurses' satisfactory level of practice regarding ABG analysis, pre and post implementation of online-learning module*, this table represents that there was a highly statistically significant difference of nurses' level of practice pre and post implementation of online-learning module at p <0.001.

Table (4): *Relation association between nurses' total satisfactory level of knowledge and demographic characteristics*, the table represents that there was a highly statistically significant relation between nurses' total satisfactory level of knowledge and their level of education and exposure to In-service education program (p <0.001 & <0.001). Table also reveals that there were a significant relation between nurses' total satisfactory level of knowledge and their years of experience and sex at p value (0.026 & 0.024) respectively. While no significant relation was found as regards to age at p value (0.103).

Table (5): *Relation association between nurses' total satisfactory level of practice and demographic characteristics*, this table represents that there was a statistically significant relation between nurses' total satisfactory level of practice and their exposure to in-service education program, years of experience, level of education and sex (0.047, 0.044, 0.002, 0.008) respectively. While no significant relation was found as regards to age at p value (0.511).

Table (6*):* *Relation association between nurses' total satisfactory level of knowledge and nurses' total satisfactory level of practice regarding ABG analysis*, the table shows that there was a statistically significant relation between nurses' total satisfactory level of knowledge and nurses' total satisfactory level of practice pre and post implementation of online-learning module at p <0.001.

Table (7):*Level of nurses' satisfaction as regards online-learning module of arterial blood gas (ABG) interpretation*, it was found that 66.6% of the nurses under study were very satisfied from the online-learning module of arterial blood gas (ABG) interpretation, where 16.7% were dissatisfied.

10. Discussion

The current study was attempted to assess the effect of online-learning module on nurses' knowledge and practice regarding Arterial Blood Gas (ABG) interpretation. Regarding the demographic characteristics of the studied subjects, the distribution of nurses by sex and age showed that less than two thirds of nurses were female and more than half of the studied sample, their age were less than thirty years old with the mean age 28.67±4.23 and they had less than ten years of experience. These findings are congruent with ***(Khodish, Mohammed, Abdel-Aziz & Ibrahem, 2013)*** entitled "*Knowledge and Performance of Critical Care Nurses Toward Nebulizer Therapy in the Intensive Care Unit at Assiut University Hospital*" who identified that more than two thirds of nurses were female, more than three quarter of them were less than thirty years old, and less than two thirds of nurses had less ten years of experience. Moreover, two thirds of the studied subjects were having bachelor degree, and the rest were diploma degree. The researcher point of view, this might be due to the trend of the administration of the hospital to employ the bachelor degree in critical area in the step of change to make all the staff nurse in the ICU bachelor degree. This result is inconsistent with a study conducted by ***(Gaumer, El Beih & Fuoad, 2008),*** entitled *'Health Workforce Rationalization Plan for Egypt'* who reported that in Egypt were 87% -93% of nurses graduate of secondary nursing schools. Finally, most of the subjects didn't receive any previous training courses regarding (ABGs) interpretation, the nurses reported that they didn't have the time to engage in face-to-face classes.

Regarding the nurses' level of knowledge and practice pre and post implementation of online learning module. The present study findings showed that, there was a highly statistically significant difference of nurses' level of knowledge pre and post implementation of online-learning module at $p < 0.001$. The results of pre-test showed that the majority of the staff nurses got unsatisfactory level of knowledge, that might be due to lack of nurses' time to update their knowledge, due to time constraints, lack of co-workers' support and work commitments, especially those who are working in the intensive care units for several years and overloaded by increased number of patients for each nurse but after implementing the online-learning module the result of post-test was more than ninety percent of the nurses got satisfactory level of knowledge. This finding is congruent with the finding of the study conducted by ***Schneiderman, Corbridge & Zerwic (2009)*** entitle '*Demonstrating the effectiveness of an online, computer-based learning module for arterial blood gas analysis*' who found that computer-based learning modules were effective in teaching ABGs analysis for critical care nurses. The present finding also is consistent with ***Youssef, Yahia, Ali & Elhabashy (2013)*** entitle '*Factors Affecting Validity of Arterial Blood Gases Results among Critically Ill Patients: Nursing Perspectives'*, who reported that 100% of the studied subjects demonstrated satisfactory level of knowledge and practice in relation to ABG sampling, after using Web-based resources to teach nurses.

The present research moved beyond the improvements observed between pre- and post-tests, related to the practical skills of the studied nurses in relation to ABG interpretation, the highly significant differences improvements were observed from the studied nurses it could be due to they become familiar with the online learning module it can be seen more easy to use. The findings of current study support the use of a self-directed module as an alternative to a face-to-face teaching session. This results supported by ***(Lan, 2015; Sung, Wu, Chen & Chang, 2015)***who mentioned thatusing eLearning to enhance nurses' literacy has been recognized as an important approach of teaching. This consistent with ***Phillips' (2005)*** conclusion '*Strategies for active learning in online continuing education* ' who stated that educational modules provided frequent feedback to learners, used a self-paced technological medium that provided active learning, problem solving, and immediate feedback to the nurses.

This supported by ***Saif (2009)*** who stated

that urses might have difficulties during their attendance in such face-to-face classes. Using self-instruction methods such as online educational modules, which are an approach of education could be a better idea so that the individual can control the time and place of learning. Furthermore, several studies have shown that when adults are involved in consistent learning, they have a better perception in learning. Another feature of adults is their tendency to choose the time and place for learning. Hence, applications in self-instruction method is so effective in comparison with lecture method.

The present study found that there were highly significant relation between the level of knowledge of staff nurses on ABG interpretation results with demographic variables regarding level of education and in-service education program, meanwhile no significant association between the level of knowledge and age, whereas the majority of nurses with bachelor's degree and who didn't receive in-service education program were had satisfactory level of knowledge. This finding may be explained by the researchers, there were challenges enthusiast the nurses the first one, this procedure is a life-threatening, the second one, there were a concept that this procedure is related to physician who is the only one prepared and capable to perform. These challenges motivate those nurses to actively engage in the online-learning module to develop their abilities to perform this procedure. Based on the results of a study conducted by ***Shahhosseini & Hamzehgardeshi (2015)***, the researchers concluded thatthe educational programs should be developed and implemented based on nurses' professional needs.

Considering the level of nurses' satisfaction post implementation of online-learning module regarding Arterial Blood Gas (ABG) interpretation, it was observed that, more than half of them were very satisfied and the minority of them were dissatisfied regarding to the relevant of the course to their work, quality of the course content, organization and the adequacy of section coverage and overall content coverage., spelling, length, appropriateness of the materials used, stimulating participation / reflection online, good relationship, acquisition of new skills and knowledge, possibility of practical application and relevance to the aim of the module. The nurses highlighted the effects of online-learning module and Arterial Blood Gas (ABG) interpretation. This finding could indicate the success of the learning module which involved nurses from two different units and shifts for mastering a vital procedure.

This finding in agreement with ***Karaman (2011)*** who reported that many studies have shown positive outcomes of online nursing education in terms of achievement, satisfaction, outlook and increased desire for learning. Studies comparing online learning with traditional classroom experiences have shown that academic achievement, socialization, and mentoring opportunities are comparable or improved by using online education.

11. Conclusion

In conclusion, the present study showed that, the level of nurses' knowledge and level of nurses' practice regarding Arterial Blood Gas (ABG) interpretation increased significantly after implementing the online-learning module.

12. Recommendations

- In Research:
- In-service

13. Acknowledgement

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