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Effect of Nursing Educational Guidelines about pulse oximetry on Critical Care Nurses' Knowledge at a Selected University Hospital in Egypt

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Abstract: **Pulse oximetry is a frequently used, noninvasive monitoring tool for assessing arterial blood oxygenation. Physicians, registered nurses, and respiratory therapists are responsible for the accurate interpretation of pulse oximetry data as part of the evaluation and management of acutely and critically ill patients. Aim of the study: (1) to evaluate the extent of current critical care nurses' knowledge about pulse oximetry and (2) to evaluate the effect of nursing educational guidelines about pulse oximetry on critical care nurses' knowledge. Research Design: A quasi-experimental design was used in this study, one group pre/post – test. Research hypothesis: The total mean posttest knowledge scores of nurses who will be exposed to educational guidelines about pulse oximetry will be significantly higher than their pre mean knowledge scores. Setting: one of the intensive care units affiliated to university hospital in Cairo. Tools of data collection: 1) critical care nurses' personal characteristics data sheet, 2) Pre/post knowledge questionnaire sheet of 19 true-false questions based on the research-based practice protocol of the American Association of Critical Care Nurses was developed to evaluate nurses' knowledge about pulse oximetry. Sample a purposive sample of 30 critical care nurses was invited to complete the test before and 10 days after educational guidelines submission to improve critical care nurses' knowledge about pulse oximetry. The educational guidelines included principles of pulse oximetry functioning and conditions that can affect reliability of monitoring results. Results: total of 30 critical care nursing staff members completed the pre/post test given before and after the educational guidelines submission. The total mean pre knowledge scores was 8.6 + 2.3.This mean knowledge score increased significantly after submission of the educational guidelines from 8.6 + 2.3 to 16.6 ± 1.65 with t test 55.2 at p= 0.000). Conclusion: This educational guidelines improved critical care nurses' knowledge about pulse oximetry monitoring. Recommendations: To ensure quality patient care and safety, we recommend the implementation of focused formal short training programs to educate all health staff members regarding the principles behind, and correct clinical application of pulse oximetry, with periodic knowledge assessments. Also, this study is suggested to be duplicated in other settings, through the enrolment of larger samples. Moreover, future research is recommended to focus on the evaluation of continuing education programmes about pulse oximetry, in terms of improving both knowledge and competency about its use in clinical practice.**

Keywords: **Pulse oximetry, noninvasive monitoring tool, Nurses Knowledge and Educational Guidelines.**

1. INTRODUCTION

Pulse oximetry (PO) was released into the market in 1983 and quickly revolutionized monitoring of arterial oxygenation in patients in the peri-operative setting. The apparent ease of using a non-invasive and relatively low-cost technology quickly ensured clinical popularity. Particularly, within a decade of its broader clinical introduction, PO was so ever-present in its use that it was referred to as the 'fifth vital sign' (Jevon &Ewens 2000, Young 2003, Elliott et al. 2006).

In addition to acute care settings, PO is now budding as a popular assessment tool for paramedic and emergency services as well as sub-acute settings such as sleep disorder clinics, outpatient care, school health centers and community medical centers (DeSisto 2012). However, concern exists that utilization of PO in these broader applications appears to owe its existence to popularity rather than scientific rigors, with little data existing to decide whether patient outcomes are enhanced by PO utilization (Pretto et al. 2014). The apparent ease with which PO can be used belies the depth of understanding required to competently interpret its data. Primarily, it is important to note that PO is not a direct measure but rather an estimate of the arterial oxygen saturation of haemoglobin (Elliott et al. 2006, Casey 2011).

By directing red and infrared light throughout a pulsatile source of arterial blood (such as capillaries in the finger) the pulse oximeter uses a sensor to make out the amount of light absorbed by oxygenated and nonoxygenated blood (Nasreen 2013). The device then uses a stored, dedicated, calibrated algorithm to calculate estimated arterial haemoglobin oxygen saturation level (SaO2) which is then expressed as SpO2(Fouzas et al.2011).As PO measures the percentage of haemoglobin saturated with oxygen, both haemoglobin level and SpO2are required to interpret the amount of oxygen available for tissue perfusion. In addition, nurses must think about intrinsic limitations of the technology generated both from factors that affect the PO signal (such as movement, ambient light and nail polish) as well as physiological factors that may confound interpretation of the data (such as carboxy-haemoglobin and the changing relationship between SaO2and PaO2caused by shifts in the oxyhaemoglobin disassociation curve) (Simon & Clark 2002).

Additionally, nurses must understand that although PO plays some role in assessing oxygenation, it has no capacity to determine adequacy of ventilation (Huijgen et al. 2011,Kiekkas et al. 2012). In fact, evidence suggests that in the setting of supplemental oxygen, ventilatory compromised patients may show normal saturations in the presence of life threatening hypercapnia (Burton et al. 2006, Galvagno2012). Given the frequent use of PO as a monitoring tool in patients at risk of ventilatory compromise, it is critical that nurses understand this concept. Dyshaemoglobins can also obscure truthful explanation of PO. In particular, a patient may have unimpeded gas exchange resulting in normal SpO2, but due to reduced haemoglobin (as a result of anaemia) may alongside practice reduce oxygen carrying capacity and therefore hypoxia (Casey 2011).

Pulse oximetry has revolutionized the ability to monitor oxygenation in a continuous, accurate, and non-invasive fashion. Despite its everywhere use, it is our impression and supported by studies that many providers do not know the basic principles behind its mechanism of function. This knowledge is important because it provides the conceptual basis of appreciating its limitations and recognizing when pulse oximeter readings may be incorrect.

Significance of the study

In clinical practice both physicians and nurses employed in intensive care units, and emergency departments are responsible for the interpretation of SpO2 values. Because of that, assessment and improving of their knowledge on pulse oximetry is very important because; insufficient knowledge can lead to misinterpretation of its readings and consequently compromise the patient's safety. These knowledge deficits have the potential to affect clinical decisions, which may result in patient mismanagement. .Therefore, this study was conducted to evaluate whether current knowledge about pulse oximetry monitoring is consistent with the research-based recommendations and to improve practice patterns by increasing nurses' knowledge of research-based practices related to the appropriate use of pulse oximetry and interpretation of its results, linking knowledge to practice.

2. SUBJECT AND METHODS

2.1. Aim of the study: The aim of the study has two folds, (1) to evaluate the extent of current knowledge about pulse oximetry and (2) to evaluate the effect of nursing educational guidelines about pulse oximetry on critical care nurses' knowledge.

2.2. Research design: A quasi-experimental research design was utilized in the current study (pre/post-test one group design).

2.3. Research hypothesis:

To fulfill the aim of the study, one research hypothesis was formulated

H1: The mean posttest knowledge scores of nurses who are exposed to Educational Guidelines about pulse oximetry will be significantly higher than their pre mean knowledge scores.

2.4 Setting: The study was conducted at one of the intensive care units affiliated to university hospital in Cairo

2.5 Sample: A purposive sample consisted of 30 critical care nurses working in the selected ICU, who apply pulse oximetry to critically ill patients, were included in the current study.

The inclusion criteria: critical care nurses were both sexes, having responsibility concerned direct patient care for two years of experiences or more, and with different educational level.

The exclusion criteria: critical care nurses who refused voluntarily to participate in the study.

2.6. Tools for data collection:

Two tools were developed by the researchers and used to collect data related to the current study.

Tool 1: Critical Care Nurses' personal characteristics Sheet: to assess data related to age, gender, marital status, years of experiences and level of education

Tool 2: Pre/post knowledge questionnaire sheet:

It contains (19 items), the nurses responding is divided into true, or false.

Scoring system: each correct answer got one grade with total scores 19, scores < 75 % (14 marks) were considered as unsatisfactory, and scores > 75% were considered as satisfactory level.

3. DESCRIPTION OF THE NURSING EDUCATIONAL GUIDELINES

The nursing educational guidelines were designed by the investigators based on extensive literature review. The designed nursing educational guidelines included definition, how pulse oximetry works, causes of hypoxia, benefits and risks of using pulse oximetry, principles of pulse oximetry functioning and conditions that can affect reliability of monitoring results

4. ETHICAL CONSIDERATION

An official permission was obtained from the director of Cairo University Hospital and the heads of the Intensive Care Unit in which the study was conducted. The aim of the research was explained to the nurses. Verbal consent was obtained from each nurse to participate in the study after clarifying the procedure of the study. Nurses were informed about their right to refuse participation and to withdraw at any time without any consequences. Confidentiality of data was ensured.

5. PROCEDURE

The study was carried out through three phases (preparation, implementation and evaluation phase):

5.1. Preparation phase: After finalization of the data collection tools and getting official permissions, the researchers started to recruit the samples. The studied nurses who caring for critically ill patients were interviewed to assess their knowledge about pulse oximetry before implementing educational guidelines by using pretest checklist .The time taken was 30 min. to fill out the questionnaire. This was followed by educational guidelines about pulse oximetry. It took two sessions one hour for each. Data collection for the current study was carried out in the period from July 2018 to August 2018.

5.2. The implementation phase: In this phase, a booklet containing the component of the guidelines based on evidence based practices and the results of pretest evaluation was prepared in Arabic language and was supplemented by photos and illustrations to help the nurses in understanding the contents. Educational guidelines were carried out for all nurses in classroom in the intensive care unit.

5.3. The evaluation phase: This phase was carried out after implementing the educational guidelines. Each nurse was evaluated to determine the effect of the educational guidelines through the post test.

6. STATISTICAL DATA ANALYSIS

Upon completion of data collection, data were analyzed using SPSS program version 20; then tabulated relevant statistical analysis was used to test the obtained data. Descriptive and inferential statistical were done level of significant set as at <0.05

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7. RESULTS

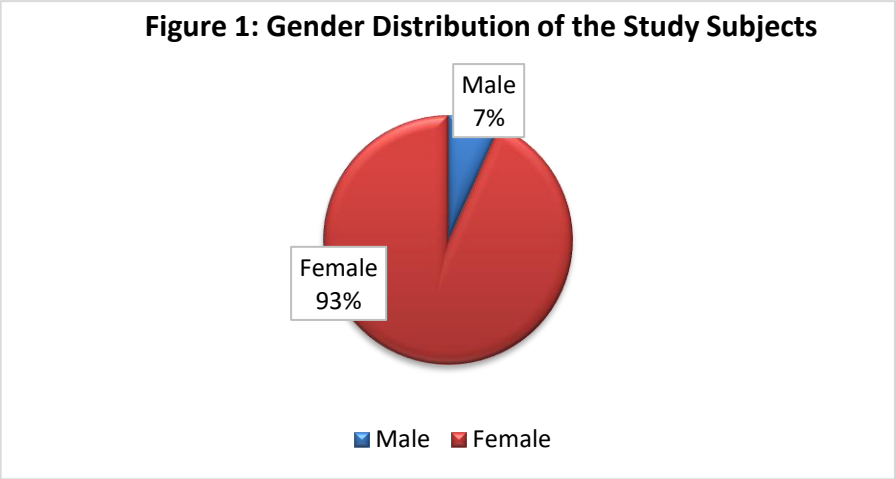

Figure (1) revealed that, majority of the study sample (93.3%) was females

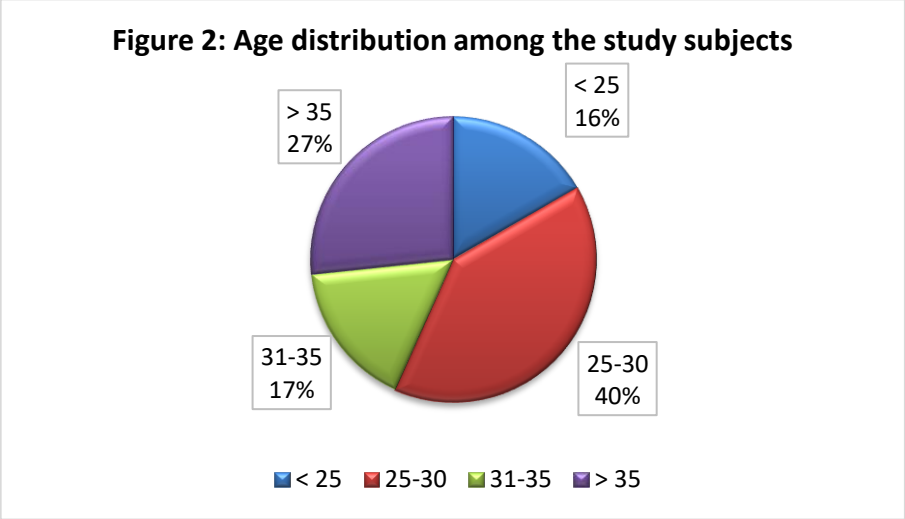

Figure (2): showed that, 40 % of the study subjects' age ranged between (25-30) years old, with mean age of (31.3)

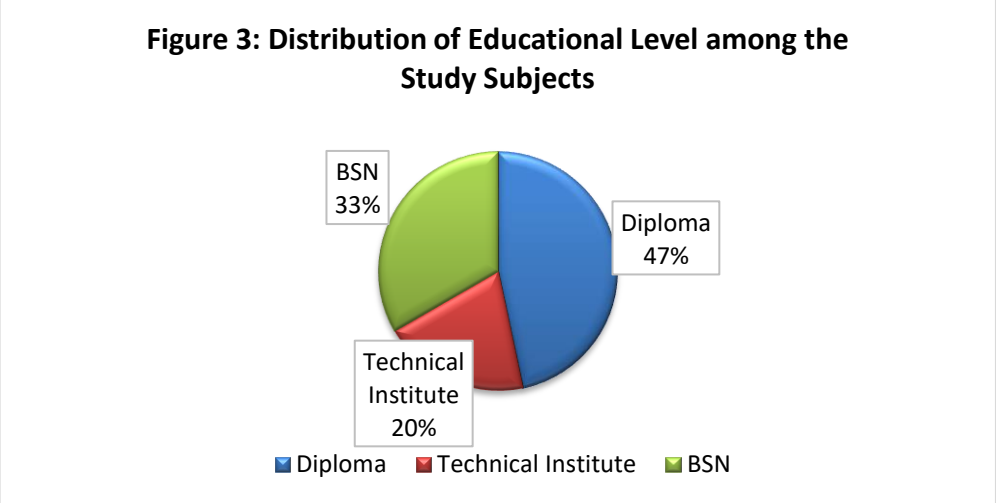

Figure (3): revealed that, about half of the sample (46.7%) had diploma certificate

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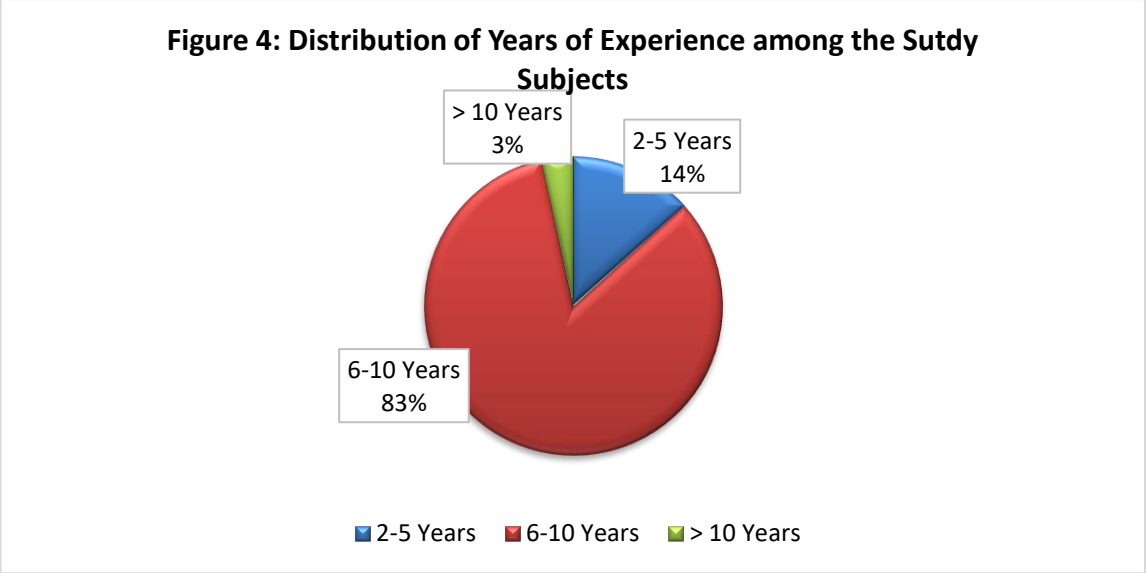

Figure (4): Majority of the study subjects' years of experience ranged between 6-10 years with mean of (8.26).

Table (1): Correct responses on pulse oximetry knowledge test (items related to principles of pulse oximetry functioning) (n=30)

	Statements about pulse oximetry–principles of pulse oximetry functioning	Correct answer Pre-Test		Correct answer Post-Test	
		N	(%)	N	(%)
1	**Pulse oximetry is a non-invasive method for measuring arterial oxygenation (T)**	20	66.7	29	96.7
2	**Pulse oximetry has been found to be accurate for oxygen saturation (SpO_2) between 70 and 100% (T)**	14	46.7	30	100
3	**Pulse oximetry is used for the rapid detection of tissue hypoxia (F)**	10	33.3	28	93.3
4	**Clinical assessment alone has been shown to be as effective as pulse oximetry monitoring in the detection of hypoxaemia (F)**	12	40	28	93.3
5	**Oxygen saturation values provided by pulse oximetry (SpO_2) are equally accurate to those provided by the analysis of arterial blood gases (SaO_2) (F)**	14	46.7	27	90
6	**Pulse oximetry is not an indicator of adequacy of ventilation (T)**	11	36.7	25	83.3
7	**The majority of pulse oximetry alarms are correct (F)**	23	76.7	25	83.3
8	**Conventional pulse oximetry is based on the absorption of red and infrared light by blood (T)**	10	33.3	25	83.3
9	**Pulse oximetry sensor is highly sensitive to mechanical damage (T)**	27	90	23	76.7
	Mean ±SD	4.7 ± 1.08		7.93 ± 0.94	

Table (1) shows that the majority of participants responding correctly to the questions asked about principles of pulse oximetry functioning after providing the educational guidelines with high total post mean knowledge scores

Table (2): Correct responses on test of knowledge about pulse oximetry (items regarding conditions that can affect reliability of monitoring results) (n=30)

	Statements about pulse oximetry – conditions that can affect reliability of monitoring results	Correct answer Pre-Test		Correct answer Post-Test	
		No	(%)	No	(%)
1	**Pulse oximetry may be unreliable in severely anaemic patients (T)**	13	43.3	27	90
2	**During vasoconstriction, sensor placement on the fingernail provides more accurate readings than its placement on central sites (i.e., ear, nose) (F)**	8	26.7	29	96.7
3	**Coloured nail polish does not affect the accuracy of pulse oximetry readings (F)**	13	43.3	27	90
4	**Pulse oximetry readings are less accurate when the patient is moving (T)**	8	26.7	27	90

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5	**Accurate pulse oximetry readings are more difficult to obtain when peripheral perfusion is poor (T)**	16	53.3	29	96.7
6	**Pulse oximetry readings are usually not affected by body position or ambient light (F)**	15	50	25	83.3
7	**Patients are at increased risk for desaturation during invasive procedures (T)**	13	43.3	24	80
8	**Use of pulse oximetry is strongly recommended during cardiopulmonary resuscitation (F)**	5	16.7	26	86.7
9	**Use of pulse oximetry is strongly recommended when the patient is on supplemental oxygen (T)**	23	76.7	24	80
10	**Pulse oximetry readings are not affected by smoke inhalation (F)**	13	43.3	24	80
	Mean ±SD	3.83 +1.41		8.73+1.11	

Table (2) revealed that, the majority of participants responding correctly to the questions asked about conditions that can affect reliability of monitoring results after providing the educational guidelines with high post total mean knowledge scores about pulse oximetry than pre mean knowledge scores

Table (3): one sample t-test comparing total knowledge scores regarding pulse oximetry among the study subjects. (Pre-test, post-test) (n=30).

Comparison	Mean ±SD	t-value	p-value
Total mean knowledge score (Pre-Test)	8.6±2.3		
Total mean knowledge score (Post-Test)	16.6 ± 1.65	55.2	0.000

This table revealed that, there is a highly significant statistical difference between total pre knowledge scores and total post knowledge score

Table (4): Comparing levels of total knowledge regarding pulse oximetry among the study subjects. (Pre-test, post-test) (n=30).

Variables	Unsatisfactory		Satisfactory		X^2/ p value
	No	%	No	%	
Level of total knowledge pre test (19)	29	96.7	1	3.3	44.9/0.006
Level of total knowledge post test (19)	2	6.6	28	93.4	

This table shows that, highly significant statistical difference between level of total nurses' knowledge pre and post receiving educational guidelines at p= 0.006

Table (5): Correlation between nurses' personal characteristics and total mean knowledge score (pre/post)(n=30)

		Total mean knowledge score (Pre)	Total mean knowledge score (Post)
Gender	Pearson Correlation	.187	-.486**
	Sig. (2-tailed)	.323	.007
	N	30	30
Age	Pearson Correlation	-.124	.064
	Sig. (2-tailed)	.513	.736
	N	30	30
Years of experience	Pearson Correlation	-.235	-.354
	Sig. (2-tailed)	.210	.050
	N	30	30
Total mean knowledge score (Pre)	Pearson Correlation	---	-.138
	Sig. (2-tailed)	---	.466
	N	---	30
Total mean knowledge score (Post)	Pearson Correlation	-.138	----
	Sig. (2-tailed)	.466	-----
	N	30	-----

This table shows that, significant statistical correlation between (gender & years of experience) and total mean nurses' knowledge score (post test) at p= 0.007 &.050 respectively

8. DISCUSSION

Thirty staff nurses comprised the sample for this study. Demographic variables included gender, age, educational levels and years of experience. The majority of participants were females. This high proportion of female nurses was most probably attributed to the fact that the study of BSN in the Egyptian universities was exclusive for females only till few years ago, so the profession of nursing in Egypt was mostly feminine. Also, it is worth mentioning that females comprised 90, 78% of the registered nursing personnel in Egypt while males comprised 9.22% (Ministry of Health and Population, 2013).

In relation to pretest knowledge score, the total level of pretest knowledge score of the study sample was unsatisfactory which suggested that the nurses had a limited overall knowledge of pulse oximetry, insufficient knowledge was found in certain areas. Insufficient knowledge was obvious in the field of principles of pulse oximetry functioning, in the items regarding what could be detected by pulse oximetry and how monitoring results could be interpreted. Similar results were found by Milutinović',Repić' &Aranđelović',(2016) in their descriptive multi-center study about clinical nurses' knowledge level on pulse oximetry, they found that the lower percentage of correct responses about principles of pulse oximetry function was found in items related to the alarm reliability and understanding technical limitations. They also, added that the factors which might affect pulse oximetry readings that were not identified by the nurses were the body position and specific kinds of ambient light.

Many studies as well as ours revealed incorrect understanding that pulse oximetry was a reliable indicator of ventilation, but not of oxygenation. Kiekkas et al. (2012) .,Milutinović',Repić' &Aranđelović',(2016), found that more than half of the participants, were incorrect to think this, also our study demonstrated that, this percentage which was significantly high. It is interesting to observe that the majority of nurses in our study thought that pulse oximetry was a method for monitoring arterial oxygen saturation, while on the other hand they stated that pulse oximetry could be used for detection of tissue hypoxia. Those findings can be interpreted as a common confusion of the terms "hypoxia" and "hypoxaemia" being seen as synonymous which they are not, since hypoxaemia refers to subnormal oxygenation of arterial blood, whereas hypoxia refers to subnormal oxygenation of tissue (Valdez-Lowe, Ghareeb, & Artinian, 2009).

The highest percentage of correct responses regarding the principles of pulse oximetry functioning was found in the statement about the alarm reliability. Our findings suggest that the majority of nurses considered most pulse oximetry alarms to be unreliable, which is inconsistent with the results obtained in similar studies (Kiekkas et al., 2012., Milutinović',Repić' &Aranđelović',2016).In the same line, Mininni, Marino, Kohler, Stephan, (2009), mentioned that ICU nurses should understand that body movements and poor perfusion can cause false alarms and erroneous readings. For instance, a false alarm can be activated during the inflation of a sphygmomanometer cuff if the sensor is placed on the same side as the cuff. Moreover, Cvach, (2012) clarified that frequent false alarms can cause "alarm fatigue" among nurses, and desensitize them this leads to their failure to react promptly to a deterioration in the patient's condition.

The analysis of responses regarding the common conditions or factors that can affect the accuracy and reliability of pulse oximetry readings revealed low level of knowledge of nurses that participated in this study. The majority of participants were not familiar with the fact that severe anaemia, body movement, invasive procedures and smoke inhalation could affect accuracy of readings. These findings were in contrast with the findings of Kiekkas et al. (2012) ., Milutinović',Repić' &Aranđelović, (2016),who reported that the majority of participants in their studies were familiar with the common factors that can affect the accuracy and reliability of pulse oximetry.

According to Çiçek et al., 2011&Villaflor et al., 2013, the effect of nail decorations on the pulse oximetry readings is a controversial subject in scientific circles which was also found among the participants of the current study. This controversy has probably arisen from conflicting evidence obtained in different studies as well as the fact that the majority of studies have included healthy participants and used different pulse oximeters, colours and types of nail polish, as well as different thickness of polish layer. In the absence of adequate evidence and in order to provide good and safe care Çiçek et al. (2011) recommended to have nail polish, acrylic gel and artificial nails removed (with the patient's consent) or to place the sensor on the earlobe or the nose as an alternative.

The current study findings revealed that the majority of the nurses had misconception that during cardiopulmonary resuscitation pulse oximetry is strongly recommended. This finding was in accordance with Kiekkas et al. (2012), the nurses participating in their study failed to know that pulse oximetry during cardiopulmonary resuscitation was not helpful because the circulation was maintained by thorax compression.

As mentioned before, the total mean score of knowledge regarding pulse oximetry before introducing educational guidelines was unsatisfactory. This finding reflected that the nurses' knowledge was low and inadequate. This finding is contradicted with Kiekkas et al. (2012) who documented that the nurses in their study had satisfactory knowledge level about pulse oximetry.

To evaluate if there was significant difference between the mean post-test knowledge scores of nurses after introducing educational guidelines and their mean pre-test knowledge scores (H_1), one sample t test was used. Results indicated statistical significant difference in the mean pre-test post-test knowledge scores of nurses. The nurses had an average increase of 8 points in the improvement of knowledge scores. This difference in the post-test scores of knowledge may be attributed to the nurses' exposure to recent updated knowledge about pulse oximetry through the introduced educational guidelines. Based on these results, H1 was supported.

These findings were supported by Attin et al. (2002), who commented that their implemented educational project resulted in improved knowledge related to pulse oximetry among nurses and it was useful in maintaining the increase in knowledge over time. Future strategies and research must be directed at more appropriate use of pulse oximetry.

In relation to correlation between sociodemographic variables and total knowledge test scores, there wasn't any correlation except for gender and clinical experience. The current study revealed significant correlation between gender and test scores. This finding was in contrast to Orimadegun, Ogunbosi& Akinbami,(2011) who documented that there was no significant correlation between gender and test scores in their study about knowledge and views of paediatricians about pulse oximetry.

In relation to clinical experience and knowledge test scores, the current study findings revealed significant correlation between them. This finding was against Lee, Yeung, Lo, & Chan, (2006), who documented that correlation analysis proved the absence of linear relationship between test scores of respondents and their experience. Also Orimadegun, Ogunbosi& Akinbami,(2011), found that there was no statistical difference and added that the absence of correlation between clinical experience and test score gives us a clue that knowledge on the use of pulse oximetry cannot be improved simply by accumulating experience.

9. CONCLUSION

The findings of the present study indicated a low level of pulse oximetry knowledge among staff nurses. Evidence about knowledge deficits was also provided, which were mainly associated with principles of pulse oximetry function. These deficits along with significant differences in the knowledge level possibly revealed that the majority of nurses acquire pulse oximetry knowledge not through systematic education, but rather on empirical basis. The study revealed also that the educational guidelines resulted in improving knowledge related to pulse oximetry among staff nurses, and thus, a better understanding of the pulse oximetry knowledge level among staff nurses can help to provide appropriate training recommendations.

10. RECOMMENDATIONS

The results of the current study clarified that pulse oximeters have slipped into clinical practice without sufficient training for nurses about it during nursing school. Thus, to ensure quality patient care and safety, we recommend the implementation of focused formal short training programs to educate all staff members regarding the principles behind, and correct clinical application of pulse oximetry, with periodic knowledge assessments. The training program should cover basic principles, physiological limitations of pulse oximetry and application of knowledge in clinical scenarios in order to ensure that staff can reach reasonable competencies in making the appropriate use of pulse oximetry. Also, this study is suggested to be duplicated in other countries, through the enrolment of larger samples. Moreover, future research is recommended to focus on the evaluation of continuing education programmes about pulse oximetry, in terms of improving both knowledge and competency about its use in clinical practice.

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