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Effect of Online Simulation-Based Education on Nurses' Knowledge and Skills Toward Electrocardiogram Interpretation

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ABSTRACT

Background: The use of simulation has gained great importance in teaching theoretical and clinical skills for nurses. It helps nurses to develop knowledge, skills and attitude and reduce probability of errors to improve quality of patients' care.

Aim: This study aimed to evaluate the effect of online simulation-based education on nurses' knowledge and skills toward electrocardiogram interpretation.

Study design: Quasi-experimental (one group pre-test/post-test) design was used to achieve the aim of this study.

Setting: This study was conducted in the classroom at Ain Shams University hospital.

Subjects: purposeful sample of (90) nurses were recruited to be included in this study.

Data collection Tools: (1) Nurses' knowledge assessment questionnaire. (2) Nurses' skills assessment questionnaire. (3) Nurses' satisfaction assessment questionnaire.

Results: The studied nurses' mean age was 33.51±8.59 years; 63.3% were females, 100% had bachelor degree, and 87.8% of them didn't attend training course before about ECG interpretation. A statistically significant difference was revealed in the knowledge and skills of nurses toward electrocardiogram interpretation before and after implementation of online simulation-based education where p value <0.001.

Conclusion: Implementation of online simulation-based education positively affects nurses' knowledge and skills toward electrocardiogram interpretation.

Recommendations: It is recommended to incorporate the online simulation to teach and train nurses working in the critical care units about electrocardiogram interpretation to help them improve their performance and enhance quality of patients' care.

Keywords: *Electrocardiogram interpretation, nurses' knowledge and skills, online simulation education.*

1. INTRODUCTION

The objective of nursing education is the acquisition of theoretical knowledge, as well as clinical skills, which are necessary for nurses to be integrated into the workforce. Integrated learning, critical thinking, and appropriate decision-making skills can help nurses to provide quality health care. This can be achieved through the inclusion of simulation in the education process [1]. Simulation is considered a teaching and training method for nurses aiming at the substantial understanding, enhancement and dissemination of knowledge, skills and attitudes of nurses [2].

Simulation-based education (SE) refers to the use of simulation software, tools, and serious games to enrich the teaching and learning processes [3]. Simulation is an educational tool or device with which the learner physically interacts to mimic real life situation and in which they emphasize the necessity of interacting with authentic objects [4]. It is a teaching method by which nursing educators are trying to achieve results approximating clinical practice as closely as possible [1].

Teaching practices based on the use of simulation education software, tools, and

games are receiving the attention of academic and industrial partners, who see in SE a way to enhance the training of their students. It was shown that there was an evolution in Google Scholar citations, of the term "simulation education" during the last two decades, and that the number of citations has evolved from 47 in the year 2000 to 968 in 2018. According to this forecast, the number of citations will reach a level of approximately 1,200 by 2022 [3].

Electrocardiogram (ECG) interpretation is an essential clinical skill that helps to rapid diagnosis of potentially life-threatening conditions. Cardiac dysrhythmia is the disruption in the sequence of normal functioning of the heart muscle at any age. In people with heart disease, 50% of deaths are caused by cardiac arrhythmias. Misinterpretation of the electrocardiogram can lead to inappropriate clinical decisions with adverse outcomes [5]. Nurses have an important role in the process of obtaining, interpreting, and communicating ECG abnormalities. The interpretation of ECG findings by nurses is very important for early detection of the abnormality, ensuring early intervention, and reducing errors in diagnosis. However, the interpretation of ECG findings requires nurses to have high levels of knowledge and skill to be able to deal with the increasing numbers of patients who access healthcare settings because of any health problems that affect the stability of cardiac rhythm [6].

The use of simulation to teach ECG interpretation has been shown to have advantages in the classroom, improving self-confidence and critical thinking. Web simulation and individualized training show good results in efficiency in arrhythmia interpretation [7]. Simulation range from low fidelity simulation to high fidelity simulation improves nurses' educational performance, knowledge and attitudes [8]. Through simulation, nurses can practice their abilities and clinical skills, make errors that will not be harmful for the patients, and repeat the process (more than once) leading to mastery and subsequently promote the self-confidence. In addition, they have time to re-examine and reflect on their performance [9].

1.1 Significance of the study:

Worldwide, sudden and unexpected cardiac death is the most common cause of death, accounting for 17 million deaths every year with sudden cardiac death accounting for 25 % of these [10]. According to a study published in the Journal of the American Heart Association, which used data from the Centers for Disease Control and Prevention. Researchers focused on 276,373 people ages 35 to 84 who died between 2011 and 2018 from cardiovascular disease related to Atrial Fibrillation [11].

Working in the intensive care units requires the nurses to be competent in knowledge and practice to be able to provide high-quality care for the critically ill patient, who may face a life-threatening condition such as cardiac arrhythmias. A change in the conduction system of the heart results in different types of arrhythmias that may be fatal or non-fatal. Using electrocardiogram simulation to teach and train nurses is very critical because it allows nurses to practice more, which reduces the risk for patients, helps them identify and interpret the patient's cardiac rhythm, and helps them make correct and timely decisions in order to save the patient's life and improve outcomes.

1.2 Aim of the study

This study aimed to evaluate the effect of online simulation-based education on nurses' knowledge and skills toward electrocardiogram interpretation through:

a) Assessing knowledge of nurses toward electrocardiogram interpretation.
b) Assessing skills of nurses toward electrocardiogram interpretation.
c) Developing and implementing online simulation-based education.
d) Evaluating the effect of online simulation-based education on nurses'

knowledge and skills toward electrocardiogram interpretation.

1.3 Research hypothesis

The current study hypothesized that

H_1: Implementation of simulation-based education positively affects nurses' knowledge toward electrocardiogram interpretation.

H_2: Implementation of simulation-based education positively affects nurses' skills toward electrocardiogram interpretation.

2. METHODS

2.1 Research design

Quasi-experimental (one group pre-test/post-test) design was used to achieve the aim of this study. A quasi-experimental design was done to test whether online simulation-based education would improve the knowledge and skills of nurses toward electrocardiogram interpretation. Quasi-experiments are studies that aim to evaluate interventions but that do not use randomization. Similar to randomized trials, quasi-experiments aim to demonstrate causality between an intervention and an outcome. Quasi-experimental studies can use both pre-intervention and post-intervention measurements as well as non-randomly selected control groups [12].

2.2 Setting

This study was conducted in the classroom at Ain Shams University hospital affiliated to Ain Shams University. The classroom is located in the first floor and contains data show apparatus, liquid crystal display (LDC) screen; computer, white board, comfortable chairs and tables, and air condition. It is clean and well ventilated with three windows and has a good lightening.

2.3 Subjects

A purposeful sample of 90 bachelor nurses who are working in the medical, neurological, and surgical intensive care units at Ain Shams University and El-Demerdash hospitals affiliated with Ain Shams University hospitals and are willing to participate in the study were recruited to be included in this study.

2.4 Tools for data collection

2.4.1 Nurses' knowledge assessment questionnaire:

This tool was developed by the researcher in English after reviewing the related literatures [13]. It was divided into two parts. Part I included data about nurses' demographic characteristics such as age, gender, marital status, educational level, years of experiences, previous training in ECG.

Part II is concerned with the assessment of nurses' knowledge about electrocardiogram interpretation. It includes 30 questions that were divided into seven (7) sections as follows; conduction system of the heart (3 questions), calculation of heart rate (4 questions), components of ECG (5 questions), cardiac cycle (3 questions), causes, symptoms and complications of arrhythmias (4 questions), types of arrhythmias (6 questions), and management of arrhythmias (5 questions). The questions were in the form of multiple choice questions (MCQ).

Regarding the scoring system of the nurses' knowledge assessment questionnaire, the response for each question was by choosing the correct answer. The correct answer was given one grade. Incorrect answer was given zero. The total grade was 30 grades. The total score for every section was calculated by summing the nurses' responses. Then, the total scores of the entire questionnaire for every nurse were calculated, and for all nurses after that. The score of the total questionnaire was categorized into:

- Failed <60% (≤17 degree).
- Accepted 60% (18 degree).
- Good 65% (19 degree).
- Very good 75% (22 degree).
- Excellent 85% (25 degrees).

2.4.2 *Nurses' Skills assessment tool:*

This tool was used to assess nurses' skills regarding electrocardiogram interpretation. It was developed by the researcher in English after reviewing the related literatures [13]. The tool consisted of 10 electrocardiogram rhythm strips. Nurses were asked to interpret each rhythm strip by choosing the best answer from the MCQs. The correct answer was given one grade. The incorrect answer was given as zero. The total score of the tool was calculated for every nurse after that; the total score for all nurses was calculated. The score of this tool was categorized into:

- Failed <60% (≤5 degree).
- Accepted 60% (6 degrees).
- Good 65% (7 degrees).
- Very good 75% (8 degrees).
- Excellent 85% (9 degrees).

2.5 Tools validity and reliability:

The tool was evaluated in terms of face and content validity by a panel of five experts (one professor, two assistant professors, and two lecturers) from the Faculty of Nursing, in medical surgical nursing department of Ain Shams University. The experts reviewed the tools for clarity, relevance, comprehensiveness, simplicity, and applicability. No modifications were done. Testing the reliability of the data collecting tools was done by alpha Cronbach test. It was 0.82 for the nurses' knowledge assessment questionnaire and 0.78 for the nurses' skills assessment questionnaire.

2.6 Pilot study

A pilot study was conducted on 10% (9) of nurses from the study settings to test clarity and applicability of the study tools, as well as to estimate the time needed for each tool to fill in. No modifications were carried out in any tool. Nurses who participated in the pilot study were included in the main study subjects.

2.7 Ethical considerations

The research approval was obtained from the ethical research committee at faculty of nursing before initiating the study. Permission to conduct the study was also obtained from the director of Ain Shams University and El-Demerdash hospitals. Also from the directors of the medical, neurological, and surgical intensive care units before conducting the study. The researcher clarified the aim of the study in a letter issued to the hospital's director from the dean of faculty of nursing prior to data collection. Verbal consent was obtained from nurses to ensure willingness to engage in the study. The researcher maintained anonymity and confidentiality of subjects' data. Nurses were informed that they are allowed to withdraw from the study at any time without penalty.

2.8 Procedures

Procedure included three phases: preparatory phase, implementation phase and evaluation phase.

2.8.1 Preparatory phase:

- This phase involved extensive reviewing of the recent related literatures to develop tools for data collection.
- Then, the researcher developed electrocardiogram interpretation educational materials in English. It includes topics about the anatomy and physiology of the heart, the conduction system of the heart, the cardiac cycle, methods of calculating heart rate, components of the ECG, the causes, symptoms, and complications of arrhythmias, and the management of each type. While the types of arrhythmias are available as simulator on the website for nurses to be able to practice and learn.
- The content of the educational materials was revised for content validity by a group of five experts (one professor, two assistant professors, and two lecturers) from the Faculty of Nursing, in medical surgical nursing department of Ain Shams University.

2.8.2 *Implementation phase:*

- The researcher interviewing the study subjects to explain the aim and purpose of

the study as well as taking the verbal approval of the study subjects to participate in this study prior to data collection.

- The nurses fill in the self-administered knowledge and skills assessment questionnaires in the presence of the researcher. It was used to assess nurses before implementing the simulation based education. It took about 40 minutes to complete by the nurses (30 minutes for the knowledge questionnaire and 10 minutes for the skills questionnaire).
- The collection of pre-intervention data took two months, from May 2022 to June 2022.
- The online six second ECG simulator for ECG interpretation was used as the intervention tool in this study. The six second ECG system has been taught for more than 20 years. It was chosen by the researcher from different available online simulators to teach nurses because it is easy to use, has simple interface, interactive, free, allow nurses to practice and repeat the strips as many as they want. It also generates 27 of the most common cardiac rhythms and its description. It is available at https://skillstat.com/tools/ecg-simulator/. (Figure 1).
- Then, teaching sessions were conducted at the previous mentioned setting. Nurses were divided into five groups with 20 nurses in each group except the fifth group includes 10 nurses only.
- Each session continued for four hours, one hour and half for the theoretical part and 2.5 hours for the practical part.
- The researcher uses the six second ECG simulator website during the session by displaying each rhythm strip for nurses to educate them about the types of arrhythmia, its management and interpretation, and teach them how to use the simulator. The website was sent to nurses to allow them to use and learn.
- The implementation phase continued for 1.5 months, from July 2022 to mid of August 2022 during the morning shift, one day per week.
- The educational materials were distributed to the study subjects and informed that they will be re-evaluated after implementing online simulation-based education.

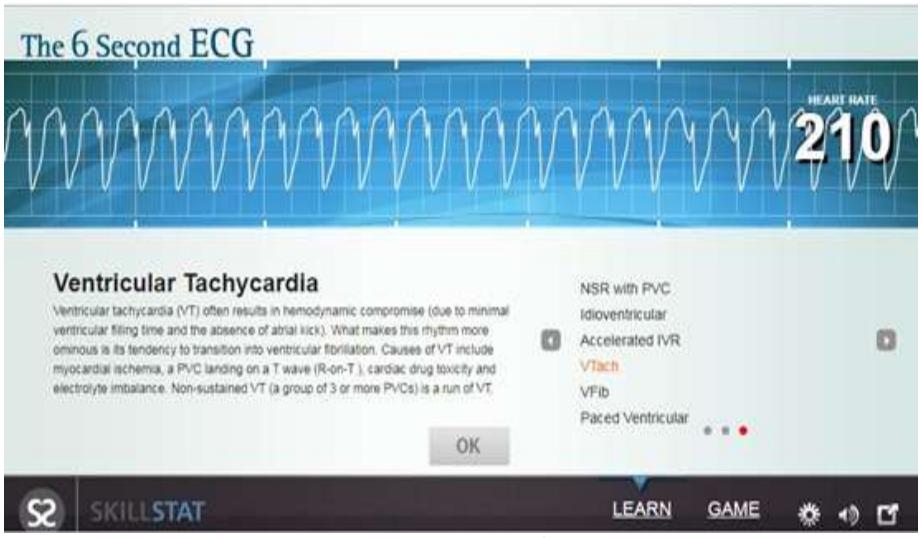

Figure 1: The six second ECG simulator for ECG interpretation.

2.8.3 Evaluation phase:

After one week of implementing the simulation based education for each group, all tools were filled in again by nurses to evaluate the effect of the online simulation based education on nurses' knowledge and skills toward ECG interpretation. Evaluation of the effect of simulation-based education was done by comparing the results of nurses' knowledge and skills before and after the implementation by using the same data collection tools.

2.9 Data analysis

The data were collected, coded and entered into a suitable excel sheet. The data were tabulated and statistically analyzed using the statistical package for social science (SPSS) for window, version 25 (SPSS Inc., Chicago, IL). Quantitative data were described as mean and standard deviation to present normally distributed continuous variables. Qualitative data were expressed as frequencies (n) and percentage (%). Bivariate analyses were performed for normally distributed data by using the paired Student's t-test. Non-normally distributed variables were compared using Wilcoxon Signed Ranks test, Mc Nemar test was used for categorical variables and marginal test of homogeneity. P value ≤ 0.05 was considered significant.

3. RESULTS

Table (1) shows the demographic characteristics of the studied nurses and reveals the mean age of nurses under study was 33.51±8.59 years and 47.8% fall at age group between 20-<30 years old. As regard to nurses' gender, two thirds of them (63.3%) of them were females, 58.9% of nurses had bachelor degree. In relation to marital status, the table demonstrated that more than half (53.3%) of nurses were married, 74.4% of them are working as staff nurse in the previous mentioned setting, 52.2% of them had years of experience in the work place from 1-<3, and majority of them (87.8%) didn't attend training course before about ECG interpretation.

Table (2) compare the nurses' knowledge regarding electrocardiogram interpretation and reveals highly statistically significant differences in all items of ECG interpretation pre and post-simulation-based education among the studied nurses at $p<0.001$, which support the first research hypothesis.

Table (3) represents comparison of nurses' levels of knowledge in electrocardiogram interpretation pre and post-simulation-based education, there is no one failed after simulation education compared with 30% pre-simulation intervention. The table also shows that 40%, 42% of nurses got very good and excellent level of knowledge post simulation education respectively, compared with no one pre-intervention, with a highly statistically significant difference where $p<0.001$.

Table (4) compare the nurses' skills regarding electrocardiogram interpretation and demonstrates highly statistically significant differences in number of nurses under study who had correct answers in electrocardiogram interpretation skills exam pre and post-simulation-based education with $p<0.001$ and this results support the second research hypothesis.

Table (5) illustrates comparison of nurses' levels of skills in electrocardiogram interpretation pre and post-simulation-based education, there is no one failed after simulation education compared with 43.3% pre-simulation intervention. In addition, table 5 reveals that majorities (81.1%) of nurses got excellent level of skills in ECG interpretation post simulation education compared with no one pre-intervention, with a highly statistically significant difference where $p<0.001$.

Table (6) compares the total mean score of electrocardiogram interpretation among the studied nurses before and after simulation intervention. It shows statistically significant differences in total nurses' mean score of knowledge and skills pre and post-implementation of simulation education at $p<0.001$, which confirms both research hypotheses.

Table (1): Frequency and percentage distribution of studied nurses' demographic characteristics (n=90)

Nurses' characteristics	No	%
Age		
20- < 30	43	47.8
30 - < 40	32	35.5
≥ 40	15	16.7
Mean ± SD	33.51±8.59	
Gender		
Male	33	36.7
Female	57	63.3
Educational level		
Bachelor nursing	90	100
Marital status		
Single	34	37.8
Married	48	53.3
Divorced	8	8.9
Position		
Staff nurse	67	74.4
Head nurse	10	11.1
Supervisors	13	14.5
Place of work		
Medical ICU	24	26.7
Neurological ICU	17	18.9
Surgical ICU	31	34.4
CCU	18	20.0
Years of experience in work place		
1- < 3 years	47	52.2
3 - < 6 years	16	17.8
6-< 9 years	12	13.3
≥ 9 years	15	16.7
Previous training in electrocardiogram interpretation		
Yes	11	12.2
No	79	87.8

Table (2): Comparison of studied nurses' knowledge mean score regarding electrocardiogram interpretation pre and post-simulation-based education (n=90)

Items	Pre		Post		Wilcoxon Signed Ranks Test	P- value
	Mean	SD	Mean	SD		
Conduction system of the heart	0.82	0.66	2.96	0.73	8.02	<0.001
Cardiac cycle	1.5	0.78	3.19	0.63	7.33	<0.001
Components of ECG	1.00	1.01	2.83	0.57	8.25	<0.001
Calculation of heart rate from ECG	0.78	0.83	3.92	0.75	8.03	<0.001
Symptoms, causes, complications of arrhythmias	1.28	0.94	4.03	0.73	8.24	<0.001
Types of arrhythmias	1.19	1.71	2.24	0.72	8.10	<0.001
Management of arrhythmia	1.22	1.14	4.89	0.88	8.13	<0.001

Table (3): Comparison of the studied nurses' levels of knowledge regarding electrocardiogram interpretation pre and post-simulation-based education (n=90)

Levels of success	Pre intervention		Post intervention		Marginal test of homogeneity	P- value
	N	%	N	%		
Failed	27	30.0	0	0.0	8.85	<0.001
Accepted	56	62.2	4	4.4		
Good	7	7.8	12	13.3		
Very good	0	0.0	36	40.0		
Excellent	0	0.0	38	42.2		

Table (4): Comparison of studied nurses' correct answer regarding skills of electrocardiogram interpretation pre and post-simulation-based education (n=90)

Items	Pre		Post		Mc-Nemar Test	P- value
	N	%	N	%		
Normal sinus rhythm	59	65.6	88	97.8	25.2	<0.001
Sinus arrhythmia	25	27.8	82	91.1	55.04	<0.001
Ventricular tachycardia	27	30.0	85	94.4	52.41	<0.001
Atrial flutter	24	26.7	82	91.1	52.4	<0.001
Sinus tachycardia	26	28.9	82	91.1	50.41	<0.001
Atrial fibrillation	19	21.1	83	92.2	55.12	<0.001
Ventricular fibrillation	24	26.7	87	96.7	61.01	<0.001
Sinus bradycardia	40	44.4	85	94.4	37.96	<0.001
Third degree heart block	5	5.6	82	91.1	75.1	<0.001
Premature ventricular contraction	16	17.8	78	86.7	58.14	<0.001

Table (5): Comparison of the studied nurses' levels of skills regarding electrocardiogram interpretation pre and post-simulation-based education (n=90)

Levels of success	Pre intervention		Post intervention		Marginal test of homogeneity	P- value
	N	%	N	%		
Failed	39	43.3	0	0.0	9.30	<0.001
Accepted	46	51.1	0	0.0		
Good	5	5.6	3	3.3		
Very good	0	0.0	14	15.6		
Excellent	0	0.0	73	81.1		

Table (6): Comparison of studied nurses mean score of total knowledge and skills regarding electrocardiogram interpretation pre and post-simulation-based education.

Total Success score	Pre		Post		Paired t-test	P- value
	Mean	SD	Mean	SD		
Total knowledge mean score	7.79	4.95	23.62	2.38	32.72	<0.001
Total skills mean score	2.94	1.86	9.27	0.85	28.12	<0.001

DISCUSSION

One of the important duties of nurses in intensive care unit is interpretation of ECG. The use of training simulator is a new innovative method in the age of technology. Simulation is proven to have a significant effect as a teaching method in nursing education. Simulation enables nurses to practice in an environment closely resembling that of a hospital and helps them to gain healthcare and experiences, before they start working with actual patients. Simulation enables nurses to cope with any difficulties and problems, and make mistakes without causing damage, and all that in a safe environment, without any risk for patients [14].

The interpretation of electrocardiogram is an essential skill for frontline providers, including nurses working in the emergency and intensive acute care settings. Accurate ECG interpretation can make a significant difference in clinical decisions, leading to rapid recognition and treatment of cardiac arrhythmias and avoiding unnecessary interventions resulting from false interpretations [15]. This study aimed to evaluate the effect of online simulation-based education on nurses' knowledge and skills toward electrocardiogram interpretation.

The current study shows that approximately half of the nurses under study fall in the age group between 20 and 30 years old, with a mean age of 33.51±8.59 years; two thirds of them were females; and more than half had a bachelor's degree. Moreover, it was illustrated that three-quarters of nurses are working as staff nurses, more than half of them have 1–3 years of experience in the previous mentioned settings, and the majority of them have never attended training courses about ECG interpretation.

These findings are in accordance with Alkhalaileh and Mohideen (2022) [6], who reported that the mean age of nurses under study was 29.3 + 4.3 years. Three-quarters (74.5%) were females. Most of the participants (61%) had 5 years of experience or less and more than two fifths (44%) of nurses worked in critical care units. But this was contradicted by the fact that two-thirds of the participating nurses had taken courses regarding ECG interpretation in the previous years.

The present study demonstrated highly statistically significant differences in all sub-items of ECG interpretation (causes, symptoms, complications, management and types of arrhythmia), pre- and post-online simulation-based education. This result may be due to the fact that online simulation-based education is an effective and attractive learning method used in teaching ECG interpretation, as stated by nurses, because it allows them to repeat and revise the knowledge several times at their own pace until they acquire it. In addition, due to the simple, easy, and understandable language used by the researcher during the teaching sessions, help to motivate nurses to study well to achieve good results.

This result is agreed with Bazrafkan & Hemmati, (2018) [16] who stated that evaluation of test questions shows that the rates of answers to the correct options in the sections of causes, identifying treatment, and recognizing the type of cardiac dysrhythmias have increased respectively. Also, another study conducted by Tubaishat et al. (2015) [17] mentioned that training cardiac arrhythmias with simulator improved the knowledge of nurses.

One of the noticeable findings of this study is the improvement in nurses' skills toward electrocardiogram interpretation, with highly statistically significant differences in the skills exam pre and post-online simulation-based education. This result may be due to the fact that learning by doing is an efficient way to acquire and retain information because it allows the nurses to make mistakes and repeat the skills as many times as they want until they master them. Nurses also reported that the simulation method is interactive, which encouraged and motivate them to learn deeply.

This finding is in the same line with Uslu et al, (2021) [18] who reported that the mean total score for educational practices was 4.66±.56, which was very high. The results of the study also suggest that the active learning underlying simulation-based education has positive effects on nursing student in their study that was conducted to evaluate the effectiveness of basic electrocardiography education designed in accordance with the simulation-based cooperative learning method. In addition to Granero et al. (2015) [19] who illustrated that learning with a simulator improves and enhances the satisfaction, learning, performance, and achieve better grades of the learners.

The current study demonstrated that more than two fifths of study subjects were failed in the practice exam before simulation intervention, while majorities of nurses achieved as excellent level of success after online simulation education. This result may explain the fact that interactive learning and continuous hands-on help to retained and remembering information for long time. This finding is in accordance with Almarhomy et al, (2021) [20] who stated that most of nurses under study were agreed that using simulation learning is flexible, more interactive, more exciting, more motivated, most effective and attractive and help them acquire the information. In addition, Olaiya et al. (2017) [21] recognized simulator as a factor further improving the nurses' knowledge in interpreting the dysrhythmias.

Nurses usually are the first clinicians to monitor the ECG of the patients and to identify any abnormalities which may require immediate attention. Therefore, it is necessary that nurses are knowledgeable to carry out an initial assessment and make an early identification and quick decisions to manage ECG abnormalities and activate appropriate emergency health teams or initiate first-line treatments. Simulation based education can assist nursing educators to achieve these demands because the simulation permits opportunities to capture the essential knowledge and skills for developing self-confidence that has been linked to safe practices and positive patient outcomes [22].

CONCLUSION

Based on the findings, the researcher concluded that implementing online simulation-based education positively affects nurses' knowledge and skills in electrocardiogram interpretation with statistically significant difference before and after simulation intervention, and these results supported both research hypotheses.

RECOMMENDATIONS

- Based on the findings of the present study, it is recommended to integrate online simulation- based education in the teaching of nurses working with critical ill patients in order to improve patients' outcomes.
- Further research is needed to study the effect of online simulation on the nurses' performance as well on patients' outcomes

with a large sample size and in different settings.

- Continuous training using the online simulation method for nurses who are working in critical areas at hospitals help to keep nurses up to date to any changing and development in the management of different types of cardiac arrhythmias.

Declaration by Authors

Ethical Approval: Approved

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