Nurses competencies in Electrocardiogram interpretation: A cross-sectional survey

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Background: Knowledge of ECG principles and being competent in ECG interpretation are prerequisites for nurses. Registered nurses frequently report misunderstanding and ambiguity due to their lack of knowledge related to electrocardiography interpretation. The main purpose of this study is to identify the nurses' competencies in ECG interpretation. Cross-sectional survey was conducted and the data was collected from January 2020 to August 2020. A convenience sample of 110 nurses was used. Electrocardiography Interpretation Competence Questionnaire was used to collect data. Descriptive and non-parametric inferential statistics were used to describe the sample characteristic and responses and to compare the scores means between groups. Data were analysed using the Statistical Package for Social Science (SPSS) version 22. Fifty percent of participants showed low competency levels in ECG interpretation, the total percentage mean score out of 10 was (6.68, SD 2.26). There was significant differences between groups in term of speciality (H (3) = 16.114 p = .003), no significant difference in ECG competencies scores with regards to gender (U = 975.500, z = -1.193, p= .233) or prior education course (U = 1180. 00, z = -1.690, p = .108). Nurses had insufficient knowledge regarding ECG interpretation, especially on practical aspects. The study's findings have implications for the design of course development for ECG and evaluation methods. This study may help in enhancing nurses' competencies in ECG and will also help provide the appropriate care to the patients in emergency situations.

Keywords: Competencies; Electrocardiography; Interpretation; Knowledge; Nurses.

INTRODUCTION

Nurses play a vital role and are a crucial component of any healthcare team. They spend the longest time with patients (Butler et al. 2018). Electrocardiography (ECG) is considered as one of the most important emergency tools used in the emergency room as well as in the pre-hospital setting (Trimmel et. al. 2018). If utilized appropriately, it can be used to diagnose or guide the management of a variety of life-threatening conditions. Recognition and identification of diseases and injuries that need emergent medical and nursing care are two of the main tasks for nurses working in any healthcare setting (Coll-Badell, Jiménez-Herrera, & Llaurado-Serra, 2017). Nurses are the important contributors to heart health in managing clients in cardiac units. Nurses play a frontline role in heart diseases, such as monitoring patients, managing their symptoms, providing education and counselling, developing new approaches to decreasing hospital readmissions, morbidities, and improving the quality of life for individuals with heart diseases. So the need for developing cardiac competencies in nursing education is important. (Riley, 2015).

According to the World Health Organization (2014), heart disease is the top cause of death. An estimated 17.9 million people died from Cardiovascular Diseases (CVDs) in 2016, representing 31% of all global deaths. Of these deaths, 85% are due to heart attack and stroke (Mozaffarian et al. 2015). That number is expected to rise to 23.6 million by 2030 (Mozaffarian et al. 2015). According to the national report of the Saudi Ministry of Health (MOH), 18,535,077 patients' visits to emergency departments were recorded in 2012. More than 6% of them were found to have heart disease (MOH, 2012). In addition, about 5900 patients died due to circulatory heart diseases in the same year (MOH, 2012).

The American Heart Association recommends that all patients attending the emergency department with chest pain/angina receive an initial ECG within 10 minutes of presentation (Harris, 2016). Electrocardiogram is used to assist in the diagnosis, monitoring, and treatment of several conditions such as arrhythmias, coronary syndromes, and cardiac revascularization (Lessard et al. 2009). An ECG is a quick bedside investigation that assesses the electrical activity of the heart. This is a non-invasive and low cost technique which provides valuable information about heart rate and rhythm, and helps assess for cardiac disease. ECG monitoring is not only the primary concern in the critical care unit, it is widely used in

many health care settings such as acute care, cardiac care, preoperative care, outpatient care etc. It is important for the nurses to understand the basic physiology behind the electrical and mechanical events of the heart and it is crucial for ECG interpretation. Inadequate, false monitoring and misreading of results is dangerous and may result in costly delays in health care. It is vital for the nurses and other health care professionals to accurately place the electrodes, which will help in accurate diagnosis and treatment (Jarvis S, 2021). The ECG is one of the first diagnostic tests that are usually performed when patients visit the emergency department complaining of chest pain.

The first and foremost clinical application of ECG is directly related to the patient in identifying the myocardial injury. ECG helps to differentiate the cardiac chest pain from non-cardiac mimickers. (Luderitz, B., de Luna, A.B., 2017). The correct interpretation of the ECG helps in the early identification of acute myocardial infarction and several types of ventricular and atrial arrhythmias that threaten a patient's life if not quickly treated (Peace et al. 2015). Thus, knowledge of ECG principles and being competent in ECG interpretation are prerequisites for physicians and nurses as well (Dulandas & Brysiewicz, 2018). Registered nurses frequently report misunderstanding and ambiguity due to their lack of knowledge related to electrocardiography interpretation (Nickasch, Marnocha, Grebe, Scheelk, & Kuehl, 2016). This may take on extra importance for nurses working in accident and emergency departments, critical care units, and coronary care units. Performing and analysing an ECG quickly directs clinical decisions and management plans such as the administration of thrombolytic agents (Dulandas & Brysiewicz, 2018).

Nurses have a pivotal role in the process of obtaining, interpreting, and communicating ECG findings (Sheiline, 2008). The interpretation of ECG findings by nurses is very important in terms of early detection of the abnormality, ensuring early intervention, and reducing errors in diagnosis (Sheiline, 2008). However, the interpretation of ECG findings requires high levels of knowledge and skill (Nickasch, et al, 2016). Nurses must maintain a level of competency to deal with the increasing numbers of patients who access healthcare because of heart problems (Harding, Walker-Cillo, Duke, Campos, & Stapleton, 2013). There is a paucity of studies that evaluated the competencies of nurses in ECG interpretation. One of the few studies that were conducted among ambulance nurses in three different districts in western Sweden indicated that nurses had a relatively low level of knowledge in ECG interpretation (Werner, Kander, & Axelsson, 2016). Another study was conducted in Egypt in which the results revealed unsatisfactory knowledge levels and practices concerning management of life-threatening ventricular dysrhythmias among the nurses (Khalil, Rahman, & Yaser Hamouda, 2018). Furthermore, a study conducted in the United States has shown

deficiencies in ECG interpretation skills among nurses (Stephens, Anderson, Carey, & Pelter, 2007). Moreover, another study conducted in the United States, revealed low scores on the ECG monitoring knowledge among nurses (Funk et al. 2017).

Continuous medical education is a significant approach that equips nurses with ECG interpretation competencies (Bolin, Peck, Moore, & Ward-Smith, 2011). In a study conducted in Spain, the authors found that the emergency nurses' knowledge of ECG who attended an ECG education session was significantly higher than nurses who did not (Coll-Badell et al. 2017). Furthermore, structured and adequate preparation in ECG interpretation skills helps nurses to identify, intervene and care for emergency conditions. In this way emergency healthcare systems can be supported (Werner et al. 2016). Moreover, another study indicated a significant improvement in nurses' competencies after educational intervention (Funk et al. 2017). Furthermore, nurses who attended educational training and advanced cardiac life support training had high knowledge and skills (Ruhwanya, Tarimo, & Ndile, 2018). A study from Iran (Rahimpour et al. 2021) showed that the female nurses employed in hospital emergency unit demonstrated higher ECG interpretation competencies than male nurses. Additionally the type of hospital, speciality and educational courses showed significant difference in the competency level. Nurses from cardiac-speciality who took training had higher competencies than others. Tahboub, O.Y., & Yilmaz, U.D. (2019) in a study conducted in the Turkish Republic of Northern Cyprus reported that nurses' work experience as well as their clinical and ECG training courses had a positive impact on their knowledge. Cardiology department nurses had the highest percentage of correct answers ($p = 0.002$). These studies have shown a significant impact of age, sex, working area, type of hospital and previous training on ECG interpretation competencies. Similar demographic characters were also studied by various researchers (Zhang, H., & Hsu, L. L. (2013), Coll-Badell, et al (2017), Al-Husaunawy, (2015) & Dulandas, & Brysiewicz, (2018)). Searching the literature revealed a paucity of studies that evaluated nurses' competencies in ECG interpretation within the Arab world, including the Kingdom of Saudi Arabia. Thus, the main purpose of this study is to identify the nurses' competencies in ECG interpretation. This study aimed to answer the following research questions**.**

What is the Saudi nurses' level of competencies in ECG interpretation?

Are there differences among nurses in ECG interpretation competencies regarding demographic data such as (level of education, specialty, and nationality)?

MATERIALS AND METHODS

Design

A quantitative cross-sectional survey design was used.

Setting

This study was conducted in two governmental hospitals with a bed capacity of 450 beds in Tabuk Governorate in KSA. These hospitals offer a variety of health services from outpatient departments to in-service patients. These hospitals are equipped with cutting-edge technologies and medical appliances.

Sample and sampling

One hundred and fifty nurses were approached and recruited by convenient sampling techniques from the selected hospitals. Convenience sampling was chosen to include the staff availability and time factor. It was difficult to randomize the staff since they worked on different shifts. This study included nurses with a diploma and at least six-months' clinical experience and who agreed to participate in the study. This study included both Saudi and non-Saudi nurses who were working in the wards, intensive care unit, and emergency unit in the selected hospitals. There was no age bar to participating in the study. Only nurses who were not willing to participate in the study were excluded from the study.

Instrument

The Electrocardiography Interpretation Competence questionnaire (EICQ) was adopted from the original instrument developed by (Coll-Badell et al. 2017). The instrument consists of two parts, with part 1 including demographic data such as age, gender, hospital, experience, electrocardiographic training, and type of training. Part 2 consisted of 12 questions, including 2 theoretical questions and 10 clinical questions with ECG strips representing the most important arrhythmias. Each question had one correct answer and three distractors. The questionnaire was considered valid if the participants completed all 12 items. One mark was given to each item. The authors of the questionnaire indicated that nurses can be considered competent in electrocardiographic interpretation if they got a score of 7.5 out of 10 points (Coll-Badell et al. 2017). After the completion of the questionnaire, the maximum score was converted from 12 points to 10 to simplify interpretation. Questionnaire Test-retest reliability was 0.87 (Coll-Badell et al. 2017). The reliability showed good temporal stability. Permission to use the instrument was obtained from the principal author of the questionnaire.

Data collection procedure

The data was collected from January 2020 to August 2020. The investigator visited the selected hospitals to recruit the study participants. The investigator explained the aims, procedure, and participant`s role to all interested nurses. Once they agreed, the participants were asked to complete the consent form. Then, the study questionnaire was given to each participant. The researcher was available to provide help for them in case it was needed. Completed questionnaires were collected in person (by the researchers). The questionnaires were checked for missed items and entered into an SPSS sheet.

Ethical considerations:

This study was approved by the Ethics Committee in the University of Tabuk (University of the Authors) with approval number UT 74-25-2018 and dated 25.12.2018. Then the researcher obtained permission to conduct the study from the selected hospitals. Confidentiality and anonymity of participants were maintained. The participants were assured that participation in this study was voluntary and that participants had the right to withdraw from the study at any time without any penalties. Anonymity and confidentiality were ensured throughout the study; names of participants were not requested and each questionnaire was coded numerically. The collected data were kept confidential and it was only accessed by the research team.

Data Analysis

Descriptive statistics such as percentages and frequencies were used to describe the sample characteristics and their responses to EICQ. The Mann-Whitney-U test was used to compare the EICQ score distribution between two-group variables (e.g., gender, previous ECG education and years of experience) and the Kurskal-Wallis test to compare the EICQ score distribution between variables from two or more groups (e.g. nationality and specialty) (Field, 2009).

RESULTS

Sample characteristics

One hundred fifty (150) questionnaires were distributed to study participants, one hundred and ten (110) were returned completed (response rate= 80%). The mean age of participants was 29.3 SD 4.3 years. Eighty-two (74.5%) were female, 53 of them were Indian (48%), 25 were Philippine nurses (23%), and 32 were Saudi (29%). Most of the participants had 5 years or less experience (61%). Forty-eight nurses worked in critical care units (44%). Sixty-seven participants had taken courses regarding ECG interpretation in the previous years, (table 1)

Table 1: Sociodemographic description of the study population (n = 110)

Socio demographic characteristics	N	Frequency (%)
Gender		
Female	82	74.5
Male	28	25.5
Nationality		
Saudi	32	29
Philipino	25	23
Indian	53	48
Specialty		
Ward	26	23.6
ICU	48	43.6
Emergency	36	32.7
Experience		
< 5 years	65	59
≥ 5 years	45	41
ECG education		
Yes	67	61
No	43	39
Time of last ECG course		
last year	32	29
≥ 2 years	35	27

Electrocardiogram Knowledge

The total mean score was 6.68 (SD 2.26) out of 10 (the maximum score), with scores ranging from 1 to 10. The percentage of correctly answered items was still below the required level, ranging from 55% (item no. 6; related to pathological Q wave) to 91 % (item no. 1 related to waves and ECG intervals). Table 2 shows the participants' answers, showing the number and percentage of items answered. The best-answered items were as follows: no. 1 (91%) which related to waves and ECG intervals, no. 2 (81%) which related to P wave, no. 7 (74 %) which related to atrioventricular third-degree bundle branch block. A large number of nurses had difficulty in identifying the normal ECG atrial flutter, pathological waves, atrial fibrillation and acute myocardial infarction.

According to the author of the instrument, nurses should achieve a minimum score of 7.5 out of 10 to be considered competent in ECG interpretation. Nurses who scored less than 7.5 points were therefore considered as not reaching the minimal score. Half of the nurses (50%) scored below 7.5. Overall, the results of this study revealed that nurses had insufficient knowledge regarding ECG interpretation.

Table 2: Descriptive results of RN answers on ECG test

Item	Nurses` answers	
	Wrong	**Correct**
	Frequency (%)	**Frequency (%)**
Question 1: Waves and ECG intervals	10 (9%)	100 (91%)
Question 2: P wave	21 (19%)	89 (81%)
Question 3: Atrial flutter	38 (34.5%)	72 (65.5%)
Question 4: Ventricular fibrillation	30 (27%)	80 (73%)
Question 5: Atrial fibrillation	43 (39%)	67 (61%)
Question 6: Pathological Q wave	55 (50%)	55 (50%)
Question 7: Atrio-ventricular third-degree bundle branch block	29 (26%)	81 (74%)
Question 8: Ventricular tachycardia	39 (35%)	71 (65%)
Question 9: Acute myocardial infarction	37 (34%)	73 (66%)
Question 10: Normal ECG	46 (42%)	64 (58%)
Question 11: Ventricular extra systole	40 (36%)	70 (64%)
Question 12: Atrial tachycardia	50 (45%)	60 (55%)

Differences in ECG interpretation according to socio-demographic characteristics

Since the mean score was not normally distributed, along with inequality of sample size in the groups, the assumptions of ANOVA were violated. The nonparametric Kruskal-Wallis test was used to test the significant differences in the mean rank of the total ECG interpretation competencies scores concerning nationality, and specialty. No significant differences were found in terms of nationality. However, there were significant differences between groups in terms of specialty (H (3) = 16.114 p = .003) (table 3)

Table 3: Comparisons ECG test score distribution for arranging of nurses` variables.

RN variable	n	Kurskal-Wallis H	df	P-value
Nationality				
Saudi	32	.906	2	.636
Philipino	25			
Indian	53			
Specialty				
Ward	26	16.114	2	0.003
Critical care units	48			
Emergency units	36			

The Mann-Whitney Test was performed to compare the total mean ranks of the total scores regarding gender, previous ECG education, and years of experience showed no significant differences in the mean ranks with regard to these variables, (table 4)

Table 4: the results of the Mann Whitney U test

Variable	n	Mean Rank	Mann-Whitny U	df	P-value
Gender					
Male	28	60.73	464.5	2	.313
Female	82	60.34			
ECG previous education					
Yes	43	51.85	1265.0	2	.636
No	67	57.67			
Years of experience					
< 5 years	65	59.09	1229.0	2	.152
≥ 5 years	45	50.31			

DISCUSSION

The current study aimed to assess ECG interpretation competencies among nurses. The results of this study demonstrated that nurses had insufficient knowledge in ECG interpretation. In the present study, the minimal competence level was set at 7.5 out of 10 based on the study (Coll-Badell et al. 2017). This result is not surprising given the majority of participants had no prior cardiac rhythm interpretation education. The results of this study were supported by Coll-Badell et al. (2017) who found unsatisfactory knowledge levels and practices concerning the management of life-threatening ventricular dysrhythmias. Furthermore, Rahimpour et al. (2021) found low level ECG interpretation competencies among nurses. In another study Werner et al. (2016) showed that the ambulance nurses' competency in ECG interpretation was low. A study from a selected hospital in Ludhiana, India reported that the staff nurses had a low level of skill regarding ECG Interpretation (Reena Raju & Libin Babu, 2021). However, an Indonesian study showed that the knowledge possessed by the nurses in ECG interpretation was quite good, but the ability on interpretation skills was lacking (Sila et al 2018). An Egyptian study revealed that the majority of the study participants had an unsatisfactory level of knowledge regarding ECG due to workload, lack of concentration, insufficient knowledge and duty overload. This study also identified the effectiveness of training programs on the post score. The main emphasis of this study was on refresher courses and training for the nurses. Results of Malk and Hassn, (2018) on practices regarding electrocardiogram procedures revealed that the majority of the study participants had an unsatisfactory level of skills regarding electrocardiogram procedure. Many studies have shown different findings. However, most of them reported lower knowledge and interpretation skills among the nurses ((Funk et al. 2017) (Sheilini & Devi, 2014), (Stopa et al. 2018), and (Werner et al. 2016)). Conversely, higher scores among the nurses were observed by (Coll-Badell et al. 2017) among emergency nurses (ED1- 8.61 (1.08), ED2- 8.86 (0.90), ED3- 8.46

(1.19)) utilizing the same questionnaire. Furthermore, a study conducted in Iraq on critical care and emergency nurses, Al-Husaunawy, (2015) also found successful scores of 74.5%. These findings indicate the necessity of ECG training among nurses. The highest scores with correct responses were about the waves and ECG intervals (91%) and identification of p wave (81%). The lowest score was found with the item on pathological Q wave (50%) and atrial tachycardia (55%). Moreover, the results of this study revealed that nurses had difficulty in identifying the normal ECG, atrial flutter, pathological waves, atrial fibrillation and acute myocardial infarction. These results are congruent with the result of Qaddumi et al. (2019) who found that a large number of nurses had difficulty in identifying atrial fibrillation, ventricular tachycardia and ventricular fibrillation. However, the identification of atrial fibrillation and other arrhythmias on the ECG serves as the important element in diagnosing and helps to alter the client management Luderitz, (2017).

The current study showed no significant differences in the level of knowledge among study participants concerning some demographic data such as gender, years of experience, nationality, and type of hospital. Three-fourths of the study participants were female. More nurses from ICU had participated in the study than emergency and wards (43%). Three-fifths of the nurse had less than 1-year's working experience from the ministry of health hospitals. Three-fifths of the participants took the ECG course. In that only, 29% of the nurses took the course within 1year. Since the setting of the study is under the ministry of health, there is no difference in terms of facilities and staff work pattern. These results were consistent with the findings of Al-Husaunawy, (2015) who found no significant relationship between the ECG knowledge and gender, place of work, and experience. However, in their study, Coll-Badell et al. (2017) reported that a nurse's knowledge was not influenced by years of experience or the hospital where he or she was working. Other studies also reported no significant differences found among nurses related to mentioned demographic data (Werner et al. 2016). In contrast, Sheilini & Devi,

(2014) reported significant differences with ECG knowledge and experience.

The current study showed significant differences among nurses' ECG knowledge in terms of working area. Nurses who worked in the emergency department and critical care units had better knowledge than nurses who worked in medical-surgical wards. These differences may be due to frequent exposure of nurses in emergency and critical areas to critical cases that need ECGs. The nurses who work in wards have less chance to practice ECG interpretation. Similarly, some studies have found higher knowledge among the nurses working in emergency areas and cardiology departments. Zhang & Hsu, (2013) found that nurses who worked in the cardiology department scored higher in basic ECG knowledge. Furthermore, Coll-Badell et al. (2017) reported a high level of ECG knowledge among the emergency room nurses. Tahboub & Dal Yilmaz, (2019) also reported higher scores in ECG interpretation among the critical care nurses. Santana-Santos et al, (2017) also found that nurses working in critical areas analyse more effects in their routine compared to those in non-critical areas and they feel more confident in their ability to interpret ECG.

This study concludes that nurses who work in the emergency department and critical areas had better knowledge than nurses who work in wards. This study recommends that the hospital nursing director needs to plan for staff rotation to the different areas to have appropriate exposure and knowledge transfer for the nurses. This study also recommends further research projects focus on the ECG interpretation with a larger sample, comparative studies, and correlation studies on the practical aspect.

Limitations

The current study includes the following limitations: The sampling method used was convenience sampling. Moreover, this study was conducted in two government hospitals in Tabuk governance only; military and private hospitals were not included in this study which may limit the generalizability of the current study.

CONCLUSION

The present study had identified that nurses had insufficient knowledge regarding ECG interpretation, especially on abnormal ECG rhythms; this necessitates the need for improving nurses' competency. The study's findings have implications for the design of course development for ECG and evaluation methods. Frequent training programs for the nurses may be used to enhance nurses' ECG interpretation competencies through the department of continuous medical education. Further, there is a need for evaluating undergraduate course outlines for the ECG teaching content, and making ECG competency mandatory for undergraduate nurses. Nurses working in wards need to have training and updates to retain the knowledge and skills for interpreting ECG.

Frequent follow-up training and workshops are necessary for the nurses who are not working in intensive care units because they have less opportunity to interpret ECG. Without frequent feedback, it is difficult for the nurses to enhance their skills. So the nursing education team and supervisors need to arrange for feedback for staff on ECG competency. Participation in seminar workshops and active training helps the staff nurses to improve their ECG competency skills.

CONFLICT OF INTEREST
The authors declared that present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS
MA: Conception and design, acquisition of data, analysis and interpretation of data, drafting the manuscript, revising and supervision. and final approval of manuscript.MM Conceptualization, Methodology, Data collection and curation, Manuscript preparation.

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