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ORIGINAL RESEARCH

Competency of Nurses on Electrocardiogram Monitoring and Interpretation in Selected Hospitals of Al-Ahsa, Saudi Arabia

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Purpose: The ability of healthcare nurses to monitor and interpret electrocardiograms (ECGs) is essential for the identification of heart-related abnormalities and rapid treatment initiation. Lack of expertise of nurses in this competency may cause confusion and complications. The aims of this study were to assess the competency levels of nurses in monitoring and interpreting ECGs and to associate the knowledge with the demographic variables.

Patients and Methods: A descriptive cross-sectional study design was used. A total of 156 nurses were selected from five hospitals located in Al-Ahsa, Saudi Arabia by computer generated simple randomization. A structured self-administered tool for knowledge and observational checklist for skills regarding ECG monitoring and interpretation was used. Tool validity and reliability were tested. Descriptive and inferential statistics, including the mean, standard deviation, and chi-square test, were applied. Statistical significance was set at $p < 0.05$.

Results: Mean participant age was 32.59 ± 5.35 years, 30% of nurses had adequate knowledge, and the overall mean score was 17 ± 3.97. Seventy-two (46.2%) nurses correctly interpreted the ECG axis, and 76 (48.7%) could identify the Q-T interval on ECG strips. Significant associations of nurse knowledge level were detected with age ($p < 0.0208$), education ($p < 0.0001$), experience ($p < 0.0001$), nationality ($p < 0.0002$), and hospital type ($p < 0.0018$).

Conclusion: Most nurses had a low level of expertise in interpreting ECGs, and it will be crucial for them to improve their competence. Adequate training on ECG interpretation will enhance the proficiency of nurses and help provide appropriate care and life-saving measures to patients in emergency situations.

Keywords: cardiac diseases, competency, ECG interpretation, electrocardiogram, nurses

Introduction

Cardiovascular disease (CVD) is the leading cause of death worldwide, accounting for 17.9 million deaths annually. Of the deaths from CVD, more than four out of five are caused by heart attack, and one-third of these deaths are premature, occurring in individuals under the age of 70 years.[1] According to the World Health Organization and the Ministry of Health Statistical Yearbook, 42% of the deaths in Saudi Arabia in 2010 caused by non-communicable diseases were attributable to CVDs.[2]

The electrocardiogram (ECG) is a useful, non-invasive, diagnostic tool that can serve to quickly identify various heart conditions, including coronary artery diseases, myocardial infarction, cardiac arrhythmias, ischemic heart disease, heart block, and many other problems.[3,4] ECG monitoring and interpretation can provide clear evidence of a heart attack that has already occurred or is occurring, and the precise location and extent of injury to the heart can be determined by analyzing ECG signals.[5]

There has been tremendous progress in healthcare, and new equipment and software applications are under development. Technological advances have also been made in ECG monitoring and analysis, with ECG innovations poised to

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revolutionize the medical field. Newer developments, such as wearable technology, artificial intelligence (AI)-powered interpretation, and noncontact monitoring systems can help to identify a variety of cardiac diseases. The latest advancement in healthcare influencing contemporary ECG technology and their implications for patient care are detailed in previous publications.[6,7] Patients and healthcare professionals have benefited greatly from recent developments in ECG technology, which have led to better patient outcomes, more effective healthcare delivery, and overall improvements in the diagnostic process.[8]

Nurses are vital to the delivery of care in hospitals, especially in settings where critical care is needed, such as the intensive care unit (ICU), cardiac care unit (CCU), and emergency department (ED),[9] in which ECG monitoring of patients is mandatory. Nurses are usually the first medical professionals to examine ECG readings and identify abnormalities that may require immediate attention. Hence, nurses can be expected to conduct initial assessments, rapidly identify ECG abnormalities, and determine whether to initiate first-line therapies or request emergency medical assistance.[10,11] Various strategies have been proposed to increase the expertise of nurses in ECG interpretation.[12] Fred Killingbeck created the 'cardiac rhythm identification for simple people' (CRISP) method, which is an algorithm that helps nurses to understand basic ECG rhythms, and to easily and more accurately interpret abnormalities.[13,14] In some hospitals, training is conducted to educate nurses in ECG monitoring and interpretation; however, a study found that ICU nurses had poor experience in interpreting basic ECGs,[15] and there is research evidence that negative attitudes persist, despite the favorable attitudes among study subjects toward ECG interpretation.[16,17] Further, it has been proposed that, rather than depending solely on the advice and opinions of other medical professionals, nurses should recognize that interpreting ECGs is part of their job.[18]

In Spain, an ad hoc questionnaire was used to conduct a multi-center cross-sectional study, including nurses with at least one year of experience working in emergency rooms in three Spanish cities as study participants. The conclusion of the study was that nurses who had received training within the last five years scored much higher than those who had not received recent training,[19] underlining the importance of regular instruction in ECG interpretation.

The current study was conducted in Saudi Arabia to assess the level of competence of nurses regarding ECG interpretation and knowledge for the management of arrhythmic conditions in critical care settings. We found that critical care nurses had little experience of using ECGs, including their interpretation and use for arrhythmia management. Further, relative to nurses working in the ED, those in the ICU and CCU scored far higher on competency tests.[11]

The ability to monitor and interpret ECGs is essential for nurses to treat patients requiring cardiac evaluation by ECG. Nurses need to attain proficiency in ECG interpretation because identification of any abnormal waves and heart functions is important for prompt initiation of necessary treatment, which will save many lives worldwide. In Al-Ahsa, we observed that many newly recruited nurses were placed in cardiac wards, ICU, CCU, and ED, and some nurses depended on other healthcare professionals to monitor and interpret ECGs. Considering previous recommendations, the aim of the current study was to assess the level of competence of nurses, including their knowledge and skills in ECG monitoring and interpretation.

Materials and Methods

Study Design

A descriptive cross-sectional methodology was employed to ascertain the level of knowledge and skills of nurses in ECG monitoring and interpretation. This study was conducted from September 2023 to January 2024 in various hospitals, according to the guidelines of the Declaration of Helsinki and was approved by the Research Ethics Committee of the Deanship of Scientific Research at King Faisal University, Saudi Arabia (KFU-REC-2023-JUN-ETHICS968). Informed consent was obtained from all subjects involved in the study before data collection and confidentiality was ensured, confirming no risk, complete anonymity, and voluntary participation.

Study Setting and Participants

This study was conducted to identify the knowledge and skills regarding ECG monitoring and interpretation of nurses who worked in the ICU, CCU, or ED of five selected hospitals, including government and private sector institutions.

Patients with various medical conditions, including cardiac diseases, can receive a wide spectrum of care from the five main hospitals in Al-Ahsa, which is in the eastern province of the Kingdom of Saudi Arabia. Considering the characteristics, results, and outcomes of a previous study,[11] and assuming 50% of the study population had accurate knowledge and were proficient in ECG interpretation, with a 5% acceptable margin of error at a 95% confidence level, and accounting for a finite population of 320 nurses, a minimum sample size of 175 was calculated. Using simple randomization sampling with the assistance of computer-generated software, 156 nurses from various hospitals who expressed that they were willing to participate were included for data collection. Participants in the study were male and female nurses aged ≥ 20 years, who worked in the ICU, CCU, or ED of government or private hospitals in Al-Ahsa and had at least 6 months of professional experience in caring for patients with cardiac conditions. Nurses included in the study provided informed consent and were available at the time of data collection.

Data Collection

Data were collected using structured self-administered questionnaires to assess the knowledge of nurses on advances in ECGs.[9] An observational checklist was also used to identify the skills required to monitor and interpret ECG data.[12]

The first section was used to collect sociodemographic information about nurses. The second section focused on knowledge related to advances in ECG technology. The third section was an observational questionnaire that assessed the skills of nurses in monitoring and interpreting ECGs. The tool used to gather data is developed in English. Three doctorate critical care nursing specialists, three cardiac consultants, and two emergency physicians, who are experts in clinical research and cardiac management reviewed the structured questionnaire to assess its validity, clarity, and feasibility for data collection. Some modifications were made to the tool, based on expert suggestions.

To test the tool, a pilot study was conducted including ten nurses. The reliability of the questionnaire tested using Cronbach's alpha was excellent (r = 0.91). Time taken to complete the questionnaire ranged from 30 to 40 minutes. The objectives of the study were explained to the nurses before the start of data collection. The privacy of respondents was assured as no identifying information, such as their name or employee identity number, was collected in the questionnaire. To maintain privacy and confidentiality, all data collected for the study were electronically encrypted and kept in a secure location, with a password known only to the principal investigator. After obtaining written informed consent from each participant, a structured questionnaire was distributed to gather all data, separately from the instrument used to assess the skills. Data collectors used observational methods to complete the practice questionnaire.

Demographic Information

Nurse demographic data collected included age, sex, educational qualification, professional experience, working area, nationality, and ECG training performed.

Knowledge Questionnaire

The tool comprised 25 multiple-choice questions, each of which had four options: three incorrect and one correct. The tool comprised of six subscales, including five, three, five, three, four, and five questions related to basic information about the ECG, wearable devices, AI-assisted ECG interpretation, the portable ECG monitor, the contactless monitoring system, and ECG integration with telemedicine, respectively. The structured knowledge questionnaire was scored as either one for a correct response or zero for an incorrect response. Total knowledge scores were summed and computed for analysis. Scores were interpreted as follows: 75%–100% (19–25), adequate knowledge; 50%–74% (13–18), moderate knowledge; and < 50% (< 13), inadequate knowledge.

Observational Checklist

The nurses' skills in interpreting ECG and understanding advances in ECGs used in healthcare was evaluated using 10 observational checklist questionnaires with ECG strip readings. The questionnaire included the following topics: (1) Positioning of ECG leads while monitoring; (2) Duration of ECG segments: (3) Heart rate; (4) Heart rhythm; (5) Heart axes; (6) P and P-R interval changes; (7) Q-wave and QRS complex findings; (8) ST segment changes; (9) QT interval; and (10) T-wave interpretation. During data collection, nurses provided answers directly to researchers. If the nurses correctly interpreted the findings, one point was awarded. For incorrect interpretations, a zero score was given. The skills

of nurses in interpreting ECG and understanding advances in ECGs used in healthcare was evaluated using 10 observational checklist questionnaires with ECG strip readings. The questionnaire included the following topics: (1) Positioning of ECG leads while monitoring; (2) Duration of ECG segments: (3) Heart rate; (4) Heart rhythm; (5) Heart axes; (6) P and P-R interval changes; (7) Q-wave and QRS complex findings; (8) ST segment changes; (9) QT interval; and (10) T-wave interpretation. During data collection, nurses provided answers directly to researchers. If the nurses correctly interpreted the findings, one point was awarded. For incorrect interpretations, a zero score was given. The frequency distribution table provided in the results section was used to calculate and interpret the overall skills of nurses.

Data Analyses

The Statistical Package for Social Sciences (SPSS) (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY, USA: IBM Corp) was used to analyze the study data. Numbers and percentages were tabulated in the form of a frequency distribution. Means and standard deviations were calculated using descriptive statistics. A chi-square test was used to assess associations between the knowledge of nurses regarding advances in ECG monitoring and their demographic characteristics; $p \leq 0.05$ was considered significant.

Results

Socio-Demographic Information of Nurses

Of 156 nurses included in the analysis (Table 1), 83 (53.2%) were between the ages of 20 and 30 years, and the majority (135, 86.5%), were female. Mean ± standard deviation participant age was 27.59 ± 5.35 years. The highest educational

Table 1 Demographic Characteristics of Nurses (n = 156)

Items		N	%
Age (years)	20–30 years	83	53.2
	31–40 years	54	34.6
	41–50 years	19	12.2
Gender	Male	21	13.5
	Female	135	86.5
Educational qualification (highest)	Diploma	29	18.6
	Bachelor	95	60.9
	Master or doctorate	32	20.5
Professional experience	6 months to 1 year	35	22.4
	1–3 years	63	40.4
	4–6 years	39	25.0
	6–9 years	15	9.6
	10 years and above	4	2.6
Nationality	Saudi	58	37.2
	Non-Saudi	98	62.8
Type of hospital	Government hospital	112	71.8
	Private hospital	44	28.2

(*Continued*)

Table 1 (Continued).

Items		N	%
Area of Work	ICU	34	21.8
	CCU	42	26.9
	ED	41	26.3
	Cardiac Ward	27	17.3
	Others	12	7.7
Training undertaken on ECG advancement	Yes	32	20.5
	No	124	79.5

Notes: N: Number; %: Percentage.

qualification of most participants (95, 60.9%) was a bachelor's degree; only 29 (18.6%) were diploma-holders. Regarding the professional experience of nurses, 63 (40.4%) had 1–3 years of experience and 39 (25%) had 4–6 years of experience. Among nurses, 58 (37.2%) were Saudi and 98 (62.8%) were non-Saudi nationals. Concerning working area, most participants (112, 71.8%) worked in a government hospital, while 42 (26.9%) worked in CCU. Further, 32 (20.5%) nurses had undergone training on ECGs, and 124 (79.5%) had not received training.

Knowledge Level of the Nurses About ECG

The overall knowledge level of nurses is shown in Figure 1; 47 (30%) had adequate knowledge, 76 (49%) had moderate knowledge, and 33 (21%) had inadequate knowledge. The mean scores for the knowledge of nurses regarding technological advances in ECGs per subscale are shown in Table 2. Mean overall score was 17 ± 3.97; a high percentage (90.77%) understood basic ECG information, whereas a low percentage (52.99%) were proficient in portable ECG monitoring.

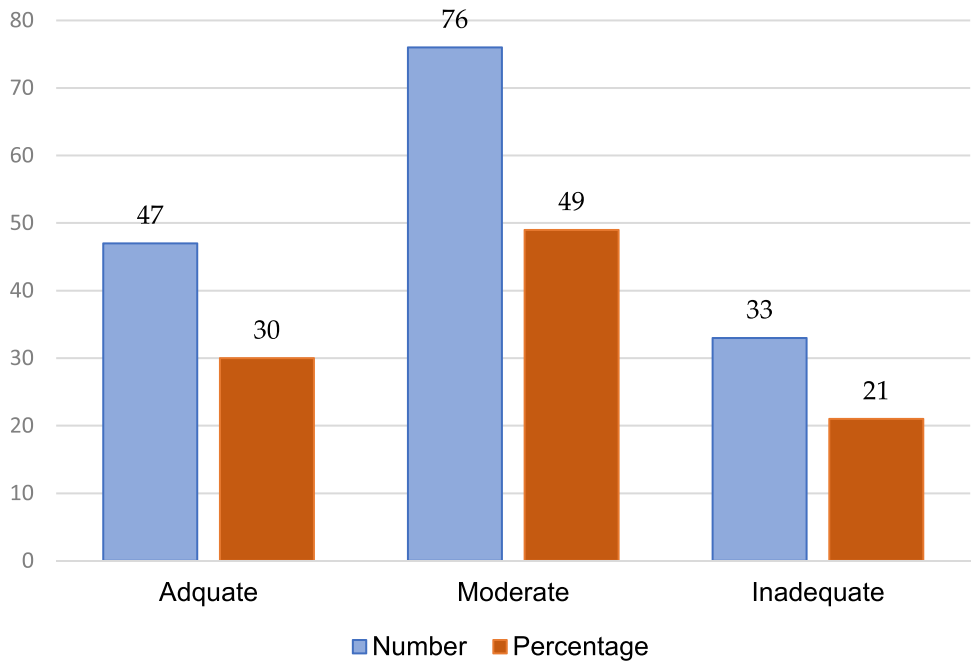

Figure 1 Knowledge level of nurses about ECG technology advancement (n=156).

Table 2 Mean Scores of Nurses' Knowledge of ECG Interpretation per Subscale (n = 156)

Knowledge Questionnaire Subscale	Number of items	Range	Mean (± SD)	Nurses' score out of 100%
Basic ECG Information	5	0–5	4.53 (0.99)	90.77
Wearable ECG devices	3	0–3	2.26 (0.9)	75.64
AI-assisted ECG interpretation	5	0–5	2.96 (1.4)	59.1
Portable ECG monitor	3	0–3	1.59 (1.02)	52.99
Contactless monitoring system	4	0–4	2.23 (1.25)	55.77
ECG integration with telemedicine	5	0–5	3.42 (1.49)	68.33
Total	25	0–25	17 (3.97)	68.26

Notes: SD-Standard deviation.

Skills of the Nurses About ECG Interpretation

Data on the ECG interpretation skills of nurses are presented in Table 3. Of the 156 nurses, 122 (78.2%) correctly interpreted heart rate on the ECG strips, while 132 (84.6%) knew how to correctly position ECG leads. One hundred twenty (65.4%) nurses correctly identified ECG segment durations, while 98 (62.8%) correctly interpreted heart rhythm on ECG strips; however, only 72 (64.2%) nurses could identify the axis on the ECG strip. Ninety-six (61.5%) nurses answered correctly regarding P-wave and P-R intervals. Further, 98 (62.8%) nurses identified the Q-wave and the QRS complex, and 104 (66.6%) knew about ST segment changes and could diagnose a heart condition. Moreover, 76 (48.7%) nurses answered correctly regarding the Q-T interval, and 108 (69.2%) nurses identified T-wave changes in ECG strips.

Association of the Knowledge of Nurses About ECG Interpretation with Demographic Variables

As shown in Table 4, there was a significant association between the level of knowledge of nurses regarding ECG interpretation and five demographic variables: age ($p < 0.0208$), educational qualification ($p < 0.0001$), professional

Table 3 Frequency Distribution of Nurses' Practices Regarding ECG Interpretation (n = 156)

S. No.	Practice about ECG interpretation	Correct Answers
		N (%)
1.	Positioning of ECG leads	132 (84.6)
2.	Duration of ECG segments	102 (65.4)
3.	Heart Rate	122 (78.2)
4.	Rhythm	98 (62.8)
5.	Axis	72 (46.2)
6.	P-wave and P-R interval	96 (61.5)
7.	Q-wave and QRS complex	98 (62.8)
8.	ST segment	104 (66.6)
9.	Q-T interval.	76 (48.7)
10.	T-wave.	108 (69.2)

Notes: N-number; %-percentage.

Table 4 Association of Nurses' Knowledge with Demographic Information (n = 156)

Demographic information		Adequate Knowledge	Moderate Knowledge	Inadequate Knowledge	X^2
Age (years)	20–30 years	17	47	19	X^2 = 11.575 p = 0.0208*
	31–40 years	10	23	21	
	41–50 years	9	6	4	
Gender	Male	8	9	4	X^2 = 0.619 p = 0.7338 NS
	Female	40	67	28	
Educational Qualification (Highest)	Diploma	1	15	13	X^2 = 23.028 p = 0.0001*
	Bachelor	35	42	18	
	Master or doctorate	12	19	1	
Professional experience	6 months to 1 year	4	30	1	X^2 = 103.882 p = 0.0001*
	1–3 years	2	60	1	
	4–6 years	12	25	2	
	6–9 years	1	2	12	
	10 years and above	1	1	2	
Nationality	Saudi	11	25	22	X^2 = 16.702 p = 0.0002*
	Non-Saudi	36	51	11	
Type of hospital	Government hospital	38	59	15	X^2 = 12.604 p = 0.0018*
	Private hospital	9	18	17	
Area of Work	ICU	10	21	3	X^2 = 4.023 p = 0.855 NS
	CCU	15	24	3	
	ED	13	24	4	
	Cardiac Ward	10	12	5	
	Others	3	8	1	
Training on ECG advancement	Yes	8	20	5	X^2 = 2.489 p = 0.2881 NS
	No	42	56	26	

Notes: X^2 – Chi–square test; * Significant; NS - Non Significant; p<0.05.

experience ($p < 0.0001$), nationality ($p < 0.0002$), and type of hospital ($p < 0.0018$). No significant association was detected between the knowledge of nurses and their sex, work area, or training on advances in ECGs.

Discussion

The aims of this study were to assess the competency level of nurses regarding technological advances in ECG monitoring and interpretation. In our study, approximately half of nurses (53.2%) were aged 20–30 years and most (86.5%) were female. Overall, most nurses who worked in the CCU, ICU, ED, and cardiac wards had a good ability to

interpret ECGs. In a previous study conducted to determine the proficiency in managing arrhythmias and interpreting ECGs among critical care nurses in Saudi Arabia, most participants were female, and non-Saudi nationals. There was a lack of proficiency in the initial line management of ECG arrhythmias.[20]

The findings of a cross-sectional study conducted to determine the level of competence in ECG interpretation and knowledge of arrhythmia management among nurses in critical care settings in Saudi Arabia showed that 87.5% of the participants were female and mean sample age was 32.1 years, similar to our study; however, the majority of the participants (94.9%) in that study had taken ECG interpretation training courses,[11] while in the present study, only 20.5% of the nurses had undergone training on technological advances in ECGs.

Another multicentre cross-sectional study conducted in adult emergency room of Addis Ababa, Ethiopia, in which, most nurses had a bachelor nursing degree, and they had 1–3 years of experience. Remarkably, most nurses showed non-competent on the electrocardiography interpretation.[21] However, among the 156 nurses included in the present study, 122 (78.2%) were able to accurately interpret heart rate on ECG strips, while 132 (84.6%) nurses could accurately position ECG leads, 102 (65.4%) accurately identified ECG segment durations, and 98 (62.8%) nurses could accurately determine heart rhythm from ECG strips; however, only 72 (46.2%) nurses recognized the axis on ECG strips.

Research conducted to assess the competency in ECG interpretation of registered nurses in private and government hospitals in Nablus, Palestine, found that registered nurses in private hospitals were far more adept than those in government hospitals at interpreting primary ECG parameters, such as heart rate and rhythm; however, they were less adept in determining the type of arrhythmia.[22] In contrast, in the present study, nurses in governmental hospitals had similar knowledge to those in private hospitals. Further, the results of this investigation support those of a study by Goodridge,[23] which hypothesized that ICU nurses may require additional instruction and training in ECG interpretation.

Only 20% of nurses took the ECG training program, but this was not significantly associated with participant knowledge. Our results were also consistent with those of Apaza-Ramos et al, showing that extracurricular courses on ECG interpretation had no discernible impact on overall participant performance.[24]

In the present study, the overall mean score for nurse knowledge level was 17 ± 3.97, and a high percentage (90.77%) had knowledge of basic ECG information, whereas a low percentage (52.99%) were competent in portable ECG monitoring. These findings are similar to the results of two previous studies, which revealed that the majority of nurses had unsatisfactory knowledge concerning the early management of life-threatening ventricular arrhythmias.[25–27]

In this study, significant associations were found between the level of knowledge of nurses about ECG interpretation and five demographic variables: age ($p < 0.0208$), educational qualification ($p < 0.0001$), professional experience ($p < 0.0001$), nationality ($p < 0.0002$), and type of hospital ($p < 0.0018$). No significant associations were detected between the knowledge of nurses and sex, work area, or training on advances in ECGs.

Further, we found a significant association between the level of knowledge of nurses in ECG interpretation and their age, with higher age proportional to the adequacy of knowledge ($p < 0.0208$). These findings differ to those of a cross-sectional design descriptive study of 102 nurses working in CCU, ICU, and ED conducted in 2015, which showed no significant association between knowledge score and age.[28]

We also detected a highly significant association between the ECG interpretation knowledge of nurses and their educational qualifications ($p < 0.0001$), which differs from the results of another study, which reported no association between the knowledge of nurses and their professional qualifications.[29]

Moreover, we found a highly significant association between the level of knowledge of nurses regarding ECG interpretation and their professional experience ($p < 0.0001$), inconsistent with the findings of a study that assessed knowledge and practice regarding ECG interpretation among nurses working in CCU in selected hospitals in Guwahati, Assam, which indicated no significant relationship between knowledge and practice regarding ECG interpretation among nurses with years of work experience.[30]

According to a study conducted in Fujian province, China,[9] nurses working in cardiac ICU had a higher likelihood of possessing a high level of ECG expertise than those working in general, medical, and surgical ICUs. In this study, we found no significant association between the knowledge of nurses and their area of work. Similarly, other studies found no significant relationship between the knowledge of nurses and their work departments.[31]

Tremendous changes have occurred in medicine due to technological advances. The main applications of AI in the context of healthcare include its use to improve diagnostic speed and accuracy. Hence, rigorous ECG refresher course training programs must be conducted at least every two years, under the supervision of qualified personnel. Further, the nursing education curriculum should include more classes on ECG theory and its applications, and handbooks should be created to increase the ECG knowledge of nurses. An interventional research study could be conducted in the future, with a larger sample including all types of healthcare professional. In this study, we employed randomization in the sample selection process, to reduce bias; however, the study has limitations, including a potential for recall bias, due to the need for participants to recall information pertaining to knowledge.

Conclusion

In conclusion, half of the nurses had moderate knowledge about ECG and most of them interpreted the ECG strips correctly. However, few nurses had inadequate knowledge regarding AI-assisted ECG interpretation, portable ECG monitoring, and contactless monitoring systems. In addition, participant interpretation of the axis in ECG strips, Q-wave, and QRS complex was poor. Better patient outcomes depend on physicians and nurses working together to interpret ECGs; however, our findings indicate that frequent continuing education on ECGs is necessary in Al-Ahsa, to develop the relevant knowledge of ICU, CCU, and ED nurses, which would improve their skills in ECG interpretation and lead to efficient ECG monitoring during nursing care. Therefore, it is important for nurses to improve their knowledge of ECG interpretation, diagnosis, and management, including by undertaking continuous training.

Abbreviations

AI, Artificial intelligence; CCU, Cardiac care unit; CRISP, Cardiac rhythm identification for simple people; CVD, Cardiovascular disease; ECG, Electrocardiogram; ED, Emergency department; ICU, Intensive care unit.

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Disclosure

The author declares that there is no conflict of interest.

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