

KNOWLEDGE AND PRACTICE OF NURSING STUDENTS REGARDING ECG INTERPRETATIONS.

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Abstract

ABSTRACT

Background:

Electrocardiogram (ECG) interpretation is an essential clinical competency for nurses because early recognition of cardiac abnormalities supports timely intervention and improves patient safety. Nursing students require adequate theoretical knowledge and practical skills to accurately interpret ECG findings; however, gaps in ECG competency remain a concern in nursing education.

Aim:

The study aimed to assess the knowledge and practice of nursing students regarding ECG interpretation and determine the association between formal ECG training and competency levels.

Methods:

A descriptive quantitative cross-sectional study was conducted among 420 final-year nursing students enrolled in BSN Generic, Post-RN BSN, and Diploma in General Nursing programs. Participants were selected through a non-probability convenience sampling technique. Data were collected using a structured 31-item self-administered questionnaire assessing socio-demographic characteristics, theoretical ECG knowledge, and practical interpretation skills. Data were analyzed using descriptive statistics and Pearson Chi-Square test through SPSS version 27.0.

Results:

The findings revealed that 45.2% of students had inadequate theoretical knowledge, while 50.0% demonstrated low practical competency. The mean theoretical score was 8.65 ± 2.81 , and the mean practical score was 4.90 ± 1.95 . Formal ECG training was significantly associated with higher competency levels ($\chi^2 = 78.45$, $p < 0.001$).

Conclusion:

Nursing students demonstrated insufficient ECG interpretation competency, highlighting the need for structured ECG education, simulation-based training, and regular skill assessments within nursing curricula.

INTRODUCTION

Electrocardiography (ECG) is a non-invasive diagnostic test used to record the electrical activity of the heart using electrodes attached to the body and can help to provide important information regarding cardiac rhythm, conduction abnormalities, and myocardial changes. ECG interpretation is the systematic procedure of interpretation of ECG spectrum, evaluation of heart rate, rhythm, intervals, segments and patterns to detect both normal and abnormal cardiac conditions. Nursing students are people who are currently studying to become professional nurses, and are ready to give safe and evidence-based care to the patients. Knowledge about ECG interpretation is the theory of ECG principles, waveform identification and recognition of cardiac abnormalities, while practice is the application of the ECG interpretation skills accurately in clinical situations. ECG interpretation is an important nursing skill because nurses are often faced with patients who require cardiac monitoring and/or emergency assessment and intervention (Hassan et al., 2023; Naz et al., 2024).

Cardiovascular diseases (CVDs) continue to be the cause of the majority of deaths worldwide, and there is an ongoing requirement for health care workers to have appropriate skills in ECG interpretation. Recent reports on global health indicate that millions of people are dying of cardiovascular disease each year; moreover, early detection of cardiac abnormalities by continuous ECG monitoring can greatly enhance patient care (World Health Organization [WHO], 2023). Although ECG skills are very significant, studies have reported that the knowledge and skills of nursing students and health care staff are low and lack confidence in performing the skill. Lack of clinical experience, inadequate hands-on training, and a lack of a structured training approach in nursing education have been linked to poor ECG education (Ahmadi et al., 2022).

The lack of competency in the interpretation of ECGs is a global challenge in healthcare education due to nursing students. The problem of competency in ECG interpretation among nursing students is one of the healthcare

education challenges globally. Research in various countries has shown that there is a range of different levels of knowledge in nursing students, with many nursing students having problems recognizing arrhythmias, interpreting ECG rhythms and transferring theoretical knowledge into clinical practice. Misinterpretation of the ECG can result in a delay in the detection of life-threatening cardiac conditions including myocardial infarction, atrial fibrillation and ventricular arrhythmias. New research suggests that simulation-based education, digital learning materials and structured ECG training programmes are associated with a substantial enhancement of the knowledge and interpretation of students (Brady et al., 2023; Kohan et al., 2024). In Pakistan, with changing lifestyle and aging population, the incidence of cardiovascular diseases is on the rise and poses a growing threat to people due to rising risk factors like hypertension, diabetes, obesity etc. Hospitals are where many nurses are likely to be tasked with first-line reports of abnormalities detected by the patient during an ECG procedure and with monitoring patients. But repeated ECG interpretation practice sessions could be limited in nursing education in Pakistan due to differences in the curriculum focus, clinical experience, and the availability of qualified instructors. A recent study among the nurses of Lahore found that there were drawbacks in the confidence of interpreting ECGs, shortage of training and frequent use of ECG skills by the nurses which needs improvement in their approach to teaching (Naz et al., 2024).

Additionally, the local healthcare and educational landscape is indicative of issues concerning competency in ECG for nursing students. The nursing students need to experience cardiac cases continuously, be exposed to supervised practice and be taught well in order to gain confidence in interpreting the ECG findings. The fact that some students have a limited number of simulation laboratories, lack of practice time and rely on theoretical teaching approaches could impact students' clinical decision making skills when it comes to using their ECG knowledge. The studies have revealed that the use of technology in

learning and interactive teaching of ECG has been found to enhance students' understanding and clinical performance (Kohan et al., 2024; Radha et al., 2021).

Properly interpreting ECGs is a skill of nursing students that also enhances patient safety, speed of clinical decision making and management of cardiac emergencies. Highly competent ECG nurses are able to quickly detect irregularities, relay information, and actively engage in emergency protocols. It is found that the competency in interpretation of ECG can be improved by continuing education, workshop, simulation training and clinical mentorship among nursing students and professionals. Open education institutions are in a position to enhance the content of learning outcomes related to ECG through hands-on practice and theory (Dhillon et al., 2023; Krantz et al., 2022).

Evaluating the knowledge and practice of nursing students with regard to the interpretation of ECGs is crucial in identifying learning deficits and creating strategies to enhance the competency in cardiac care provision. Teaching strategies for nursing education, simulation programs, and curricular changes can be planned based on a knowledge assessment of students' existing knowledge and clinical application. This study is intended to evaluate the knowledge and practice of the nursing students about interpretation of ECG to find evidence for better nursing education for preparing competent future health care providers who can provide safe care for the cardiac patients.

Methods

A descriptive quantitative cross-sectional study design was used to assess the electrocardiology knowledge and practical competencies of nursing students. The study was conducted among final-year nursing students enrolled in accredited nursing education institutions offering Bachelor of Science in Nursing (BSN Generic 4-Year), Post-RN BSN (2-Year), and Diploma in General Nursing programs. Participants were selected based on their completion of core adult health nursing clinical rotations to ensure adequate exposure to cardiac care settings. A non-

probability convenience sampling technique was applied for participant recruitment. The sample size was determined using Cochran's formula for unknown population parameters, considering a 95% confidence level, an estimated population proportion of 0.50, and a 5% margin of error. The calculated sample size was 384 participants, which was increased by 10% to compensate for possible non-response and incomplete questionnaires, resulting in a final sample size of 420 nursing students.

Data Collection Procedure

Data were collected through a structured self-administered questionnaire adapted from validated electrocardiology assessment frameworks. The questionnaire consisted of 31 items divided into three domains. The first domain included six items related to socio-demographic and educational characteristics, including age, gender, marital status, academic program, clinical rotation exposure, and previous ECG training or workshop participation. The second domain assessed theoretical ECG knowledge through 15 True/False questions covering electrophysiological concepts, ECG intervals, lead orientation, and abnormal waveform characteristics. The third domain evaluated practical ECG interpretation skills using 10 clinical scenario-based questions involving rhythm recognition, ST-elevation patterns, atrioventricular blocks, bundle branch blocks, and electrolyte-related ECG changes. Participants completed the questionnaire voluntarily after receiving information about the study purpose and providing informed consent.

Data Analysis Procedure

Collected data were coded, entered, and analyzed using IBM SPSS Statistics version 27.0. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize participants' demographic characteristics and responses to ECG knowledge and practice items. Each correct response in the theoretical and practical domains was assigned one mark, while incorrect or unanswered responses received zero marks. Scores were

converted into percentages and categorized into inadequate competency (<60%), moderate competency (60–75%), and adequate competency (>75%). The Pearson Chi-Square test was applied to determine associations between demographic

characteristics, particularly previous formal ECG training, and competency levels. Statistical significance was considered at a p-value of less than 0.05.

Results

Demographic Analysis

Table 1 Socio-Demographic Characteristics of Study Participants (N = 420)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	22–26 years	357	85.0
	27–31 years	42	10.0
	32–36 years	15	3.6
	Above 36 years	6	1.4
Gender	Female	336	80.0
	Male	84	20.0
Marital Status	Single	361	86.0
	Married	59	14.0
Academic Program	BSN Generic	294	70.0
	Post-RN BSN	84	20.0
	Diploma in General Nursing	42	10.0
Clinical Rotation Exposure	1–5 months	189	45.0
	6–10 months	147	35.0
	11–15 months	55	13.1
	Above 15 months	29	6.9
Formal ECG Training	No Formal Training	252	60.0
	Formal Training Received	168	40.0

Note. Mean age of participants was 24.8 ± 2.4 years.

Table 1 presents the socio-demographic characteristics of the 420 nursing students included in the study. The majority of participants were aged between 22–26 years (85.0%, $n = 357$), with a mean age of 24.8 ± 2.4 years. Female participants represented the majority of the sample (80.0%, $n = 336$), while males accounted for 20.0% ($n = 84$). Most participants were

enrolled in BSN Generic programs (70.0%, $n = 294$), followed by Post-RN BSN (20.0%, $n = 84$) and Diploma in General Nursing students (10.0%, $n = 42$). Regarding ECG-related educational exposure, 60.0% ($n = 252$) reported having no formal ECG training or workshops, indicating limited structured opportunities for ECG skill development among nursing students.

Table 2 Theoretical Knowledge Performance Regarding ECG Interpretation Among Nursing Students (N = 420)

Knowledge Item	Correct Response n (%)	Incorrect Response n (%)
P wave represents atrial depolarization	269 (64.0)	151 (36.0)
QRS complex represents ventricular depolarization	315 (75.0)	105 (25.0)
T wave represents ventricular repolarization	294 (70.0)	126 (30.0)
Normal ECG T waves are inverted in precordial leads	210 (50.0)	210 (50.0)
Normal PR interval ranges between 0.12–0.20 seconds	273 (65.0)	147 (35.0)

Lead V1 and aVR display negative QRS deflection	189 (45.0)	231 (55.0)
Pathological Q waves indicate myocardial necrosis	231 (55.0)	189 (45.0)
Atrial fibrillation has regular R-R intervals	168 (40.0)	252 (60.0)
ECG can detect left ventricular hypertrophy	252 (60.0)	168 (40.0)
Inferior MI ST elevation appears in V1-V6	147 (35.0)	273 (65.0)
Lateral MI ST elevation appears in I, aVL, V5, V6	210 (50.0)	210 (50.0)
Anterior MI ST elevation appears in II, III, aVF	126 (30.0)	294 (70.0)
ST depression indicates subendocardial ischemia	281 (67.0)	139 (33.0)
RSR' pattern indicates Right Bundle Branch Block	168 (40.0)	252 (60.0)
Tall peaked T waves and widened QRS indicate hyperkalemia	273 (65.0)	147 (35.0)

Table 2 demonstrates the theoretical ECG knowledge performance of nursing students. Participants showed better understanding of basic ECG concepts, with the highest correct response observed for identifying the QRS complex as ventricular depolarization (75.0%, n = 315), followed by T wave interpretation (70.0%, n = 294). However, considerable knowledge gaps were

observed in advanced ECG interpretation areas. Only 30.0% (n = 126) correctly identified anterior myocardial infarction lead localization, while 70.0% (n = 294) responded incorrectly. Similarly, 60.0% (n = 252) failed to recognize the irregular rhythm pattern associated with atrial fibrillation, indicating inadequate understanding of clinically significant ECG abnormalities.

Table 3 Practical ECG Interpretation Competency Among Nursing Students (N = 420)

Practical Skill Item	Correct n (%)	Incorrect n (%)
Visual recognition of acute ST-segment elevation	231 (55.0)	189 (45.0)
Identification of PR interval prolongation (>0.20s)	189 (45.0)	231 (55.0)
Differentiation of complete AV dissociation (3rd degree block)	126 (30.0)	294 (70.0)
Recognition of lead reversal/somatic tremor artifact	252 (60.0)	168 (40.0)
Identification of sinus bradycardia	294 (70.0)	126 (30.0)
Identification of Mobitz Type II AV block	147 (35.0)	273 (65.0)
Recognition of symmetrical T-wave inversion	210 (50.0)	210 (50.0)
Differentiation of VT from SVT with aberrancy	168 (40.0)	252 (60.0)
Calculation of heart rate on irregular ECG strip	189 (45.0)	231 (55.0)
Correct placement of precordial leads V1-V6	231 (55.0)	189 (45.0)

Table 3 presents practical ECG interpretation competency among nursing students. The highest performance was observed in identifying sinus bradycardia (70.0%, n = 294) and recognizing lead placement artifacts (60.0%, n = 252). Significant deficiencies were identified in advanced rhythm interpretation, particularly complete heart block identification, where only 30.0% (n = 126)

answered correctly. Furthermore, 65.0% (n = 273) were unable to recognize Mobitz Type II atrioventricular block, and 60.0% (n = 252) failed to differentiate ventricular tachycardia from supraventricular tachycardia with aberrancy. These findings indicate inadequate practical application of ECG knowledge among nursing students.

Table 4 Association Between Formal ECG Training and Overall ECG Competency Level (N = 420)

Formal ECG Training	Inadequate Competency n (%)	Moderate Competency n (%)	Adequate Competency n (%)	χ^2	p-value
No Formal Training (n=252)	160 (63.5)	72 (28.6)	20 (7.9)	78.45	<0.001
Formal Training Received (n=168)	30 (17.9)	58 (34.5)	80 (47.6)		

Table 4 demonstrates a statistically significant association between formal ECG training and overall competency level among nursing students. Students who had not received formal ECG training showed a higher proportion of inadequate competency (63.5%, n = 160), while only 7.9% (n = 20) achieved adequate competency. In comparison, students who received formal ECG training demonstrated considerably better performance, with 47.6% (n = 80) achieving adequate competency and only 17.9% (n = 30) remaining in the inadequate category. Pearson Chi-Square analysis revealed a statistically significant relationship between ECG training exposure and competency level ($\chi^2 = 78.45$, $p < 0.001$), suggesting that structured ECG education positively influences nursing students' interpretation skills.

Discussion

The present study assessed the knowledge and practical competency of nursing students regarding ECG interpretation and revealed important gaps in both theoretical understanding and clinical application. The findings demonstrated that a large proportion of students had inadequate ECG competency, with 45.2% showing inadequate theoretical knowledge and 50.0% demonstrating low practical competency. The mean theoretical score was 57.6%, while the mean practical score was 49.0%, indicating that students experienced greater difficulty applying ECG knowledge in clinical scenarios. Similar findings were reported by Rubbi et al. (2021), who identified insufficient ECG interpretation skills among nursing students and highlighted that theoretical exposure alone does not ensure clinical competency. A study by Ahmadi et al. (2022) also

reported that nursing students and healthcare professionals frequently experience challenges in ECG interpretation due to limited structured training and inadequate practical exposure. The current findings emphasize the need for competency-based ECG education within undergraduate nursing programs.

The demographic characteristics of the current study showed that most participants were young female nursing students enrolled in BSN Generic programs, with 60.0% reporting no formal ECG training. The predominance of female participants is consistent with findings from several nursing education studies, where female students represent the majority of nursing cohorts due to higher female enrollment trends in the profession (Hassan et al., 2023). The lack of formal ECG training observed in this study reflects educational limitations reported in previous research. Naz et al. (2024) identified that many nurses lacked adequate ECG interpretation training and recommended the integration of regular ECG workshops and competency-based learning activities. The current study supports previous evidence that limited exposure to formal ECG education may contribute to reduced confidence and poor interpretation performance among nursing students.

The study findings showed that students demonstrated stronger knowledge regarding basic ECG concepts compared with complex diagnostic interpretation. The highest knowledge score was observed for identifying the QRS complex as ventricular depolarization (75.0%), while major deficiencies were found in myocardial infarction lead localization and arrhythmia recognition. Similar patterns were reported by Brady et al. (2023), who found that healthcare learners

commonly understand fundamental ECG components but experience difficulty interpreting complicated rhythm abnormalities and ischemic patterns. Kohan et al. (2024) also reported that undergraduate nursing students frequently struggle with advanced ECG concepts, including conduction abnormalities and clinical decision-making. The findings suggest that nursing education may provide adequate theoretical information regarding ECG fundamentals but insufficient opportunities for developing higher-level interpretation skills.

The practical competency findings indicated significant weaknesses in identifying complex cardiac rhythms and conduction disorders. Only 30.0% of students correctly identified complete heart block, and 35.0% recognized Mobitz Type II atrioventricular block. These findings are comparable with a study conducted by Radha et al. (2021), which demonstrated that nursing students had difficulty translating ECG theory into practical interpretation without repeated clinical practice and interactive learning strategies. Brady et al. (2023) reported that simulation-based ECG training significantly improved rhythm recognition abilities among nursing professionals and students. The low practical performance in the present study highlights the importance of increasing clinical simulation sessions, case-based ECG discussions, and supervised interpretation practice during nursing education.

The current study identified a significant relationship between formal ECG training and competency level. Students who received formal ECG training demonstrated substantially higher competency, with 47.6% achieving adequate competency compared with only 7.9% among students without formal training. The statistically significant association between training exposure and competency level ($\chi^2 = 78.45$, $p < 0.001$) supports previous research findings. Kohan et al. (2024) reported that structured ECG educational interventions significantly improved students' interpretation accuracy and confidence. Ahmadi et al. (2022) emphasized that repeated educational interventions, workshops, and simulation-based approaches are effective methods for improving ECG interpretation abilities. The present findings

strengthen the evidence that formal ECG training should be incorporated as an essential component of nursing curricula.

The findings of this study are consistent with international evidence demonstrating that ECG interpretation remains a challenging competency among nursing students. Studies from different healthcare education settings have reported variations in knowledge levels depending on curriculum structure, clinical exposure, and availability of specialized ECG teaching. Dhillon et al. (2023) found that targeted educational programs improved ECG interpretation accuracy among nurses, suggesting that competency can be enhanced through appropriate instructional strategies. The current study differs from some studies reporting higher competency levels among nursing students, which may be related to differences in educational resources, simulation facilities, clinical exposure, and availability of ECG-focused training programs. These differences indicate the importance of considering institutional and regional factors when evaluating ECG competency.

The study findings highlight the importance of strengthening ECG education among nursing students to improve patient safety and clinical decision-making. Inadequate ECG interpretation skills may delay recognition of life-threatening cardiac conditions, affecting timely interventions and patient outcomes. The results support previous recommendations that nursing education programs should incorporate structured ECG modules, simulation-based learning, regular assessment, and clinical mentorship opportunities (Brady et al., 2023; Kohan et al., 2024). The significant improvement observed among students with formal ECG training demonstrates that educational interventions can effectively address existing competency gaps. Strengthening ECG training within nursing curricula can prepare future nurses to provide safer and more effective cardiac care.

CONCLUSION:

The present study concluded that nursing students demonstrated inadequate knowledge and practical competency regarding electrocardiogram (ECG)

interpretation. Although students showed better understanding of basic ECG concepts, considerable gaps were identified in advanced interpretation skills, including recognition of arrhythmias, myocardial infarction patterns, conduction abnormalities, and clinical application of ECG findings. The overall theoretical and practical performance indicated difficulty in translating ECG knowledge into clinical practice. A significant proportion of students had not received formal ECG training, and those without structured training demonstrated lower competency levels compared with students who had received ECG education. The significant association between formal ECG training and competency highlights the importance of incorporating structured ECG modules, simulation-based learning, clinical practice sessions, and regular competency assessments within nursing education programs. Strengthening ECG interpretation skills among nursing students can improve clinical decision-making, enhance early recognition of cardiac abnormalities, and contribute to safer and more effective patient care.

RECOMMENDATIONS OF THE STUDY: for Excellence in Education & Research

Based on the findings of the present study, it is recommended that nursing education institutions should integrate structured electrocardiogram (ECG) interpretation training into undergraduate and post-registration nursing curricula to improve students' theoretical knowledge and practical competency. Regular ECG workshops, simulation-based learning sessions, case-based discussions, and supervised clinical practice should be conducted to enhance students' confidence in recognizing cardiac rhythms and abnormalities. Nursing educators should use interactive teaching strategies, including digital ECG interpretation tools and scenario-based assessments, to strengthen clinical reasoning skills. Continuous evaluation of ECG competency should be incorporated into nursing programs through practical examinations and skill assessments. Healthcare institutions should provide nursing students with increased opportunities for exposure to cardiac care units and real clinical

ECG monitoring experiences. Further research should be conducted across multiple nursing institutions with larger samples to explore additional factors influencing ECG interpretation competency and to evaluate the long-term effectiveness of educational interventions.

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