Original Article

Development and Validation Instrument for Assessment of Competence in Electrocardiogram Rhythm

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ABSTRACT

OBJECTIVE: This study aimed to develop and assess three instruments to evaluate student competence in interpreting electrocardiograms (ECGs).

METHODOLOGY: The study was conducted within a nursing education program in Indonesia in 2022, involving a sample size of 73 participants. This research employs a research and development framework utilizing the Tessmer Method. Three assessment instruments were developed to evaluate students' ECG interpretation knowledge, skills, and self-confidence. These instruments underwent psychometric analysis, which included Evaluation of face validity, content validity, structural validity, and reliability assessments focusing on internal consistency and stability.

RESULTS: The findings indicated that the interpretation competency instruments denoted as 3 ECG were valid, as they effectively measured the intended constructs, achieving an average validity value of 0.87. The instruments assessing knowledge, skills, and self-confidence exhibited a Content Validity Index (CVI) value of 1 or greater. Furthermore, these instruments demonstrated reliability, with Cronbach's alpha coefficients recorded as follows: Knowledge: 0.913, Skills: 0.855, and Attitude: 0.904.

CONCLUSION: The three instruments for evaluating nursing student's knowledge, skills, and self-confidence effectively assess their competency in interpreting ECGs. Knowledge evaluates theoretical understanding; Skills measure practical ability to analyze ECGs; Self-Confidence assesses students' belief in their skills, influencing performance in clinical settings. Together, these tools offer a comprehensive framework to gauge nursing students' proficiency in this critical healthcare area.

KEYWORDS: competence, knowledge, skill, attitude, electrocardiogram

INTRODUCTION

An electrocardiogram (ECG) is a vital diagnostic tool for evaluating patients with heart rhythm disorders, particularly in emergency scenarios and for disease screening. All nurses must be competent to identify and interpret dysrhythmias in patients[1]. Failure to recognize ECG abnormalities early undermines nurses' sensitivity to potential arrhythmias, jeopardizing patient safety. Incorrect ECG interpretation may result in unsuitable clinical decisions that could exacerbate the patient's condition, even risking their life[2,3].

The prevalence of coronary heart disease is alarmingly high, with reports indicating approximately 315 million cases in 2022[4]. Consequently, it is crucial for nurses to promptly recognize arrhythmias, thereby ensuring that patients receive timely treatment to avert serious outcomes, such as death or disability[5]. Despite the significance of this issue, there remains a notable deficit in nurses' ability to identify heart arrhythmias accurately. As nursing students transition from academic education to professional training in hospitals, they must be proficient in recognizing arrhythmias to maintain patient safety and ensure the appropriate management of those with heart rhythm disorders.

Various strategies have been implemented to enhance ECG interpretation skills among nurses and nursing students, including different educational approaches such as lectures, peer learning, ECG applications, web-based learning modules, training sessions, and workshops. Moreover, these training initiatives aim to bolster the retention of knowledge, skills, and confidence in ECG interpretation among nursing professionals[6–8]. Hence, it is essential to assess whether the evaluation format for ECG interpretation competency has been adequately developed and encompasses all necessary aspects of assessment.

Competency evaluation for nurses has predominantly been reported in two domains: knowledge and skills [9]. These domains will indicate that the competence of nursing students in recognizing ECG rhythms has yet to be thoroughly assessed. Nursing educators are

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therefore tasked with designing and developing valid and reliable instruments that comprehensively measure this competency.

The research utilizes Bloom's taxonomy approach, a well-regarded educational framework highlighting the significance of knowledge, attitudes, and skills in shaping an individual's actions toward achieving optimal results. Confidence is critical, enabling individuals to perform tasks effectively, particularly under pressure. These three elements-knowledge, attitudes, and skills-are interrelated and collectively contribute to an individual's competence[10]. The assessed attitude in this context concentrates on students' self-confidence regarding their ECG interpretation capabilities, with the affective aspect focusing on their confidence levels in this skill.

While Hernández-Padilla et al. have designed a comprehensive instrument for assessing ECG interpretation competence, encompassing knowledge, skills, and attitudes, it has been deemed overly complex for third-semester nursing students. There is a pressing need for a new assessment tool specifically designed to focus on arrhythmias related to ischemia/ infarction[11]. Developing a novel assessment instrument is necessary to evaluate the competencies associated with ECG learning, a vital skill within the adult nursing curriculum, particularly concerning the cardiovascular, respiratory, and hematological systems. Based on the above data, this research endeavors to design and create a valid and reliable assessment tool, comprehensively measuring nursing students' proficiency in interpreting ECGs.

METHODOLOGY

Study Design

This research is classified as a study focused on research and development. It employs a cross-sectional study design, allowing for simultaneously examining a specific population. This design facilitates the collection and analysis of data to understand various factors and relationships within the research context.

Population and Sample

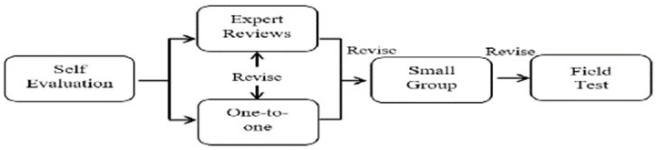
This study targets students enrolled in a Nursing faculty in Aceh Province. It employed a convenience sampling method, with specific inclusion criteria, to select all active 2022/2023 academic year students who had yet to undergo ECG training during the preceding year. Ultimately, a sample size of 73 participants was achieved. The research activities were conducted from August to September 2022.

Instrument

This instrument was developed utilizing the Tessmer method, a framework frequently implemented within educational contexts. This model is appropriate for developing and assessing media and learning resources. According to the Tessmer model, the evaluation process is categorized into two distinct phases: preliminary and formative evaluation[12].

The initial stage entails identifying various theories and references underpinning the instrument's development to evaluate undergraduate students' competencies in interpreting ECGs. The formative evaluation phase encompasses self-evaluation, expert reviews, one-to-one testing, small group testing, and research with larger sample sizes. Revisions will be made to each testing stage based on the feedback received[12].

Figure I: Tessmer Formative evaluation stages



The self-evaluation stage commences with examining the curriculum and learning outcomes pertinent to the Adult Nursing course, explicitly focusing on the cardiovascular, respiratory, and hematologic systems. This initial analysis aims to enhance instrument development and delineate the characteristics of participants constituting the research sample. Formative Evaluation entails several methodological stages, specifically:

1) Expert Review engaging subject matter experts to provide critical insights and collaborate with researchers;

2) One to One Evaluation, where an individual student collaborates with experts to assess the developed instrument;

3) Small Group Assessment conducted trials involving students in small cohorts and

4) Field Testing—executing trials on a larger group corresponding to the research subjects [12].

While an initial focus group discussion among experts was anticipated, logistical constraints due to some experts undergoing training necessitated substituting this method with in-depth interviews centred on competencies in ECG interpretation. Subsequently, thirty-five questions were formulated in the Indonesian language, encompassing three components of competence: knowledge, skills, and self-confidence.

Moreover, the instrument was reviewed by four experts, including two faculty members from the Adult Nursing department with extensive academic and professional experience in ECG interpretation. The remaining two evaluators are faculty and nursing professionals training students in cardiac wards and intensive coronary care units. Concurrently, the instrument was trialed with three students to identify potential difficulties or ambiguities in responding to the questions. Experts and students were solicited for evaluations regarding the instrument's clarity, conciseness, and comprehensibility[13].

Experts rigorously assessed the instrument's content validity using a relevance scale ranging from 1 (Not Relevant) to 4 (Very Relevant). Instrument questions achieving an acceptable Item Content Validity Index (I -CVI) value of 1 were retained for the study, while those with an I-CVI value below 1 were discarded [13].

Validity and reliability assessments of the knowledge, skills, and self-confidence instruments were executed on a singular occasion. The validity analysis employed Pearson correlation to establish the relationship between each item's score and the cumulative score of the questionnaire, operating at a significance level of $\alpha = 0.05$, with a corrected ITC threshold of > 0.3, denoting validity. The instrument's reliability was evaluated via Cronbach's Alpha, wherein an $\alpha > 0.70$ indicates reliability, a score between 0.80 and ≤ 0.90 reflects good reliability, and $\alpha > 0.90$ signifies excellent reliability. A higher Cronbach's Alpha score infers a more substantial internal consistency reliability[14].

Data Analysis

Pilot study

The pilot study involved ten respondents who were not included in the subsequent primary research. This phase was run to evaluate students' competencies in ECG interpretation, and a comprehensive questionnaire comprising 30 questions was developed. The validity assessment results revealed a Pearson correlation coefficient of less than 0.05. Conversely, the reliability analysis indicated by Cronbach's Alpha demonstrated that the instruments possessed high reliability values (knowledge: 0.933, skills: 0.932, and self-confidence: 0.956). Therefore, it can be concluded that the three instruments are both valid and reliable.

Final data analysis

Data analysis is performed on a computer system to evaluate the assessment tool's validity and reliability. Below is the description of the ECG interpretation competency assessment instrument designed for students:

Instrument for ECG interpretation knowledge

This part comprises ten multiple-choice questions, each featuring five answer options with a singular correct response. The questionnaire evaluates fundamental concepts of electrocardiography, including the characteristics of ECG waves and abnormalities associated with P, Q, ST, and T waves, as well as the features indicative of sinus rhythm ECG and conditions involving ischemia and infarction. The assessment results provided by four experts are deemed valid if the item-level content validity index (I-CVI) equals 1, the ITC value exceeds 0.3, and Cronbach's alpha is more significant than 0.85, indicating that the overall score would not significantly increase upon removing any items. Data analysis of the ten questions evaluating knowledge has yielded an I-CVI score of 1. Furthermore, Pearson correlation results indicate a significance value lower than 0.05. The reliability assessments demonstrate an ICT greater than 0.3 and a Cronbach's alpha of 0.913, suggesting that all questionnaires are suitable for retention.

ECG interpretation skills instrument

The Evaluation of ECG interpretation skills comprises ten questions that participants are required to answer. Each question includes a specific ECG strip identified as 1 ECG and shall consist of six sub-items that participants must complete. These sub-items include the assessment of rhythm, duration, and amplitude of the P wave, duration of the QRS complex, PR interval, heart rate, and an overall conclusion. Notably, this assessment tool necessitates that students formulate their responses without providing answer choices, thereby eliminating the possibility of scoring by random guessing. Furthermore, all sub-items must be thoroughly addressed and analyzed in the context of the presented ECG strip. This research aims to validate this instrument's effectiveness in gauging students' competencies in ECG interpretation. The data analysis outcomes for the ten skill assessment items yielded an Item Content Validity Index (I-CVI) score of 1 for all items. However, three items received I-CVI values below 1, excluding them from the analysis.

Conversely, the data about knowledge assessment similarly recorded an I-CVI score of 1 across all ten questions. The Pearson correlation results indicated a statistically significant relationship with a p-value less than 0.05. Additionally, the reliability analysis reflected an Intraclass Correlation Coefficient (ICT) exceeding 0.3 and a Cronbach's Alpha coefficient of 0.855, thus affirming the retention of all questionnaires.

Self-confidence assessment instrument

The self-confidence assessment tool comprises statements about students' confidence levels in interpreting ten displayed ECG images, evaluated using a Likert scale ranging from 1 to 5. Twelve ECG images were prepared, requiring students to gauge their confidence regarding interpreting these images. Data analysis results for the ten confidence-related questions indicated an I-CVI score of 1 for all items; however, two questions exhibited I-CV values below 1, necessitating their exclusion from the analysis. Additionally, Pearson correlation results demonstrated statistical significance with a p-value of less than 0.05. Reliability testing yielded an ICT greater than 0.3 and a Cronbach's alpha of 0.956, confirming that the questionnaires are suitable for retention. Further descriptions of the ECG images utilized to evaluate confidence in ECG interpretation are detailed in Table 4.

Ethical Statement

This study was undertaken following the approval from the Faculty of Nursing ethics committee at Syiah Kuala University, reference number 113088050922. Before the commencement of the research, participants were given comprehensive information regarding the research design, objectives, and their rights as respondents. Those who consented to participate were required to sign an informed consent form.

RESULTS

Characteristics of Respondent

The data on the characteristics of the respondents in

this study are:

Table I: Characteristic Respondents

Characteristics	F	%
Gender		
Female	68	93
Male	5	7
Age (Years)		
19-20 (Late Teenage)	73	100
Education		
Bachelor Nurse	73	100

Table I indicates that most respondents are female, comprising 93% of the sample. Furthermore, all respondents (100%) fall within the age range of 19 to 20 years, and 100% hold a Bachelor's degree in nursing.

The results of the test of the three instruments of knowledge, attitude, and self-confidence are as follows:

Table II: Psychometric statistic of ECG knowledge questionnaire tool

Topic	Corrected-Item total correlation	Cronbach's Alpha If Item Deleted	I-CVI
Identification of ECG sinus rhythm	0,699	0,904	1
Calculating heart rate	0,555	0,914	1
Identifying ST Segment in STEMI	0,726	0,904	1
Identifying T Wave abnormalities	0,590	0,910	1
Identifying P wave abnormalities	0,708	0,903	1
Characteristics of anterior infarction	0,591	0,910	1
Identifying Q Wave and QRS characteristics	0,671	0,905	1
Identifying PR interval	0,726	0,902	1
Characteristics of First-degree AV block	0,839	0,895	1
Identifying atrial fibrillation	0,786	0,898	1

Tables II, III, and IV present the validity and reliability analysis results of the three instruments utilized to evaluate the ECG interpretation capabilities of nursing students. The reliability assessment, determined by Cronbach's Alpha, yielded the following coefficients for the instruments: knowledge (0.913), skills (0.855), and self-confidence (0.904), indicating a high level of reliability. The obtained ITC values for knowledge ranged from 0.555 to 0.839, skills from 0.530 to 0.813, and self-confidence from 0.586 to 0.791. All item ITC values surpassed the 0.3 threshold, demonstrating that every test item adheres to the criteria for internal consistency, with higher scores indicating greater internal consistency reliability. Regarding the validity of the instruments, an analysis conducted by four experts revealed an I-CVI value of 1 for the three instruments. According to the results displayed in Table 5, the validity tests confirm that all items are valid, as evidenced by the table's r value of 0.2303, which exceeds the required r value. The elevated Cronbach's Alpha and I-CVI scores further underscore the consistent and accurate nature of the instrument.

Table III: Psychometric statistic of ECG Skill Assessment tool

Topic	Corrected-Item total correlation	Cronbach's Alpha If item deleted	I-CVI
Inferior Infarction	0,530	0,844	1
Asystole	0,715	0,830	1
Sinus Tachycardia	0,813	0,890	1
Sinus Arrhythmia	0,764	0,824	1
Pulseless Electrical Activity	0,645	0,845	1
Ventricular Tachycardia	0,692	0,836	1
Right Bundle Branch Block	0,576	0,845	1
Electrolyte Imbalance: Hyperkalemia	0,776	0,837	1
Sinus Arrest	0,770	0,844	1
Ventricular Fibrillation	0,776	0,837	1

Table IV: Psychometric statistic of ECG self-confidence assessment tool

Topic	Corrected-Item total correlation	Cronbach's Alpha if Item deleted	I-CVI
I feel…..when interpreting the following ECG…			
Anterolateral infarction	0,598	0,898	1
Inferior Infarction	0,700	0,892	1
Atrial Flutter	0,639	0,895	1
Sinus tachycardia	0,640	0,895	1
Sinus Arrest	0,618	0,896	1
Sinus Bradycardia	0,586	0,899	1
Third-degree AV block	0,594	0,899	1
Sinus Arrhythmia	0,791	0,855	1
Asystole	0,702	0,891	1
Ventricular Fibrillation	0,738	0,889	1

Table V: Validity Test of 3 instruments: Knowledge (K), Skill (S), and Self-Confidence (S.C.)

r calculation (0,2303)		
K	S	SF
0,758	0,606	0,679
0,661	0,769	0,761
0,773	0,876	0,711
0,669	0,884	0,718
0,778	0,726	0,698
0,672	0,703	0,675
0,735	0,599	0,690
0,789	0,760	0,839
0,876	0,746	0,766
0,838	0,760	0,798

DISCUSSION

Current literature indicates that nurses and nursing students need more competency when interpreting ECGs. This shortcoming has the potential to affect patient recovery outcomes15–17 adversely. This situation underscores the imperative for nursing educators to promote safe clinical practices, which can be accomplished by developing robust and trustworthy assessment instruments to evaluate ECG interpretation competence holistically[18–20]. The competency assessment encompassing three critical components-knowledge, skills, and confidence - has been formulated and subjected to empirical testing for validity and reliability by Hernandez-Padilla et al. Upon thorough analysis, it has been determined that the assessment tool presents significant complexity when employed to evaluate nursing students' ECG interpretative capacities, specifically within adult nursing courses, mainly focusing on the cardiovascular, respiratory, and hematological systems. Furthermore, there is a pressing need for more targeted inquiry to recognize ischemia or infarction in the educational curriculum accurately. This necessity is the foundation for developing a revised assessment instrument, incorporating strategic modifications predicated on the above three competencies, skills, confidence, and desired learning outcomes[11].

Knowledge is the bedrock of understanding and is pivotal for the adept execution of clinical skills. The synergy of well-established knowledge and honed skills is significantly enhanced when underpinned by high levels of self-confidence, allowing nursing practitioners to perform their tasks effectively and correctly[21]. Therefore, ensuring a comprehensive evaluation of nursing students' competencies in ECG interpretation is essential. This Evaluation must include the assessment of the tripartite and interdependent constructs of knowledge, skills, and confidence[10]. The assessment instruments currently employed to gauge students' competencies in ECG interpretation need more completeness and continuity in their application. Consequently, there is a pronounced need to create and validate instruments that accurately assess students' competencies in this critical area. Historically, methods for evaluating ECG interpretation competency have primarily focused on knowledge and skills; however, it is essential to integrate components of self-efficacy and self-confidence into these assessments[2,22,23].

This study employed the judgment of four experts to ascertain content validity, which measures the extent to which an assessment tool corresponds with a specified research focus as evaluated by field experts. The resulting Item-Content Validity Index (I-CVI) was scored at 1. According to established guidelines, an I-CVI of 1, given the Evaluation by three to four experts, indicates that the instrument is of high quality and suitable for research purposes. This approach aligns with previous studies, which support the conclusions reached regarding content validity[24,25].

Validity testing evaluates the accuracy of a measuring instrument in capturing the intended constructs. Content validity evaluates the instrument's relevance and appropriateness through expert analyses. By engaging experts in the content validation process, researchers can ensure that the developed instrument reflects the theories or concepts it aims to measure. The greater the instrument's alignment with the entire construct, the higher the content validity [14,26].

Additionally, this study assessed reliability by measuring internal consistency utilizing Cronbach's Alpha coefficient. The computed values from this analysis (K=0.913, S=0.932, SF=0.956) indicate internal consistency levels well above 0.8, concluding that the instruments developed are of excellent quality. This conclusion is further corroborated by research conducted by Srivastava et al. and Meanjung, et al., which also reported Cronbach's alpha values exceeding 0.9, further validating the reliability of the assessment instruments[27].

A significance level of 0.05 (α=0.05) was applied within this study, which stipulated that an inter-correlation coefficient above 0.3 (≥ 0.05) reflects the validity of the three assessment instruments, and these findings align with earlier validity assessments [24,27]. Internal consistency is critically evaluated by determining how uniformly the items or components of the instrument correlate with one another. An inter-correlation coefficient of 0.30 is considered adequate for satisfactory discriminative power at a 0.05 significance level [22,23,26].

The three developed instruments are intended for educators to foster enhanced, comprehensive ECG interpretation competencies among nursing students. They will equip them with the skills necessary to provide exemplary care for patients suffering from heart rhythm disorders, positively impacting patient health outcomes. Despite the established validity and reliability of the three assessment instruments, certain limitations persist. Notably, the sample size utilized during testing could have been bigger, necessitating subsequent validation with more extensive sample populations. Furthermore, the reliability assessment was confined to a singular period; thus, implementing test-retest reliability assessments during pilot and field tests remains vital. Future research should focus on conducting randomized instrument evaluations among students and practicing nurses in clinical hospital settings.

CONCLUSION

Following comprehensive validation, the instrument designed to evaluate competencies in ECG interpretation has exhibited exemplary psychometric quality. The associated questionnaire, which encompasses knowledge, skills, and self-confidence, is particularly noteworthy for its validity, reliability, and conciseness. It offers a holistic assessment framework

for educators to evaluate nursing students' competencies in ECG interpretation.

Evaluating learning outcomes emphasizing three competency dimensions is paramount, as it thoroughly appraises an individual's knowledge, skills, and self-confidence proficiencies. Such Evaluation is instrumental in equipping students with the requisite competencies in ECG interpretation during their academic tenure. Furthermore, this instrument facilitates a detailed assessment of students' capabilities, explicitly allowing for effective practice with patients experiencing arrhythmias, ensuring patient safety and security during their subsequent professional engagements.

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AUTHOR CONTRIBUTION

Darliana D: developed the idea and carried out the research, collected data, wrote the research report, reviewed the results, and contributed to the final manuscript.

Kamil H: developed the idea and carried out the research, collected data and wrote the research report, Verified the analytical techniques, reviewed the results and contributed to the final manuscript.

Mustanir: developed the idea and carried out the research, collected data and wrote the research report, Verified the analytical techniques, reviewed the results and contributed to the final manuscript.

Heriansyah T: developed the idea and carried out the research, collected data and wrote the research report, Verified the analytical techniques, reviewed the results and contributed to the final manuscript.

REFERENCES

1. Ignatavisius DD, Workman ML, Rebar C, Heimgartner M. Medical-Surgical Nursing: Concepts for Interprofessional Collaborative Care. 10th ed. Elsevier; 2020.
2. Coll-Badell M, Jiménez-Herrera MF, Llaurado-Serra M. Emergency nurse competence in electrocardiographic interpretation in Spain: A cross-sectional study. J Emerg Nurs. 2017; 43(6): 560-70. doi: 10.1016/j.jen.2017.06.001.
3. Kerbage SH. Critical care nurses' knowledge and confidence in arrhythmia interpretation. Nurs Stand. 2017; 8(3): 124-36. doi: 10.4225/03/58c9df 84b2c20.
4. Benjamin S, Catherine J, Andrew RG. Global prevalence of coronary artery disease: An update from the global burden of disease study. J Am Coll Cardiol. 2024; 83(13_Supplement): 2320. doi: 10.1016/S0735-1097(24)04310-9.
5. Belay YH, Gezahegn D, Melaku B, Adal O. Nurses' competency on electrocardiography interpretation in adult emergency room: Addis Ababa, Ethiopia, 2021. Multicenter cross-sectional study. Int Emerg Nurs. 2024; 74: 101453. doi: 10.1016/j.ienj.2024.101453.
6. Liu Y, Chou PL, Lee BO. Effect of an interactive e-book on nursing students' electrocardiogram-related learning achievement: A quasi-experimental design. Nurse Educ Today. 2020; 90 (100): 104427. doi: 10.1016/j.nedt.2020.104427.
7. Fent G, Gosai J, Purva M. Teaching the interpretation of electrocardiograms: Which method is best? J Electrocardiol. 2015; 48(2): 190 –3. doi: 10.1016/j.jelectrocard.2014. 12.014.
8. Holthaus A, Wright VH. A 3D app for teaching nursing students ECG rhythm interpretation. Nurs Educ Perspect. 2017; 38(3): 152–3. doi: 10.1097/ 01.NEP. 0000000000000129.
9. Zieber M, Sedgewick M. Competence, confidence and knowledge retention in undergraduate nursing students—A mixed method study. Nurse Educ Today. 2018; 62(April 2017): 16–21. Available from: doi: 10.1016/j.nedt.2017.12.008.
10. Krathwohl DR. A revision of Bloom's taxonomy: An overview. Revision. 2008; 41(4): 212–8. doi: 10.1207/s15430421tip4104_2.
11. Hernández-Padilla JM, Granero-Molina J, Márquez-Hernández VV, Suthers F, López-Entrambasaguas OM, Fernández-Sola C. Design and validation of a three-instrument toolkit for the assessment of competence in electrocardiogram rhythm recognition. Eur J Cardiovasc Nurs. 2017; 16(5): 425–34. doi: 10.1177/1474515116687444.
12. Tessmer M. Formative evaluation alternatives. Wiley Online Libr. 1994; 7(1): 3–18. doi: 10.1111/j. 1937-8327.1994.tb00613.x.
13. Polit DF, Beck CT. Nursing Research: Generating and Assessing Evidence for Nursing Practice. 10th ed. Wolters Kluwer Health; 2017.
14. Waltz CF, Strickland OL, Lenz ER. Measurement reliability. In: Measurement in Nursing and Health Research. 5th ed. Springer Publishing Company; 2017.
15. Kim SO, Choi YJ. Nursing competency and educational needs for clinical practice of Korean nurses. Nurse Educ Prac. 2019; 34: 43-7. doi: 10.1016/j.nepr.2018.11.002.
16. Giannetta N, Campagna G, Di Muzio F, Di Simone E, Dionisi S, Di Muzio M. Accuracy and knowledge in 12-lead ECG placement among nursing students and nurses: A web-based Italian study. Acta Biomed. 2020; 91(12-S): 1–11.

doi: 10.23750/abm.v91i12-S.10349.
17. Tawalbeh LI. Effect of simulation modules on Jordanian nursing student knowledge and confidence in performing critical care skills: A randomized controlled trial. Int J Africa Nurs Sci. 2020; 13: 100242. doi: 10.1016/j.ijans.2020. 100242.
18. Breen CJ, Kelly GP, Kernohan WG. ECG interpretation skill acquisition: A review of learning, teaching and assessment. J Electrocardiol. 2019; (xxxx). doi: 10.1016/j. jelectrocard.2019.03.010.
19. Dahlberg K, Brady JM, Jaensson M, Nilsson U, Odom-Forren J. Education, competence, and role of the nurse working in the PACU: An international survey. J Perianesthesia Nurs. 2021; 36(3): 224-231.e6. doi: 10.1016/j.jopan.2020.08.002.
20. Antiperovitch P, Gula L, Blissett S. Improving online ECG interpretation through self-generation of diagnoses during practice: A randomized study. Can J Cardiol. 2021; 37(10): 1644-7. doi: 10.1016/ j.cjca.2021.04.026.
21. Karabacak Ü, Serbest Ş, Kan Öntürk Z, Eti Aslan F, Olgun N. Relationship between student nurses' self-efficacy and psychomotor skills competence. *Int J Nurs Pract*. 2013; 19(2): 124-30. doi: 10.1111/ijn.12051.
22. Arrogante O, González-Romero GM, Carrión-García L, Polo A. Reversible causes of cardiac arrest: Nursing competency acquisition and clinical simulation satisfaction in undergraduate nursing students. *Int Emerg Nurs*. 2021; 54: 1-7. doi: 10.1016/j.ienj.2020. 100938.
23. Jiménez-Rodríguez D, Torres Navarro M del M, Plaza del Pino FJ, Arrogante O. Simulated nursing video consultations: An innovative proposal during Covid-19 confinement. *Clin Simul Nurs*. 2020; 48: 29-37. doi: 10.1016/j.ecns. 2020.08.004.
24. Dehghani A. Development and validation of the clinical judgment capability questionnaire in nurses: A sequential exploratory mixed method study. *Int J Nurs Stud Adv*. 2024; 6: 100191. doi: 10.1016/j.ijnsa.2024.100191.
25. Zengin N, Pinar R, Akinci AC, Yildiz H. Psychometric properties of the self-efficacy for clinical evaluation scale in Turkish nursing students. *J Clin Nurs*. 2014; 23(7-8): 976-84.
26. Heale R, Twycross A. Validity and reliability in quantitative studies. *Evid Based Nurs*. 2015; 18 (3): 66–7. doi: 10.1136/eb-2015-102129.
27. Jo M, Ha Y. Development and validation of an instrument to measure nursing information literacy competency. *J Korean Acad Community Health Nurs*. 2019; 30(1): 25–37. doi: 10.12799/jkachn. 2019.30.1.25.