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Original article

The skill of nursing students trained in the evaluation of electrocardiographic trace: a comparison with emergency nurses

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Abstract. *Background and aim of the work:* Cardiovascular diseases represent the main cause of death in Italy. Early recognition of pathological electrocardiographic (ECG) trace is an important skill for nurses. The theoretical knowledge and the practical skills on the recognition of pathological ECG trace of trained nursing students were compared with those of emergency nurses. *Methods:* The study involved 35 nursing students and 41 nurses from the emergency room, emergency medicine and ambulance service. Students were previously trained through a theoretical and practical ECG course. The data were collected using two questionnaires aimed at evaluating in the two groups the ability to recognize electrocardiographic signs. The tools were uploaded to an online platform and remotely administered. *Results:* Both the students and the nurses showed a satisfactory theoretical knowledge of the ECG trace, with a statistically significant difference in favor of the nurses. Regarding practical skills, both groups showed difficulty in recognizing pathological electrocardiographic signs, particularly blockages and acute coronary syndromes. *Conclusions:* Nursing students' knowledge of ECG did not differ much from that of nurses. Training through simulation probably played a key role in improving the skill of ECG evaluation among students. More theoretical and practical courses on ECG should be recommended in Nursing Programme.

Keywords: nurse, education, simulation, knowledge, ECG interpretation, emergency department

Introduction

In Italy, cardiovascular diseases represent the main cause of death, with a prevalence of 44% in all deaths. In particular, ischemic heart disease is the leading cause of death (28% of all deaths) (1). In the emergency department, chest pain is a common clinical sign and 10-13% of patients are diagnosed with acute coronary syndrome (2). Coronary heart disease is the most common pathology underlying Sudden Cardiac Death (SCD) and frequently induces cardiomyopathies, arrhythmic syndromes and heart valve diseases (3). In general, arrhythmias, myocardial infarction and heart failure are the main causes of cardiac arrest, with a prevalence ranging from about 50% to 60% (4). Although clinical evaluation of heart disease commonly begins with an electrocardiogram (ECG) performed within 10 minutes from symptom presentation (5), the literature also recommends collecting a thorough patient history, performing a focused physical examination and evaluating specific biochemical markers, regardless of pain intensity. The ECG changes indi-

cating ischemia include: elevation of ST segment, depression of ST segment or inversion of T wave (6). Knowledge of electrocardiographic pathological signs is an essential skill for all nurses (7). In fact, the interpretation of 12-lead ECG and monitor trace is a routine practice in emergency medicine (8,9). Assessment of nurses' skills in recognizing heart rhythms at ECG has been highlighted by literature since the 1970s (10-14). The first studies which put in evidence the correlation between nursing skills in early recognition and treatment of life-threatening arrhythmias and mortality reduction were published in the 1980s and 1990s (15-17). Nowadays, the use of cardiac monitor and 12-lead ECG, associated with an increase in nursing competence, allow us to promptly detect not only coronary syndromes but also arrhythmias. Cardiac monitoring has become one of the most common diagnostic practices and nurses should be prepared for this practice. In an emergency condition, nurses are usually the first professionals who evaluate the patient, especially in critical area services (18,19). In 2004, the American Heart Association (AHA) published standards of practice for improving ECG monitoring inhospital (20,21). This consensus document was the first to address all aspects of hospital ECG monitoring in case of pathological conditions (arrhythmia, ischaemia, and QT interval), including practical considerations for proper and effective ECG monitoring (8). According to this document, nurses should be able to recognize basic electrocardiographic rhythms as they usually have the responsibility for ECG monitoring and have to implement the first clinical decision-making based on the information obtained from the monitor (7,22,23).

Nursing staff are responsible for both the technical aspects of monitoring ECG (e.g. positioning the electrodes, setting the alarm parameters) and the clinical decisions based on the information obtained from the monitor. Nurses must have sufficient knowledge to perform these procedures in collaboration with the physician (8). In particular, nurses should be able to record 12-lead ECG and correctly interpret it in order to start treatment as soon as possible, leading to better clinical outcomes (24). Therefore, nursing staff should recognize the specific abnormalities of ECG signs and correlate them with clinical conditions. For this competence, nurses can gain experience and knowledge through simulated settings (25-27). Although many studies examined the application of theoretical aspects (28,29), none included specific strategies for translating knowledge of ECG monitoring into clinical practice (8). GyeJeong et al. deem ECG knowledge necessary not only for nurses in the critical area, but also for all nursing students (30). For this reason, they investigated the skill in recognizing ECG signs indicating arrhythmias and cardiac tissue perfusion disorders among nursing students. Their results suggest the need to implement practical educational courses, supported by relevant preliminary knowledge of electrocardiography, through simulation settings and structured teaching material in Nursing Programme (25,30,31). Training nursing students on the understanding of electrocardiographic signs appears to be a good strategy for facilitating a deeper knowledge on ECG during training in the critical emergency area.

Some studies showed a significant learning efficacy of both remote and in-person ECG courses only for nurses who already had basic knowledge of ECG (32). Similarly, other authors reported that nurses who had learned to interpret ECG during nursing programme showed a significant increased knowledge of the abnormal ECG signs which require immediate life-saving interventions at the end of the post-basic training (33).

Aim of the work: The objectives of this study were to evaluate general knowledge of ECG and the ability to interpret pathological tracings among nursing students after specific training and compare their knowledge and skill with those of emergency nurses.

Methods

Study design

This comparative cross-sectional study was conducted in 2020.

Sample and setting

The research involved the 3rd year students of the Degree Course in Nursing at the University of Bologna and a group of nurses from the emergency department in a northern Italian hospital.

Our convenience sample consisted of 35 students

and 41 nurses who worked in emergency department (emergency room and outpatient emergency service). Our students had passed an examination on ECG after having followed a theoretical seminar and a practical simulation on electrocardiography lasting 4 hours. The seminar program was structured according to the teaching programs of first aid and critical area nursing.

The topics covered by the students were: anatomy and physiology of the heart, basic knowledge of electrocardiography (34), methodology of pathological sign evaluation, the main rhythm signs that require emergency interventions, signs of Acute Myocardial Infarction (AMI) (35) and clinical assessment methodology for critically ill patients (33,36).

The practical exercises were performed with the LLEAP® (Laerdal Learning Applications) simulator through a video projector of ECG monitor and 12-lead ECG traces.

The data were collected in July 2020 at the end of practical training. Questionnaires were remotely administered to both groups.

Ethical considerations

All the sample participants involved in the study gave their written consent after having learned the purposes and methods of the research. The anonymity and confidentiality of the participants were guaranteed. The research was authorized by the Bioethics Committee of the University of Bologna, by the Coordinator of the Degree Course in Nursing and by the Management of the Health Authority of a region of northern Italy.

Instruments

The study data were collected using two questionnaires, one theoretical aimed at evaluating the level of ECG knowledge and one practical aimed at measuring the ability to interpret the electrocardiographic signs.

ECG Knowledge Questionnaire

This questionnaire contains 15 true/false questions regarding the Knowledge of ECG. It was tested in a previous study (37) and was previously revised by literature reviewers (33,38) and the opinion of three specialized cardiology nurses.

ECG Assessment Questionnaire

The instrument consists of 11 images/videos that reproduce rhythms; the participants were asked to recognize the electrocardiographic signs. The videos of the signs on monitor and 12-lead ECG were produced through the LLEAP® simulator. This questionnaire was developed on the basis of scientific literature (8,19,22,33,38,39-42) and subsequently evaluated by multi-professional university professor experts on the subject.

Both questionnaires were uploaded to an online platform with an access link. Participants were able to answer questions via PC, tablet or smartphone at any time of the day and the time allowed them was 30-40 minutes in accordance with other studies (22,37).

Data analysis

The database was created through the use of Office Excel, the statistical analysis was conducted with a free statistical software. The statistics were descriptive, calculating the mean and standard derivations of the key cardinal variables with a 95% CI. Categorical variables were computed through the cross-tabulation and differences were detected through Pearson's chi-square.

Results

Participants were represented by 41 nurses (54%) and 35 nursing students (46%).

Characteristics of emergency nurses

Nurses were 37.6 years old on average (SD = 9.0) and have been working for a total of 13.2 years on average (SD = 9.7). 48.8% of them (n = 20) had been working for 4.75 years (SD = 7.0) on average in emergency room, 29.3% (n = 12) had been working for 12.3 years (SD = 7.0) on average in Emergency Outpatient Service and 22% (n = 9) had been working for 9 years (SD = 7.9) on average in Emergency Department in hospital. Regarding the nursing education, 42.3% (n = 30) had a Degree in Nursing, 11.3% (n = 8) a Regional Diploma and 4.2% (n = 3) a University Diploma. Moreover, 46.6% (n = 14) of the sample had attended a Master on Critical Area Procedures and Interventions and 87.8% (n = 36) had attended courses on ECG.

Characteristics of nursing students

Nursing students were 22.6 years old on average (SD = 2.2) and were enrolled in the 3rd year of Nursing Programme. All of them had passed the examination based on the ECG course.

Regarding the question "Do you think it useful for the nurse to know the electrocardiographic signs which need urgent interventions?" we observed that 97.6% (n = 40) of nurses and 100% of students of our sample considered it indispensable.

ECG Knowledge Questionnaire

The students' knowledge of ECG, compared with that of expert nurses in the critical area, is satisfactory, although we found a statistically significant higher scores among nurses (Table 1).

Correct answers were provided by 64% (n = 336) of students vs 75% (n = 460) of nurses (p = <0.0001). The general knowledge, divided into 15 theoretical questions, recorded a null hypothesis (H0) for 73.3% (n = 11) of all the questions of the tool.

The topics known best by students were those related to the cardiac cycle, the interval of P-R segment, the left ventricular hypertrophy and the depression of S-T segment, a sign of AMI. These competences were expressed by students in a range from 74.3% to 91.4%, similarly to the results of nurses who recorded a range from 90.2% to 95.1%.

However, even in the items in which a difference occurred, 65.7% (n = 23) of students gave a correct answer to the question "*ST elevation in lateral myocardial infarction appears in leads I, aVL, V5, and V6*" , 45.7% (n = 16) to the item "*Atrial fibrillation could have a regu-*

Table 1. ECG Knowledge questionnaire scores

		Students		**Nurses**		**Total**	$\chi 2$	*P*
		n = 35		n = 41		n = 76		
ECG Knowledge Questionnaire	**True/False**	n	%	n	%	n(%)		
The P wave represents right and left atrial repolarization	False	17	48.6	24	58.5	41(53.9)	0.76	0.385
QRS complex represents right and left ventricular depolarization	True	28	80.0	37	90.2	65(85.5)	1.60	0.206
T wave represents ventricular repolarization	True	32	91.4	38	92.7	70(92.1)	0.04	0.840
T wave is one of the negative waves in ECG	False	30	85.7	34	82.9	64(84.2)	0.11	0.740
Normal PR interval is between 0.12 and 0.20 seconds	True	32	91.4	39	95.1	71(93.4)	0.42	0.517
In a normal ECG, V1 and aVR leads are negative waves	True	15	42.9	27	65.9	42(55.3)	4.04	0.044*
Pathologic Q waves are a sign of previous myocardial infarction	True	24	68.6	32	78.0	56(73.7)	0.88	0.350
Atrial fibrillation could have a regular rhythm	False	16	45.7	32	78.0	48(63.2)	8.48	0.004**
ECG can detect left ventricular hypertrophy (LVH)	True	26	74.3	37	90.2	63(82.9)	3.39	0.066
ST elevation in inferior myocardial infarction appears in leads V1-V6	False	11	31.4	26	63.4	37(48.7)	7.73	0.005**
ST elevation in lateral myocardial infarction appears in leads I, aVL, V5, and V6	True	23	65.7	36	87.8	59(77.6)	5.31	0.021*
ST elevation in anterior myocardial infarction appears in leads II, III, and aVF	False	18	51.4	21	51.2	39(51.3)	0.0001	0.985
ST depression in ECG indicates myocardial ischemia	True	28	80,0	36	87.8	64(84.2)	0.87	0.352
RSR pattern appears in V1, V2, and V3 in right bundle branch block rhythms	True	18	51.4	27	65.9	45(59.2)	1.63	0.202
T long wave and QRS wide wave are seen in case of hypokalemia	False	18	51.4	14	34.1	32(42.1)	2.31	0.128
Total		**336**	**64%**	**460**	**75%**	**796(70%)**	**15.7**	**<0.0001****

* p = <0.05; ** p = <0.01

lar rhythm", and 42.9% (n = 15) to the question "*In a normal ECG, V1 and aVR leads are negative waves*" and finally with the lowest percentage [31.4% (n = 11)] to the question "*ST elevation in inferior myocardial infarction appears in leads V1-V6*".

The question "*The P wave represents right and left atrial repolarization*" was answered correctly by only 48.6% (n = 17) of students and 58.5% (n = 24) of nurses (p = 0.385).

ECG Assessment Questionnaire

The two groups obtained overlapped total score at the ECG Assessment Questionnaire, although more nurses provided correct answers at four items and more students at one item in a statistically significant way (Table 2).

Discussion

The results obtained by our students in the knowledge and evaluation of ECG trace appear to be encouraging. In fact, the score to the ECG knowledge questionnaire obtained by students was almost as high as that obtained by nurses who work daily in emergency: about 70% of students (18 responses out of 26) provided correct answers in comparison with 75% of nurses.

However, students showed some knowledge gaps both in theoretical aspects and in the recognition of pathological signs at 12-lead ECGs and ECG monitor. At the ECG knowledge questionnaire, more difficulties were encountered by students compared to professionals in the following items: "*In a normal ECG, V1 and aVR leads are negative waves*", "*Atrial fibrillation could have a regular rhythm*". Differently, at the item "*T long wave and QRS wide wave are seen in case of hypokalemia*", we did not record any significant differences between the two groups, but we observed that students obtained better results than nurses with higher percentage than those reported in the literature (37). In the ECG Assessment Questionnaire, the outcomes of the two groups are substantially similar, both showing some difficulty in recognizing the atrioventricular blocks in the monitor as well as the signs of ischemia, necrosis, AF and wave of septal depolarization.

These difficulties in recognizing the signs attribut-

Table 2. ECG Assessment questionnaire scores

	Students		**Nurses**		**Total**	$\chi 2$	*P*
	n = 35		n = 41		n = 76		
ECG AssessmentQuestionnaire	n	%	n	%	n(%)		
By evaluating the monitor, the sample recognizes:							
Alteration of ST (ST elevation)	22	62.9	28	68.3	50(65.8)	0.258	0.619
P-R prolonged up to P wave is not followed by QRS	15	42.9	30	73.2	45(59.2)	7.18	0.007**
Asynchrony between atrial and ventricular function (normal P waves with no relationship to QRS)	23	65.7	30	73.2	53(69.7)	0.497	0.481
Artifacts due to poorly positioned electrodes	25	71.4	38	92.7	63(82.9)	6.02	0.014*
Frequency <60 beats / min, P waves present, constant P-P and R-R interval	19	54.3	33	80.5	52(68.4)	6.00	0.014*
Normal P waves, but not all followed by QRS. One P wave conducted and one not (2: 1). Normal P-R section	15	42.9	29	70.7	44(57.9)	6.02	0.014*
Inverted T waves>1 mm on V4 and V5	12	34.3	10	24.4	22(28.9)	0.899	0.343
Hyperacute T wave (> 2.5mm; > 0.25mV)	11	(31.4)	4	9.8	15(19.7)	5.598	0.018*
In V4 and V6 Q wave> 30 ms, duration> 0.04 and> 1/4 with respect to the R wave	12	34.3	16	39.0	28(36.8)	0.18	0.669
No P waves, irregular R-R intervals, presence of irregular high frequency f waves	12	34.3	8	19.5	20(26.3)	2.125	0.145
R-S septaldepolarization	16	45.7	11	26.8	27(35.5)	2.94	0.086
Total	**182**	**47%**	**237**	**52.5%**	**419(50%)**	**2.314**	**0.218**

* p = <0.05; ** p = <0.01

able to acute coronary syndromes are also documented in the literature, both in students (37) and in nurses (43) who work in the ambulance service (42) and first aid (33,35).

Other research shows that the knowledge of medical and nursing staff in ECG interpretation is often limited due to the lack or inadequacy of training (22,44), which can negatively condition the quality of training (45). We put in evidence that this study was conducted in July 2020 during the pandemic period which limited the attendance of students only to the COVID-19 free services and did not give the students the opportunity to deepen their practical knowledge in the critical area departments. This could also have negatively influenced our results.

The didactic choice of training nursing students in ECG reading could have positive repercussions on their future professional activity since such a preparatory knowledge could facilitate and enhance post-basic training in the critical area of emergency, which requires a deepened knowledge of ECG and cardiac monitoring (32).

Some studies showed a significant ability in reading electrocardiographic signs among nurses specialized in the critical area of emergency who had previously acquired a preparatory training on the ECG during the course of University study (33). The purpose of ECG training should encourage clinical assessment, critical thinking and appropriate nursing interventions (46).

Regarding the teaching modality, we observed that in our study a single intervention with LLEAP® was sufficient to obtain positive results, suggesting that a single exposure to simulation-based education influences learning of ECG and related clinical practice (47,48). Clinical skills training based on simulation is a teaching modality employed to optimize learning activities in nursing education, promoting critical thinking and actively stimulating new knowledge (25,49). Simulation activities associated with practical experiences can improve the evaluation of patient clinical conditions in light of appropriate interpretation of ECG trace (46). At the same time, simulation-based teaching can strengthen students' self-confidence (25,49).

In light of our results, we suggest increasing the training activities aimed at evaluating electrocardiographic signs in the clinical practice setting during nursing education. These initiatives should be implemented through lectures and workshops with high-fidelity simulations integrated with the other clinical topics (50).

As for nurses, progress in ECG knowledge requires regular learning and practice also for students (33). For this reason, it is necessary to create an integration with internships to allow students to experience the theoretical and simulation-based knowledge in clinical practice supervised by an expert tutor (50,51).

Therefore, in accordance with the literature, we highlight the efficacy of simulation in nursing teaching, also in the case of ECG knowledge and interpretation. Further studies should be implemented in nursing laboratories for evaluating not only student satisfaction (25), but also how this teaching method can affect knowledge conservation, transferability to real world setting and patient outcomes (50,52-54).

Conclusions

The first limitation of this study is represented by the small size of the sample. Furthermore, the length of the questionnaire may have caused a decline in concentration and interest leading to automatic incorrect answers. A further limitation could be represented by the study period concomitant to COVID-19 pandemic, which could have limited the student experience in the critical area of emergency. The results of this study showed that nursing students presented a satisfactory theoretical knowledge of ECG trace after having attended a theoretical and simulation-based training, although statistically significantly inferior to the nurses who work daily in emergency area. Regarding practical skills, both groups showed difficulty in recognizing pathological electrocardiographic signs, particularly blockages and acute coronary syndromes. Training courses and simulation in ECG reading, albeit limited to a few hours, could have played an important role in improving the knowledge of nursing students. Due to our positive results, we suggest including additional courses concerning ECG knowledge and practice in the 1st level teaching planning. Training should be managed by qualified experts and the knowledge acquired should be put in practice in the internship activities supervised by expert tutors.

Finally, we suggest that a future trajectory of re-

search in this area should concern the measurement over time of the effectiveness of training courses and not only immediately after the training received.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

References

1. ISS. 2020. Malattiecardiovascolari in Italia. https://www.epicentro.iss.it/cardiovascolare/ (Accessed on July 30, 2021).
2. Fanaroff AC, Rymer JA, Goldstein SA, Simel DL, Newby LK. Does this patient with chest pain have acute coronary syndrome?: The rational clinical examination systematic review. JAMA 2015; 314: 1955-65. doi: 10.1001/jama.2015.12735.
3. Hayashi M, Shimizu W, Albert CM. The spectrum of epidemiology underlying sudden cardiac death. Circ Res 2015; 116: 1887-906. doi: 10.1161/CIRCRESAHA.116.304521.
4. Andersen LW, Holmberg MJ, Berg KM, Donnino MW, Granfeldt A. In-Hospital Cardiac Arrest: A Review. JAMA 2019; 321: 1200-10. doi: 10.1001/jama.2019.1696.
5. Barstow C. Acute Coronary Syndrome: Presentation and Diagnostic Evaluation. FP Essent 2020; 490: 11-9.
6. Barstow C, Rice M, McDivitt JD. Acute Coronary Syndrome: Diagnostic Evaluation. Am Fam Physician 2017; 95: 170-7.
7. Atwood D, Wadlunci DL. ECG Interpretation Using the CRISP Method: A Guide for Nurses. AORN J 2015; 102: 396-405. doi: 10.1016/j.aorn.2015.08.004.
8. Funk M, Fennie KP, Stephens KE, et al. Association of Implementation of Practice Standards for Electrocardiographic Monitoring with Nurses' Knowledge, Quality of Care, and Patient Outcomes Findings From the Practical Use of the Latest Standards of Electrocardiography (PULSE) Trial. CircCardiovascQual Outcomes 2017; 10: e003132. doi: 10.1161/CIRCOUTCOMES.116.003132.
9. Nickerson J, Taub ES, Shah K. A checklist manifesto: Can a checklist of common diagnoses improve accuracy in ECG interpretation? Am J Emerg Med 2020; 38: 18-22. doi: 10.1016/j.ajem.2019.03.048.
10. Deal J. Did you see what you saw? How to interpret cardiac monitor patterns. Bedside Nurse 1970; 3: 21-7.
11. Hubner PJ. Nursing guide to cardiac monitoring. 1. Introduction monitors and electrodes. Nurs Mirror Midwives J 1970; 131: 13-5.
12. Hubner PJ. Nursing guide to cardiac monitoring. 2. The normal ECG trace. Nurs Mirror Midwives J 1970; 131: 9-11.
13. Powell C. Cardiograms for nurses. 3. Ventricular abnormal rhythms. Nurs Times 1970; 66: 1229-31.
14. Takashina T. [Simple interpretation of the electrocardiogram. 4. Abnormal rhythms. 1. Intervals between the P wave and PR]. KangogakuZasshi 1976; 40: 409-12.
15. Lehmann HU. [Cardiac arrhythmias. Types and drug therapy (author's transl)]. MMW Munch Med Wochenschr 1981; 123: 680-86.
16. Van Riper S, Luciano A. Basic cardiac arrhythmias: a review for postanesthesia care unit nurses. J Post AnesthNurs 1994; 9: 2-13.
17. Scrima DA. Foundations of arrhythmia interpretation. MedsurgNurs 1997; 6: 193-202.
18. Drew BJ, Dracup K, Childers R, et al. Finding ECG Readers in Clinical Practice: Is It Time to Change the Paradigm? J Am Coll of Cardiol 2014; 64: 528. doi: 10.1016/j.jacc.2014.01.086.
19. Zègre-Hemsey JK, Lee Garvey J, Carey MG.Cardiac Monitoring in the Emergency Department. Crit Care Nurs Clin North Am 2016; 28: 331-45. doi: 10.1016/j.cnc.2016.04.009.
20. Drew BJ, Califf RM, Funk M, et al. Practice standards for electrocardiographic monitoring in hospital settings: an American Heart Association scientific statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young: endorsed by the International Society of Computerized Electrocardiology and the American Association of Critical-Care Nurses. Circulation 2004; 110: 2721-46. doi: 10.1161/01.CIR.0000145144.56673.59.
21. Drew BJ, Funk M. Practice standards for ECG monitoring in hospital settings: Executive summary and guide for implementation. Crit Care Nurs Clin North Am 2006; 18: 157-68. doi: 10.1016/j.ccell.2006.01.007.
22. 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: 425-34. doi: 10.1177/1474515116687444.
23. Lancia L, PisegnaCerone M, Vittorini P, Romano S, Penco M. A comparison between EASI system 12-lead ECGs and standard 12-lead ECGs for improved clinical nursing practice. J Clin Nurs 2008; 17: 370-77. doi: 10.1111/j.1365-2702.2007.01935.x.
24. Docherty B. 12-Lead ECG interpretation and chest pain management: 1. Br J Nurs 2003; 12: 1248-55. doi: 10.12968/bjon.2003.12.21.11882.
25. Rubbi I, Ferri P, Andreina G, Cremonini V. [Learning in clinical simulation: observational study on satisfaction perceived by students of nursing] [Article in Italian]. Prof Inferm 2016; 69: 84-94. doi: 10.7429/pi.2016.692084.
26. Lapucci G, Bondi B, Rubbi I, et al. A randomized comparison trial of two and four-step approaches to teaching Cardio-Pulmonary Reanimation. Acta Biomed 2018; 89(4-S): 37-44. doi: 10.23750/abm.v89i4-S.7129.
27. Rubbi I, Lapucci G, Bondi B, et al. Effectiveness of a video lesson for the correct use in an emergency of the automated external defibrillator (AED). Acta Biomed 2020; 91: 71-8. doi: 10.23750/abm.v91i6-S.9589.
28. Rajaganeshan R, Ludlam CL, Francis DP, Parasramka SV, Sutton R. Accuracy in ECG lead placement among technicians, nurses, general physicians and cardiologists. Int J Clin Pract 2008; 62: 65-70. doi: 10.1111/j.1742-1241.2007.01390..x.
29. DiLibero J, DeSanto-Madyea S, O'Dongohue S. Improving

accuracy of cardiac electrode placement: outcomes of clinical nurse specialist practice. Clin Nurse Spec 2016; 30: 45-50. doi: 10.1097/NUR.0000000000000172.
30. GyeJeong Y, Jeongha Y, Hyun Sook K. Development and Effects of Supplementary Textbook about EKG for Nursing Students. J Korean Acad Fundam Nurs 2020; 27: 268-76. doi: https://doi.org/10.7739/jkafn.2020.27.3.268.
31. Al-Husaunawy AA. Evaluation of Nurses Knowledge and Practice of Electrocardiogram Toward Adolescent Patient. IOSR Journal of Nursing and Health Science 2015; 4: 10-6. doi: 10.9790/1959-04421016.
32. Jang KS, Hwang SY, Park SJ, Kim YM, Kim MJ. Effects of a Web-based teaching method on undergraduate nursing students' learning of electrocardiography. J NursEduc 2005; 44: 35-9. doi: 10.3928/01484834-20050101-07.
33. Zhang H, Hsu LL. The effectiveness of an education program on nurses' knowledge of electrocardiogram interpretation. IntEmerg Nurs 2013; 21: 247-51. doi: 10.1016/j.ienj.2012.11.001.
34. Sharman J. Clinical skills: cardiac rhythm recognition and monitoring. Br J Nurs 2007; 16: 306-11. doi: 10.12968/bjon.2007.16.5.23012.
35. McGrath A, Sampson M. Electrocardiograms: a guide to rhythm recognition for emergency nurses. Emerg Nurse 2018; 26: 21-9. doi: 10.7748/en.2018.e1767.
36. National Association of Emergency Medical Technicians (NAEMT). AMLS Advanced Medical Life Support. Elsevier Srl, 2012.
37. Tahboub OYH, Dal Yılmaz Ü. Nurses' knowledge and practices of electrocardiogram interpretation. IntCardiovasc Res J 2019; 13: 80-4.
38. 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: 560-70. doi: 10.1016/j.jen.2017.06.001.
39. Hand H. Common cardiac arrhythmias. Nurs Stand 2002; 16: 43-52. doi: 10.7748/ns2002.03.16.28.43.c3175.
40. Hutchisson B, Cossey S, Wheeler RM. Basic electrocardiogram interpretation for perioperative nurses. AORN J 2003; 78: 572-81, 585-90, quiz 591-94. doi: 10.1016/s0001-2092(06)60665-0.
41. Smith JN, Negrelli JM, Manek MB, Hawes EM, Viera AJ. Diagnosis and Management of Acute Coronary Syndrome: An Evidence-Based Update. J Am Board Fam Med 2015; 28: 283-93. doi: 10.3122/jabfm.2015.02.140189.
42. Werner K, Kander K, Axelsson C. Electrocardiogram interpretation skills among ambulance nurses. Eur J Cardiovasc Nurs 2016; 15: 262-8. doi: 10.1177/1474515114566158.
43. Blakeman JR, Sarsfield K, Booker KJ. Nurses' Practices and Lead Selection in Monitoring for Myocardial Ischemia: An Evidence-Based Quality Improvement Project. DimensCrit Care Nurs 2015; 34: 189-95. doi: 10.1097/DCC.0000000000000118.
44. Richley D. New training and qualifications in electrocardiography. British Journal of Cardiac Nursing 2013; 8. doi: 10.12968/bjca.2013.8.1.38.
45. Cremonini V, Ferri P, Artioli G, Sarli L, Piccioni E, Rubbi I. Nursing students' experiences of and satisfaction with the clinical learning environment: the role of educational models in the simulation laboratory and in clinical practice. Acta Biomed 2015; 86(S3): 194-204.
46. Brown DK, Chronister C. The Effect of Simulation Learning on Critical Thinking and Self-confidence When Incorporated Into an Electrocardiogram Nursing Course. Clin Simul Nurs 2009; 5: e45-e52. doi: 10.1016/J.ECNS.2008.11.001Corpus ID: 71630627.
47. Ravert P. Patient simulator sessions and critical thinking. J NursEduc 2008; 47: 557-62. doi: 10.3928/01484834-20081201-06.
48. Blum CA, Borglund S, Parcells D. High-fidelity nursing simulation: Impact on student self-confidence and clinical competence. Int J Nurs EducScholarsh 2010; 7: Article 18. doi: 10.2202/1548-923X.2035.
49. Alamrani MH, Alammar KA, Alquahtani SS, Salem OA. Comparing the Effects of Simulation-Based and Traditional Teaching Methods on the Critical Thinking Abilities and Self-Confidence of Nursing Students. J Nurs Res 2018; 26: 152-57. doi: 10.1097/jnr.0000000000000231.
50. Cant RP, Cooper SJ. Use of simulation-based learning in undergraduate nurse education: An umbrella systematic review. Nurse Educ Today 2017; 49: 63-71. doi: 10.1016/j.nedt.2016.11.015.
51. Magnani D, Di Lorenzo R, Bari A, Pozzi S, Del Giovane C, Ferri P. The undergraduate nursing student evaluation of clinical learning environment: an Italian survey. Prof Inferm 2014; 67(1): 55-61. doi: 10.7429/pi.2014.671055.
52. Warren JN, Luctkar-Flude M, Godfrey C, Lukewich J. A systematic review of the effectiveness of simulation-based education on satisfaction and learning outcomes in nurse practitioner programs. Nurse Educ Today 2016; 46: 99-108. doi: 10.1016/j.nedt.2016.08.023.
53. Hegland PA, Aarlie H, Strømme H, Jamtvedt G. Simulation-based training for nurses: Systematic review and meta-analysis. Nurse Educ Today 2017; 54: 6-20. doi: 10.1016/j.nedt.2017.04.004.
54. Petrucci C, La Cerra C, Caponnetto V, Franconi I, Gaxhja E, Rubbi I, Lancia L. Literature-based analysis of the potentials and the limitations of using simulation in nursing education. Advances in Intelligent Systems and Coputing 2017; 617: 57-64. doi: 10.1007/978-3-319-60819-8_7.

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