

▪ **Basic Research**

Efficiency of Competency Training Program on Intensive Care Nurses Performance Regarding the Electrocardiogram Interpretation

Rasha Alsayed Ahmed¹, Shimaa Attia Ali²

^{1,2}Adult Health Nursing Department- Faculty of Nursing, Helwan University, Egypt, Cairo

Abstract

Background: Recently one of the most essential therapeutic skills that aids in the quick detection of cardiovascular disease that could be fatal is the interpretation of electrocardiograms. Nurses should have a competency training program with a high-quality content of knowledge and skills for providing competent electrocardiograms interpretation and procedure correctly that can result in wise clinical judgements with favourable effects. **Aim:** The study aims to evaluate the efficiency of competency training program on intensive care nurses' performance regarding the electrocardiogram interpretation. **Design:** This study's research methodology was quasi-experimental. **Setting:** The study was carried out in three public hospitals connected to the Ministry of Health's intensive care units. **Subjects:** A purposive sample of 60 nurses who were employed in the aforementioned location. **Data collection tools:** Nurses' knowledge structured questionnaire and electrocardiograms' practical competency checklist. **Results:** The study denoted that 85% of the studied nurses' knowledge had improved to a satisfactory level; however, this number fell to 80% on the follow-up test, as opposed to 13.3% on the pre-test, additionally, Shubra Hospital had a higher mean score of knowledge (13.9 ± 4.0 , 22.6 ± 3.4 & 22.0 ± 4.19), after that Embaba Hospital (13.5 ± 3.61 , 22.0 ± 4.1 & 21.4 ± 4.61) up from Om-Elmasreen Hospital (12.9 ± 2.93 , 21.8 ± 4.3 & 21.2 ± 4.8) through the program implementation phases respectively. **Conclusion:** The competency training program had a positive large effect size on total knowledge and practices regarding electrocardiogram interpretation and procedure across the program phases among the studied nurses at ($\eta^2 = 0.499$, & 0.284) respectively, with a highly statistically significant positive correlation between cumulative total knowledge and practice at ($r = 0.924$ & $P = 0.000$). **Recommendations:** Create a generic self-instructional program on nursing interventions for electrocardiograms procedure and interpretation with various clinical cardiovascular disorders.

Keywords: The competency training program, Electrocardiogram, Placement, Interpretation, Nurses' performance

Introduction

Electrocardiogram (ECG) is a non-invasive, speedy, harmless, and no expensive technique that is universally performed by nurses in intensive care units to make a diagnosis for a variety of cardiac arrhythmia. Mainly, electrocardiograms are interpreted by physicians and nurses in many specialties, including intensive care and emergency units. As well, an efficient educational program for nurse staff will improve the standard of nursing care and improving nurses ECG interpretation skills and knowledge (**Bdair, 2022**).

The ECG is the maximum dominant investigative implements in contemporary medicine. As a representation of cardiac electrical activity, the ECG converses exclusive and dynamic evidence concerning the electrophysiological properties, anatomical structure, myocardial tissue characteristics, and haemodynamic condition of the heart (**Mobrad, 2020; Sqalli et al., 2021**).

Only a small percentage of medical professionals, notably nurses, are confident in their independent electrocardiogram (ECG) interpretation, a cognitive talent that takes a lot of practice to perfect. The ECG recording misinterpretation may result in poor clinical judgment and unfavourable patient outcomes (**Kashou et al., 2020**).

Interpretation competency level varies among nurses as well, confirming accurate recording of ECG is imperious on the portion of nurses because it helps the physician to appropriately understand recordings, diagnose and precedes the correct procedures. As nurses actuality a participant of health team had better be capable to interpret ECG recording to her magnitude of competent practice desired in intensive care units (**Sasikala, 2019; Aljohani, 2022**).

The nurses' skills to record, monitor, and interpret ECGs correctly and properly are a essential proficiency. Furthermore, supportive prior identification and handling of numerous cardiac-related disorders, capitalize on the worth of care consequences and patient outcome. In the same line contributes in predicting and distinguishing life-threatening situations, precluding cardiac disorders, and decreasing the mortality rate (**Rahimpour et al., 2021; Bdair, 2022**).

The first clinicians to examine the ECG recording and identify anomalies that may require prompt therapy are typically nurses. As a result, it is crucial that nurses possess the necessary skills to carry out the initial evaluation, create the initial paperwork, make quick decisions in response to ECG anomalies, and start first-line managements (**Aljohani, 2022**).

Improper understanding of ECG interpretation, raising healthcare expenses, and postponing the clinical management process, impress an unpleasant responsibility on hospitals and patients. Consequently, nurses who are proficient in ECG placement and interpretation must be highly skilled in typical and atypical patterns, have the competence to properly evaluate whether the ECG recording quality is sufficient for interpretation and clarification of cardiac status, and have a strong understanding of the scientific evidence that serves as the foundation for their practice (**Tahboub and Dal-Yilmaz, 2019**).

Competency-based training is almost supplementary for nurses to obtain skillful ECG placement and acquaintance interpretation knowledge, so nurses are competent to accomplish a procedure to an indicated standard even in certain circumstances". Thus, in competency-based training, a nurse's expected consequences and outcomes must be obviously described exactly what is expected to do. Correspondingly for competency-based trainers, formerly competencies designated to nurses, the trainer will know the particular training and learning that is requisite to bring the nurses to the intended level of competency (**Melvin, 2018; Pereira, 2021**).

Clinical competency is the integration of abilities, knowledge, attitudes, values, and skills that result in high performance or effectiveness in professional settings (**Pueyo-Garriguesa et al., 2022**). So, ECG placement and interpretation competency encompasses expertise with a qualified practice including (Being proficient in lead placement, clear lead visualization and reading, continuous monitoring) and having appropriate knowledge of ECG interpretation (**Chen et al., 2022**).

The nurses' competencies in ECG placement and interpretation are crucial components of patient well-being and could diminish ECG reading and analysis misconceptions during emergency situations. In the meantime, an incorrect ECG placement or interpretation can lead to inappropriate clinical decisions with serious adverse outcomes, especially in arrhythmias and myocardial infarction (**Ribeiro et al., 2020; Penalo et al., 2021**).

Significance of the study:

The leading cause of death worldwide, Heart attacks and strokes account for more than four out of every five cardiovascular diseases (CVDs) deaths, and one-third of these deaths happen before the age of 70. The cardiovascular diseases claim an estimated 17.9 million (32.2%) lives each year which including coronary heart disease, cerebrovascular disease, rheumatic heart disease, and other illnesses are among the category of heart and blood vessel disorders (**World Health Organization, 2022**). While CVD deaths in Egypt

reached 173,871 accounting for 46% of total deaths. The age adjusted Death Rate is 268.11 per 100,000 of population ranks Egypt fifteen in the world (**World Health Ranking, 2022**).

Interpreting electrocardiograms (ECGs) is a fundamental clinical skill that aids in the quick detection of illnesses that could be fatal. Using the ECG incorrectly can result in treatment procedures that have unfavourable effects. Heart problems can be discouraged or prevented, and mortality rates can be reduced by the placement, recording, and interpretation of ECGs by nursing teams competently (**Aljohani, 2022; Amini et al., 2022**).

Aim of the study:

This study was implemented to assess efficiency of competency training program on intensive care nurses' performance regarding the electrocardiogram interpretation via the consequent:

- Checked the achievable knowledge of nurses related to electrocardiogram interpretation.
- Checked the achievable practice of nurses related to electrocardiogram interpretation.
- Developing and applying a competency training program on intensive care nurses' performance related to electrocardiogram interpretation.
- Measure the effectiveness of the competency training program on intensive care nurses' performance related to the electrocardiogram interpretation.

Research hypothesis:

H₁: The mean post and follow-up test knowledge scores of the intensive care nurses' regarding the electrocardiogram interpretation will be statistically significantly higher than the mean pre-test knowledge scores.

H₂: The mean post and follow-up test practice scores of the intensive care nurses' regarding the electrocardiogram application and interpretation will be statistically significantly higher than the mean pre-test practice scores.

H₃: There will be a large effect size on nurses' knowledge and practice across phases of the competency training program implementation.

H₄: The application and interpretation of electrocardiograms by nurses are positively correlated with nurses' understanding of interpretation.

Operational definitions:

Competency training program: refers to a pre-set of prescheduled objectives to attain knowledge (ECG interpretation and determine ECG irregularities) and practice (lead placement, recording and monitoring) for target nurses that contribute to acceptable or outstanding performance and evaluate its efficiency throughout phases of program implementation.

Research design: Quasi-experimental research design was utilized to carry out this study.

Technical Design:

The technical design contains research setting, subjects, and tools for data collection.

Setting:

The study was performed at 3 Public Hospitals accompanying the Ministry of Health. The 1st Hospital was Shopra Public Hospital which consists of one building that included a general intensive care unit located 2nd floor and a cardiac intensive care unit located on the 3rd floor. The 2nd Hospital was Imbaba Public Hospital which comprises of 2 buildings linked by a bridge. The hospital had 3 intensive care units as the following: the isolated intensive care unit located on the ground floor and the general intensive care unit located on the 1st floor which was allied in the new building and the burn intensive care unit on the third floor which was allied in the old building. The 3rd Hospital was Om-Elmasreen Hospital which contains one-building that comprises of two intensive care units; a critical intensive care unit and an emergency intensive care unit located on the first floor.

The study was directed over an arrangement between the Ministry of Health, Amira Fatma Academy, and Faculty of Nursing – Helwan University to offer a competency training program to intensive care nurses to improve the nurses' competency level of ECG placement and interpretation.

Subjects:

The Ministry of Health-affiliated hospitals with 60 staff nurses who were willing to engage in the study, available at the time of the study, and employed at those hospitals made up the sample, which was selected using a convenience sampling technique (**McCombes, 2023**). The distribution of the studied nurses in relation to the designated hospital is shown in the following table.

Hospital	Unit	No of nurses
Shora Public hospital	General intensive care unit	10 nurses
	Cardiac intensive care unit	10 nurses
Imbaba Public hospital	Isolated intensive care unit	5 nurses
	General intensive care unit	10 nurses
	Burn intensive care unit	5 nurses
Om-Elmasreen Hospital	Critical intensive care unit	13 nurses
	Emergency intensive care	7 nurses

Tools for data Collection:

Data for this study were collected using the following tools:

Tool (I): Nurses' knowledge structured questionnaire: It comprised the subsequent two parts:

Part I: Demographic characteristics of the studied nurses was including nurses' age, gender, level of education and position, experience years, and previous training courses for ECG placement and interpretation.

Part II: knowledge questionnaire which evaluates nurses' knowledge (pre/post and follow-up): Based on recently published material, the researchers in An Arabic questionnaire created this tool; The dimensions on this sheet were adapted from (Amini et al., 2022; Nabil et al., 2018; Chen et al., 2022), to determine nurses' satisfactory knowledge regarding the electrocardiogram interpretation during pre/post and follow-up phases of the competency training program. It included 18 main dimensions: the following table displays these dimensions.

Dimensions		Question No
Dimension 1	Structure and function of the heart	2
Dimension 2	Terminology and definition	2
Dimension 3	Basic cardiac electrophysiology.	1
Dimension 4	Electrical stimulation of the heart.	1
Dimension 5	Cardiac conductivity and automaticity.	1
Dimension 6	ECG paper.	1
Dimension 7	Limb leads	1
Dimension 8	Bipolar leads	1
Dimension 9	Unipolar leads	1
Dimension 10	Precordial lead	1
Dimension 11	ECG short strip	1
Dimension 12	ECG long strip	1
Dimension 13	The basic ECG waves	1
Dimension 14	Heart rate calculation:	2
Dimension 15	Heart rhythm	1
Dimension 16	Characteristics of normal sinus rhythm	3
Dimension 17	Characteristics of abnormal sinus rhythm	1
Dimension 18	Cardiac arrhythmias	2
Total		24 questions

Scoring system: The overall score for the patients' knowledge was 24, with 1 point awarded for an accurate response and 0 for an incorrect response (Amini et al., 2022; Nabil et al., 2018; Chen et al., 2022). The following was taken into account for the overall judgment:

- $\geq 75\%$ was considered a satisfactory level of knowledge. It means equal or more than 18 points.
- $< 75\%$ was considered unsatisfactory knowledge. It means less than 18 points.

Tool (II): The electrocardiograms practical competency Checklist: Researchers based it on an adaptation and wrote it in Arabic (Lynn, 2019; Ali et al., 2022) to evaluate the nurse competency practice regarding ECG placement procedure. It consisted of two parts with five standards. The following table shows these standards.

Standard		Question No	
Part one: ECG placement procedure			
Standard I	Pre-care	▪ Nurse	2
		▪ Patient	7
		▪ Gather equipment	4
		▪ Prepare environment	2
Standard II	Ongoing care	▪ Improving skin contact with the electrodes	3
		▪ Limb	6
		▪ Chest	7
		▪ Machine standard	4
		▪ Recording the ECG trace	7
Standard III	Post care	▪ Patient	2
		▪ Supply	1
		▪ Environment	1
		▪ The ECG machine and lead	3
		▪ Label the ECG with the patient's details	4
		▪ Nurse	2
		▪ Documentation	1
Total standard		56	

Scoring system: This tool had (56 items) and a (112) overall score. For each step that was finished correct and complete, a two score was assigned, and the correct and incomplete step received one score. Additionally, wrong or not done step received a score of zero (Lynn, 2019 and Ali et al., 2022). The following was taken into account for the overall score:

- $\geq 85\%$ was considered competent level of practice. It means equal to or more than 96 points.
- $< 85\%$ was considered incompetent level of practice. It means less than 96 points.

Development of the competency training program:

Based on an analysis of the pre-test knowledge and practice score, a review of the literature, consideration of other experts' advice, development of a checklist, a first draught,

application of content validity of the competency training program, and preparedness of the final design, it was created and prepared for the staff nurses.

Operational Design:

The operational design includes preparatory phase, content validity and reliability, pilot study and field work.

Preparatory Phase:

It included considering all available literature (Current and past) and theoretical knowledge and practical aspects of the study using a booklet, articles, the internet, periodicals, and magazines in arrange to formulate the data collection tools.

Content validity:

Five specialists from the medical-surgical nursing staff at the Helwan University Faculty of Nursing served on the Content Validity Juries to examine the tool for appropriateness, relevance, correction, and clearance. Professors and assistant professors from different academic fields judged the submissions. Different viewpoints were sparked in relation to the scoring system, consistency, and tool format layout.

Testing reliability:

The reliability scores of study tools, including the Arabic versions of tools I and II for the nurses' interview knowledge questionnaire and the nurses' practical observational checklist, were (0.856 & 0.908), which were confirmed using the Cronbach alpha test.

Ethical Considerations:

After explaining the purpose of the study, informed consent was obtained from nurses who were willing to participate in the research process. The right to withdraw from the study at any moment without providing a justification and the protection of their privacy and confidentiality were guaranteed to nurses. Respect for values, culture, and beliefs would be shown.

Pilot Study:

A pilot study was conducted with a group of six nurses, representing 10% of the sample, to determine the tools' applicability and the clarity of the questionnaire's design as well as to estimate the time required to complete it. Because there were no changes to the instruments from the pilot study, nurses who participated in it were also participating in the main study topic.

Field Work:

- There were three parts to this study's execution: assessment, competency training program implementation (theoretical and practical stage), and evaluation.

I- Assessment phase:

- According to the arrangement main goal of improving Public Hospital nurses' competency According to the arrangement main goal of improving Public Hospital nurses' competency in both knowledge and practice. This study was provided after the agreement between the Faculty of Nursing – Helwan University, the Ministry of Health, and Amira Fatma Academy.
- The researcher visited with the nurses who agreed to participate in the study, provided information about the purpose and necessary context of the study, and obtained nurses' consent prior to the implementation of the competency training program
- To assess the content validity, reliability, and prerequisites required to create the competency training programme, a pilot research was conducted.

Proposed the competency training program:

It was created to raise nurses' practical and theoretical understanding of electrocardiogram interpretation. The researchers created the competency training program in Arabic with the following features, based on the prerequisites for nurses' understanding of (Structure and function of the heart, terminology and definition, basic cardiac electrophysiology, electrical stimulation of the heart, cardiac conductivity and automaticity, ECG paper, limb lead, bipolar lead, unipolar lead, precordial lead, ECG short strip, ECG long strip, the basic ECG waves, heart rate calculation, heart rhythm, axis deviation, and characteristics of normal sinus rhythm and abnormal sinus rhythm).

The practical portion was made to help nurses become more proficient at interpreting ECGs. It was devoted to ECG placement procedure, which involved three standards of care (Standard I- Pre-care involved (patient and nurse, equipment and environment preparation), Standard II-On going care involved (Improving skin contact with the electrodes, Limb electrode and lead placement, chest electrode and lead interpretation (V1 – V6), Standard ECG machine settings, and recording the ECG trace), and Standard III- Post care involved (Patient, supply and environment, ECG machine, label the ECG trace with the patient's details, and nurses care and documentation). Then Apply validity for the competency training program content which was created utilizing pertinent articles, research, and web.

II- Implementation phase

- The demographic characteristics sheet and the interview knowledge questionnaire were completed by the nurses within 20 minutes, which were used by the researchers to gather the necessary data from the studied nurses during this phase.

- In order to evaluate the skill competency of nurses' practice, the researchers noticed and tested nurses using practical observational checklists. As it happened, the researchers recorded what nurses noticed and what nurses said. Each nurse needed 20 to 30 minutes to complete the task.
- Nurses participated in a group discussion in the education room to learn about the theoretical components of the competency training program. Additionally, the teaching team facilitated role plays while the practical portion was carried out sequentially at intensive care units through demonstration and re-demonstration.
 - On the same day, the competency training programme was run as the subsequent orders; nurses filled pre-test, nurses had given a soft PowerPoint that allowed to ask questions in case of misunderstanding while listening and expressing interest for them, a hand-out and send soft source for nurses on their phone, after that post-test completed, and follow-up done after 3 months.
- For the sample of this study, data collecting teaching sessions were done in morning shifts commencing at the beginning of January 2023 and lasting until June 2023.

II- Evaluation phase:

All tools were filled out again three-months after the competency training program was implemented, with the exception of the nurses' demographic information. By comparing the outcomes before and after implementation using the same data-collecting instruments, which were done again after 3 months during the follow-up phase, it was possible to assess the effect of the competency training program on the nurses' outcomes.

Administrative Design:

The Helwan University Faculty of Nursing's ethics committee gave its official approval for the current study on October 19, 2022 (N0.31). Both the nurses being studied and the recruiting hospitals have given their informed consent to the study.

Statistical Design:

With the help of the SPSS statistical package version 25, data input and analysis were carried out. Continuous data were expressed as (mean SD), whilst categorical variables were expressed as numbers and percentages. The correlation between row and column variables of qualitative data was examined using Chi-Square (χ^2). The ANOVA test was used to evaluate the means of quantitative variables that were normally distributed over more than two groups. To determine the correlation between quantitative variables, Pearson correlation was used.

A two-tailed p-value of 0.05 or less was regarded as statistically significant for all tests, and a value of 0.01 or more was regarded as highly statistically significant, and P-values greater than 0.05 were not regarded as significant. The effect size is calculated using

the eta square (η^2). the reference structure for calculating effect size. As the influence is deemed weak when Eta-square value is between 0.01 and 0.06, medium when it is between 0.06 and 0.14, and high when it is greater than 0.14 (Salcedo & McCormick, 2021).

Results

Table (1) Frequency distribution of studied nurses' personal characteristics illustrates that 73.3% of the studied nurses' age were between 20 and 30 years, with a mean age of 25.95 ± 6.02 , and that 45% of nurses had a year of experience ranging from $6 \geq 10$ years with a mean of 9.63 ± 5.34 . As well, a male-to-female ratio was 1:9 with the majority of nurses were females. In terms of educational background, the (50%, 36.7%, & 13.3%) of investigated nurses held a secondary school, a technical institute, and a bachelor's degree, respectively. Moreover, 95% of the studied nurses who did not attend training sessions on ECG interpretation, with no statistically significant difference in the personal characteristics of the nurses working at the three hospitals, with P value > 0.05 .

Table (2) Comparison among levels of the studied nurses' knowledge regarding ECG interpretation denoted that while the program was being implemented, 85% of the study's nurses improved their knowledge to a good level; however, this number fell to 80% on the follow-up test, as opposed to 13.3% on the test before the program implementation. Additionally, throughout the pre, post, and three-month follow-up phases, there were highly statistically significant differences between all items and overall knowledge of the ECG interpretation technique at $P = 0.000$.

Table (3) Comparison among total mean scores of the studied nurses' knowledge regarding ECG interpretation represents that, the total mean scores of the pre-program implementation phase ($13.4 + 3.5$) enhanced during the post-test phase ($22.1 + 3.97$), up from the follow-up phase test ($21.5 + 4.5$). This difference represents a highly statistically significant between the total mean score of knowledge during pre, post, and 3 months follow-up at $P = 0.000$.

Additionally, Shubra Hospital had a higher mean score of knowledge ($13.9 + 4.0$, $22.6 + 3.4$ & $22.0 + 4.19$), after that Embaba Hospital ($13.5 + 3.61$, $22.0 + 4.1$ & $21.4 + 4.61$) matched with Om-Elmasreen Hospital ($12.9 + 2.93$, $21.8 + 4.3$ & $21.2 + 4.8$) across the program implementation phases, respectively.

Figure (1) Percentage distribution of total levels of the studied nurses' knowledge regarding ECG interpretation displays that, Shubra Hospital acquired a greater degree of satisfactory knowledge regarding ECG interpretation procedure (15%, 90%, & 85), which was then followed by Embaba Hospital (15%, 85% & 80%), as opposed to Om-Elmasreen Hospital (10%, 80% & 75%), respectively.

Table (4) Comparison between levels of the studied nurses' practice regarding ECG interpretation procedure indicates that, 88.3% of the study's nurses reached a competent level by the post-test phase, and 80% of them passed the follow-up test, up from 28.3% who took the pre-program implementation test. Additionally, the difference between the overall mean score of practice for the ECG interpretation process across the program phases at $P = 0.000$.

Table (5) Comparison between total mean scores of the studied nurses' practice regarding ECG interpretation procedure demonstrates that, in relation to the pre-program implementation test's mean score of $83.95 + 18.0$, the practice of the examined nurses' ECG interpretation procedure increased by $106.2 + 8.84$ points at the post-test phase. Furthermore, a highly statistically significant difference presented in the overall mean score of knowledge regarding the ECG interpretation procedure across the program implementation among the study nurses, with a P value of 0.000 .

As well, both Shubra Hospital reached a higher mean score of practice ($89.30 + 17.1$, $109.1 + 5.58$, & $105.9 + 9.7$) and Embaba Hospital ($84.5 + 17.8$, $106.6 + 7.50$, & $100.1 + 13.1$) more than Om-Elmasreen Hospital ($78.0 + 18.0$, $102.9 + 11.6$, & $92.4 + 21.4$) across the program implementation phases.

Figure (2) Percentage distribution of total levels of the studied nurses' practice regarding ECG interpretation procedure demonstrates that, Shubra Hospital attained a higher competent level of practice (35%, 95% & 85), up from Embaba Hospital (30%, 90% & 80%) as opposed to Om-Elmasreen Hospital (20%, 80% & 75%) across the program phases respectively.

Table (6) The competency training program had a positive, large effect size on total knowledge and practices regarding ECG interpretation and procedure across the program phases among the studied nurses, as shown by ($\eta^2 = 0.499$, & 0.284) for the effect size and η^2 of the program on total levels of the nurses' knowledge and practises in this area..

Figure (3) Scatter dot correlation between of the studied nurses' cumulative total knowledge and practices clarifies that among the nurses who were the subject of the study, there was a highly statistically significant positive association between cumulative overall knowledge and practice regarding the ECG interpretation process over program stages ($r = 0.924$ and $P = 0.000$)..

Table (1): Frequency distribution of studied nurses' personal characteristics (n= 60)

Items	Shubra Hospital		Embaba Hospital		Om - Elmasreen		Total		χ^2	P Value
	N	%	N	%	N	%	N	%		
Age (year)										
20 < 30	14	70.0	15	75.0	15	75.0	44	73.3	0.170	0.918
30 < 40	6	30.0	5	25.0	5	25.0	16	26.7		
Mean \pm SD	27.8 \pm 6.16		26.2 \pm 6.63		23.8 \pm 4.74		25.9 \pm 6.02			
Gender										
Male	4	20.0	2	10.0	0	0.0	6	10.0	4.44	0.108
Female	16	80.0	18	90.0	20	100.0	54	90.0		
Male to female ratio	1:4		1:9		0:1		1:9			
Educational level										
Secondary school	9	45.0	10	50.0	11	55.0	30	50.0	2.04	0.728
Technical institute	7	35.0	7	35.0	8	40.0	22	36.7		
Bachelor	4	20.0	3	15.0	1	5.0	8	13.3		
Experience										
1 \geq 5 years	6	30.0	7	35.0	8	40.0	21	35.0	0.786	0.940
6 \geq 10 years	9	45.0	9	45.0	9	45.0	27	45.0		
> 10 years	5	25.0	4	20.0	3	15.0	12	20.0		
Mean \pm SD	10.80 \pm 6.24		10.0 \pm 5.76		8.10 \pm 3.53		9.63 \pm 5.34			
Attending training course regarding ECG interpretation										
No	2	10.0	1	5.0	0	0.0	57	95.0	2.10	0.349
Yes	18	90.0	19	95.0	20	100.0	3	5.0		

*Significant $p \leq 0.05$ **Highly significant $p \leq 0.01$

Table (2): Comparison among levels of the studied nurses' knowledge regarding ECG interpretation procedure throughout program phases (n=60)

Items	Pre				Post				3 months follow-up				F-test	P-Value
	Satisfactory		Un-satisfactory		Satisfactory		Un-satisfactory		Satisfactory		Un-satisfactory			
	F	%	F	%	F	%	F	%	F	%	F	%		
▪ Structure and function of the heart	4	6.7	56	93.3	52	86.7	8	13.3	49	81.7	11	18.3	108	0.000**
▪ General definition	9	15.0	51	85.0	55	91.7	5	8.3	52	86.7	8	13.3	101	0.000**
▪ Basic Cardiac Electrophysiology.	11	18.3	49	81.7	49	81.7	11	18.3	46	76.7	14	23.3	45.8	0.000**
▪ Electrical stimulation of the heart.	7	11.7	53	88.3	52	86.7	8	13.3	49	81.7	11	18.3	84.4	0.000**
▪ ECG paper.	5	8.3	55	91.7	50	83.3	10	16.7	47	78.3	13	21.7	80.8	0.000**
▪ ECG leads	8	13.3	52	86.7	51	85.0	9	15.0	48	80.0	12	20.0	70.3	0.000**
▪ ECG short & long strip	8	13.3	52	86.7	49	81.7	11	18.3	47	78.3	13	21.7	60.3	0.000**
▪ The basic ECG waves	6	10.0	54	90.0	52	86.7	8	13.3	49	81.7	11	18.3	91.6	0.000**
▪ Heart rate Calculation:	8	13.3	52	86.7	51	85.0	9	15.0	48	80.0	12	20.0	70.3	0.000**
▪ Heart rhyme	9	15.0	51	85.0	54	90.0	6	10.0	49	81.7	11	18.3	81.4	0.000**
▪ Characteristics of normal and abnormal sinus rhythm	4	6.7	56	93.3	46	76.7	14	23.3	44	73.3	16	26.7	63.2	0.000**
▪ Cardiac arrhythmias	8	13.3	52	86.7	49	81.7	11	18.3	45	75.0	15	25.0	55.4	0.000**
▪ Total	8	13.3	52	86.7	51	85.0	9	15.0	48	80.0	12	20.0	87.9	0.000**

*Significant $p \leq 0.05$ **Highly significant $p \leq 0.01$

T: T paired Test

Table (3): Comparison among total mean scores of the studied nurses’ knowledge regarding ECG interpretation procedure throughout program phases (n=60)

Items		Pre	Post	3 months follow-up	F-test	P-Value
		$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$		
▪ Shubra Hospital	Un-satisfactory	12.3 ± 1.2	13.0 ± 1.4	12.6 ± 1.15	30.9	0.000**
	Satisfactory	22.6 ± 2.30	23.6 ± 1.1	23.6 ± 1.2		
	Total	13.9 ± 4.0	22.6 ± 3.4	22.0 ± 4.19		
▪ Embaba Hospital	Un-satisfactory	12. ± 0.48	12.6 ± 1.15	12.7 ± 0.95	26.1	0.000**
	Satisfactory	21.6 ± 2.51	23.7 ± 0.98	23.6 ± 1.25		
	Total	13.5 ± 3.61	22.0 ± 4.1	21.4 ± 4.61		
▪ Om-El Masreen Hospital	Un-satisfactory	12.0 ± 1.0	13.5 ± 2.3	13.2 ± 2.1	28.9	0.000**
	Satisfactory	21.0 ± 4.2	23.9 ± 0.25	23.8 ± 0.51		
	Total	12.9 ± 2.93	21.8 ± 4.3	21.2 ± 4.8		
Total	Un-satisfactory	12.1 ± 0.75	13.1 ± 1.6	12.9 ± 1.5	87.9	0.000**
	Satisfactory	21.8 ± 2.5	23.7 ± 0.90	23.7 ± 1.0		
	Total	13.4 ± 3.5	22.1 ± 3.97	21.5 ± 4.5		

*Significant p ≤ 0.05

**Highly significant p ≤ 0.01

F: ANOVA Test

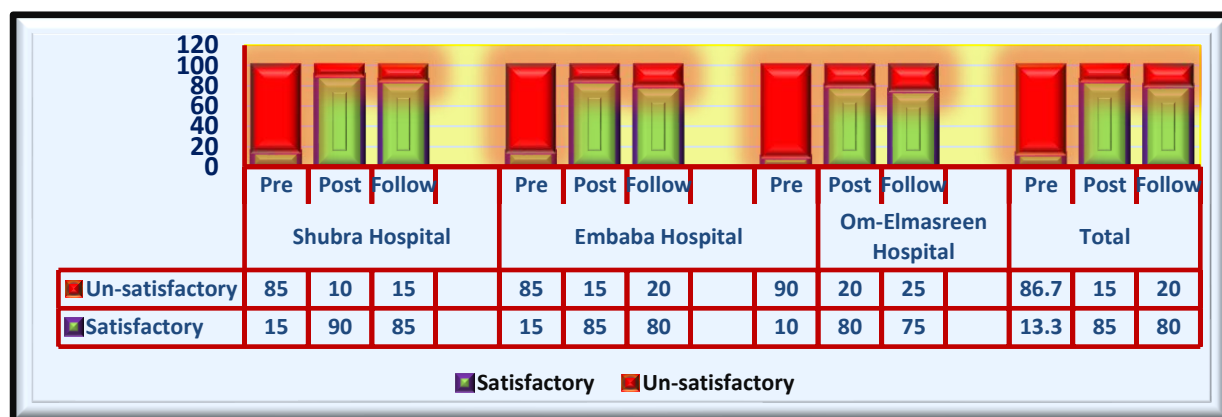


Figure (1): Percentage distribution of total levels of the studied nurses’ knowledge regarding ECG interpretation procedure during program phases (n=60).

Table (4): Comparison between levels of the studied nurses' practice regarding ECG interpretation procedure throughout program phases (n=60)

Items		Pre				Post				3 months follow-up				F-test	P- Value
		Competent		In-competent		Competent		In-competent		Competent		In-competent			
		F	%	F	%	F	%	F	%	F	%	F	%		
Pre-care	Patients and nurse preparation.	12	20.0	48	80.0	51	85.0	9	15.0	48	80.0	12	20.0	393	0.000**
	Equipment and environment preparation	44	73.3	16	26.7	57	95.0	3	5.0	54	90.0	6	10.0	8.03	0.000**
On-going care	Improving skin contact with the electrodes	18	30.0	42	70.0	51	85.0	9	15.0	48	80.0	12	20.0	12.9	0.000**
	Limb electrode and lead placement	29	48.3	31	51.7	52	86.7	8	13.3	49	81.7	11	18.3	6.82	0.000**
	Chest electrode and lead interpretation (V1 – V6)	18	30.0	42	70.0	54	90.0	6	10.0	50	83.3	10	16.7	18.3	0.000**
	Standard ECG machine settings	12	20.0	48	80.0	50	83.3	10	16.7	47	78.3	13	21.7	58.4	0.000**
	Recording the ECG trace	17	28.3	43	71.7	55	91.7	5	8.3	51	85.0	9	15.0	38.6	0.000**
Post care	Patient, equipment and environment preparation	29	48.3	31	51.7	59	98.3	1	1.7	52	86.7	8	13.3	46.2	0.000**
	ECG machine and lead care.	19	31.7	41	68.3	54	90.0	6	10.0	49	81.7	11	18.3	43.6	0.000**
	Label the ECG trace with the patient's details	21	35.0	39	65.0	51	85.0	9	15.0	49	81.7	11	18.3	31.8	0.000**
	Nurse care and Documentation	19	31.7	41	68.3	54	90.0	6	10.0	51	85.0	9	15.0	70.6	0.000**
Total		17	28.3	43	71.7	53	88.3	7	11.7	48	80.0	12	20.0	35.1	0.000**

*Significant $p \leq 0.05$ **Highly significant $p \leq 0.01$

F: ANOVA Test

Table (5): Comparison between total mean scores of the studied nurses’ practice regarding ECG interpretation procedure throughout program phases (n=60)

Items		Pre	Post	3 months follow-up	F-test	P-Value
		$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$		
▪ Shubra Hospital	In-competent	78.46 ± 9.7	91.00 ± 0.0	84.6 ± 7.2	16.1	0.000**
	Competent	109.4 ± 3.40	110.0 ± 3.7	109.6 ± 2.7		
	Total	89.30 ± 17.1	109.1 ± 5.58	105.9 ± 9.7		
▪ Embaba Hospital	In-competent	74.71 ± 10.6	87.5 ± 2.1	76.2 ± 9.91	14.1	0.000**
	Competent	107.3 ± 5.5	108.7 ± 3.87	106.1 ± 3.03		
	Total	84.5 ± 17.8	106.6 ± 7.50	100.1 ± 13.1		
▪ Om-El Masreen Hospital	Competent	71.0 ± 12.0	81.7 ± 8.9	58.4 ± 14.8	10.1	0.000**
	In-competent	106 ± 6.2	108.2 ± 2.3	103.8 ± 3.25		
	Total	78.0 ± 18.0	102.9 ± 11.6	92.4 ± 21.4		
Total	In-competent	74.49 ± 11.1	84.7 ± 7.4	70.92 ± 15.8	35.1	0.000**
	Competent	107.8 ± 4.8	109.0 ± 3.43	106.6 ± 3.8		
	Total	83.95 ± 18.0	106.2 ± 8.84	99.50 ± 16.3		

*Significant $p \leq 0.05$

**Highly significant $p \leq 0.01$

F: ANOVA Test

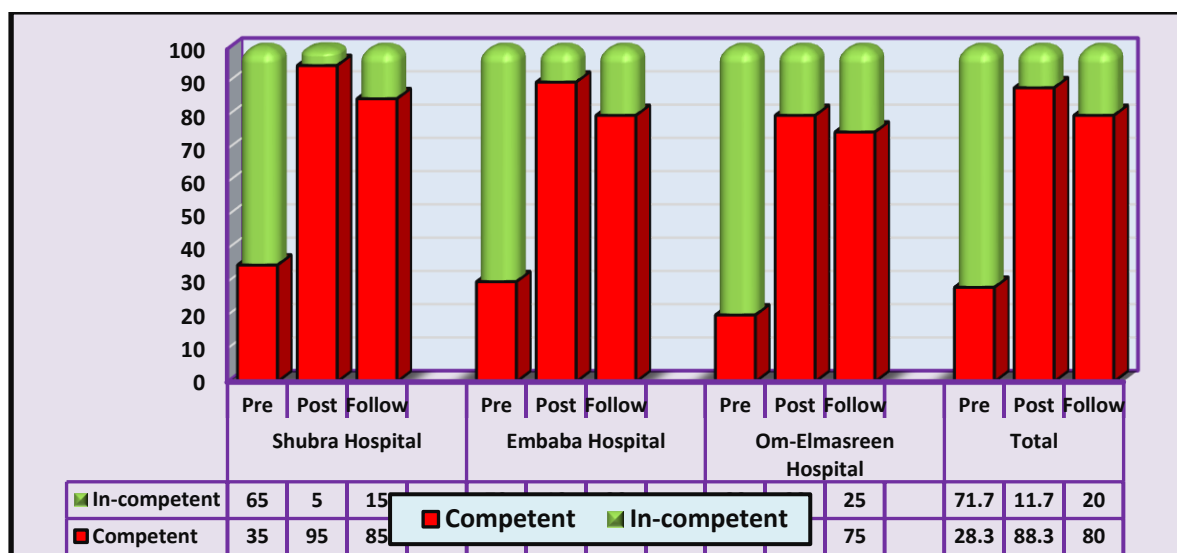


Figure (2): Percentage distribution of total levels of the studied nurses’ practice regarding ECG interpretation procedure throughout program phases (n=60)

Table (6): Effect size and η^2 of the competency training program on total levels of the studied nurses' knowledge and practices regarding ECG interpretation procedure throughout program phases (n=60)

Variables	η	η^2	Effect size
Total knowledge	0.706	0.499 ***	Large effect
Total Practice	0.533	0.284 ***	Large effect

*Significant $p \leq 0.05$ **Highly significant $p \leq 0.01$ F: ANOVA Test

Small effect size = 0.01 to < 0.06 Medium effect size = 0.06 to < 0.14 Large effect size ≥ 0.14

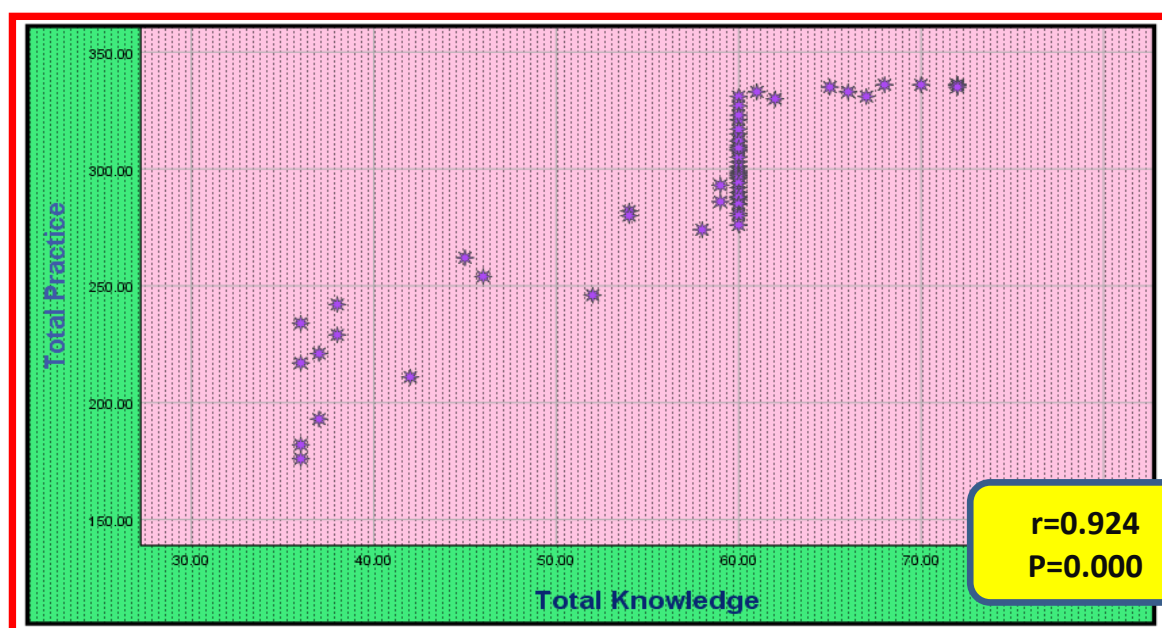


Figure (3): Scatter dot correlation between of the studied nurses' cumulative total knowledge and practices regarding ECG interpretation procedure throughout program phases (n=60)

Discussion

The electrical and muscular activities of the heart are regularly evaluated using an electrocardiogram (ECG), a diagnostic tool that is frequently utilized non-invasively. ECG is thought to be the initial diagnostic method for diagnosing chest discomfort and enables medical professionals to evaluate the dangers and symptoms. ECG has also been a focus of contemporary medicine due to its informational value in the diagnosis of cardiac arrhythmias and acute coronary syndromes (*Mahmood et al., 2023*).

Nurses are usually the first responders to in-hospital cardiac arrests. Therefore, they must master basic resuscitation skills. They should also be able to recognize basic ECG rhythms since they are responsible for monitoring and clinical decision-making based on the information obtained from the monitor. Early recognition of pathological electrocardiographic (ECG) trace is an important skill for nurses. Additionally, inappropriate interpretations, in turn, increase the cost of healthcare and can delay the admission process, which imposes an unpleasant burden on both hospitals and patients (*Rubbi et al., 2021*).

Regarding the personal characteristics of the studied nurses; the result demonstrated that approximately three-quarters of the age of the studied nurses were between twenty to less than thirty years old with a mean age of 25.95 ± 6.02 . This finding may be attributable to the fact that the majority of the nurses in the study were recently graduated and hired into the critical care units at a young age, which is required to tolerate the nature of CCU work as a specialty requires a young, qualified nurse for better nursing care offered and the capacity to tolerate working in the critical care units. This result agreed with what was reported by a descriptive research result conducted in the coronary care unit at Heart Hospital Assiut University by *Mohammed et al. (2020)* in a study titled "Assessment of nurse's knowledge and practices regarding the care of patients with cardiogenic shock" who stated that about half of study, nurses were under the age of thirty.

Concerning gender, the majority of the studied group are female with a male-to-female ratio is 1:9. This conclusion could be explained by the fact that more girls than males graduate from nursing schools in Egypt, where the majority of nurses work. In the same direction, a web-based cross-sectional study done among Japanese nurses provided evidence to corroborate these findings by *Nishiguchi et al., (2022)* who studied the "Effects of electrocardiographic monitoring education on nurses' confidence and psychological stress: an online cross-sectional survey in Japan", reported majority of the studied participant was female.

In relation to educational level, about one-half of the studied nurses held a secondary school degree, followed by more than one-third of them held a technical degree while the minority of them held a bachelor's certificate, which may be a result of their youth and ability to cope with the demands of the critical care unit's work. The study result was consistent with the findings of the study conducted by *Kabeya (2021)* which studied "Nurses' knowledge and practice on electrocardiogram lead placement and interpretation", revealed that about half of the nurses that were studied just had a diploma. Additionally, it stated that the participants' mean ages were thirty-three years old and that around two-thirds of them were female..

Considering years of experience, more than two-fifths of the studied nurses had a year of experience ranging from six to equal or less ten years with a mean \pm SD = 9.63 \pm 5.34. From the investigator's point of view, this conclusion could be explained by the fact that critical care units need highly skilled nursing staff who can handle the stress of the occupation, the severity of patients' situations, the long hours, and the occupational dangers that these units present.

Additionally, the study results were in agreement with a descriptive exploratory research study that was carried out at the coronary care unit of the Assiut University heart hospital by *Ali et al., (2022)* entitled thesis "Nurses' performance regarding electrocardiography application and its interpretation: Suggested nursing guideline", showed that nearly two-thirds of the nurses under study had experience equal or more than five years.

As well, the study finding was supported by a cross-sectional study published in the Malaysian Journal of Medicine and Health Sciences and conducted by *Ros et al., (2022)* which studied the "Critical care nurses' competency in electrocardiogram interpretation", revealed that year of working experience as a registered nurse ranged from 6 to less than 10 years. On the contrary, the study was incompatible with the study carried out by *Kabeya (2021)* which concluded that more than half of the participants worked from one to less than five years' experience.

In relation to attending training courses, most of the studied nurses did not attend training courses regarding mechanical ventilation. Finally, there is no statistically significant difference between the three hospitals in relation to personal characteristics as P value > 0.05.

On the line, The study's findings were consistent with *Batal et al., (2022)* who studied the "Effect of an educational program regarding cardiac arrhythmias on nurses' knowledge and practices in critical care units", demonstrating that none of them had any prior expertise in managing arrhythmias, and that more than three quadrants were made up of females under the age of thirty.

In contrast with the study finding, a comparative cross-sectional study performed by *Rubbi et al., (2021)* which evaluated "The skill of nursing students trained in the evaluation of electrocardiographic trace: A comparison with emergency nurses", showed that over 75% of the nurses in the study had taken ECG interpretation training.

Considering the level of knowledge regarding the electrocardiogram interpretation across program phases, the study result indicated that, a minority of the studied nurses gained a lower satisfactory level of knowledge regarding ECG interpretation. From the researchers' point of view, this can occur as a result of a lack of refresher courses on the use

and interpretation of ECGs as well as nurses' tiredness from an increase in workload, which might make it difficult for them to read and stay current on their expertise. In addition to the lack of concern from the authority and responsible persons for training the studied nurses before demonstrating the training contract with El-AMira Fatma, as well as shortage of time, financial resources, and increase workload.

A cross-sectional descriptive survey published at International Emergency Nursing conducted in Hong Kong by *Ho et al., (2021)* which "Analyzed the capability of emergency nurses for electrocardiogram interpretation", showed only one over eight of the studied participants answering all questions correctly regarding ECG interpretation.

In a similar line, the study's findings agreed with those of a cross-sectional research study carried out by *Giannetta et al., (2020)* which "Reviewed accuracy and knowledge in 12-lead ECG placement among nursing students and nurses", revealed to prevent incorrect interpretation, misdiagnosis, patient mismanagement, and/or improper procedures as a result of misplacing the 12 leads of an ECG, education is necessary.r.

Contrary, the study finding was discordance with the descriptive study result conducted on the registered nurses who worked in critical care units, including the intensive care unit, coronary care unit, emergency department, recovery department, and cardiology department by *Tahboub & Dal Yilmaz, (2019)* which studied thesis entitled "Nurses' knowledge and practices of electrocardiogram interpretation", who reported that nurses have a good degree of ECG training and experience.

Considering the level of knowledge regarding the electrocardiogram interpretation after the application of the competency training program for the studied nurses, the study result denominated that, more than four-fifths and more than three-quarters of the studied nurses gained a satisfactory level of knowledge regarding ECG interpretation at the post and follow-up application of the competency training program respectively.

This development shows how well the competency training program covered many facets of ECG interpretation. This outcome also reflects the nurses' desire to learn ECG interpretation because they are inexperienced nurses with no prior training. Moreover, there was a slight decline in the follow-up phase as compared with the post-program implementation phase. This finding may be attributed to the requirement that studied nurses be given the chance to reflect on and put new knowledge into practice, as doing so is crucial for solidifying and remembering theoretical learning.

Additionally, this data was in agreement with the study result conducted by *Batal et al., (2022)* which evaluated "The effect of an educational program regarding cardiac arrhythmias on nurses' knowledge and practices in critical care units", mentioned that a statistically significant difference between the three study phases, with more than three-

quarters of nurses having satisfactory total knowledge immediately following the implementation of an educational program as opposed to roughly one-tenth prior to and more than two-thirds at follow-up following the implementation of an educational program.

On the same line, the quasi-experimental research, executed by *Shehab et al., (2019)* which investigated "The effect of an educational program of electrocardiogram interpretation on medical and maternity nurses' knowledge and skills", reported that the majority sector of the study group had (general improvement) (satisfactory level of knowledge) in electrocardiogram interpretation in most items post-test phase compared to pre-test phase, decreased in the follow-up phase.

Moreover, this data was supported by the result of *Ko et al., (2022)* who "Assessed the effects of peer learning on nursing students' learning outcomes in electrocardiogram education", showed improved learning flow, interpretation knowledge in addition to skills and self-assurance following ECG training in comparison to before studying.

Regarding the total mean score of knowledge regarding ECG interpretation, the study result discusses that, compared to the phase of pre-application of the competency training programme, the study nurses' mean score of knowledge about ECG interpretation increased during the post-application of the competency training programme phase. This was followed by the phase of follow-up..

Moreover, there was a highly statistically significant difference between the total mean score of knowledge regarding ECG interpretation across the phases of the competency training program application among the studied nurses. Additionally, Shubra Hospital gained a higher mean score of knowledge regarding ECG interpretation, followed by Embaba Hospital as compared Om-Elmasreen Hospital during pre, post, and follow-up application of the competency training program.

The discrepancy in the mean score of knowledge between the three hospitals might be due to the differences in the availability of institutional policies and procedure guidelines, knowledge of nurses, continuing education, and equipment between the pre-mentioned hospitals.

Additionally, these findings were supported by a quasi-experimental study result, done by *Wen et al., (2022)* who "Investigated ECG teaching of arrhythmia for trainee nurses", and concluded that after training, the ECG test mean scores in the experimental group were significantly higher post-test than pre-test. Additionally, there were statistically significant differences between the total mean scores of the pre and post-test as regards nurses' knowledge regarding arrhythmia.

As well, the study finding was on the same line with *Baral et al., (2020)* who studied "The effectiveness of a nationwide interactive ECG teaching workshop for UK medical students", and reported that there were statistically significant differences between the total mean scores of the pre-and post-test knowledge scores. The study emphasized that a national ECG workshop that emphasizes activity-based learning was effective in improving the competency of medical students to interpret ECGs.

This section supported the 1st hypothesis that the mean post and follow-up test knowledge scores of the intensive care nurses' regarding the electrocardiogram interpretation will be statistically significantly higher than the mean pre-test knowledge scores.

As indicated by the study's findings when taking into account the level of practice regarding ECG procedure and interpretation at program time. A minority of the studied nurses acquired a lower competent level of practice in ECG placement procedure and ECG interpretation when the competency training program was being applied to them.

From the researcher's point of view, according to the study, this might be caused by a lack of anatomical awareness, an incorrect appraisal of anatomical landmarks, and a failure to recognize the effects of improper positioning, profession overlap, and subpar performance abilities. Additionally, the majority of nurses believed that ECG interpretation was outside the scope of their practice.

In the same vein, the systematic study result directed by *Hadjiantoni, (2020)* who studied "The correct anatomical placement of the electrocardiogram (made) electrodes essential to diagnosis in the clinical setting", concluded that the majority of nurses committed malpractice with reference to the clinical setting's crucial need for accurate anatomical placement of ECG electrode interposition. So in order to increase practice, educational intervention with required training is obligatory.

Moreover, the study finding was supported by a comparative study result by *Fålund et al., (2020)* who studied " The cardiovascular nurses' adherence to practice standards in-hospital telemetry monitoring", and summarized that a significant percentage of nurses are unsuccessful to follow the mentioned borders for electrode placement and skin preparedness.

As well, this data was supported the study result published in the British Journal of Cardiac Nursing by *Bickerton & Pooler (2019)* which reviewed "The misplaced ECG electrodes and the need for continuing training", and showed that electrode placement (EP) accuracy is not being adhered to standards and the recommended EP guidelines. It advised that obligatory relevant training and appraisal, including prior to an administrator being

permitted to obtain a precise standard 12-lead electrocardiograph recording (STLER) and refresher training for ECG operators, are desirable.

As well, this data was in the vein of a descriptive exploratory research study executed in the coronary care unit of Assiut University heart hospital by *Ali et al., (2022)*, which revealed that unsatisfactory pre-procedure care of electrocardiography application was practiced by half of the nurses. This is a result of nurses' overall disregard of several procedural preparation processes, including patient explanation of procedural stages and patient skin preparation, which involves washing electrode implantation areas and shaving off extra hair.. In the same direction, the study finding was compatible with the analytical cross-sectional study result carried out by *Kabeya (2021)*, which showed that more than two-thirds of the nurses under study had subpar practices for placing and interpreting ECG leads.

Additionally, a descriptive exploratory study result by *Malk (2018)* who evaluated "The nurses' practice regarding electrocardiogram procedures", illustrated that the majority of the nurses had an unsatisfactory practice regarding the pre-electrocardiogram procedure in relation to (Verifying the doctor's order, equipments preparation, confirming the patient's identity, explain the procedure to the patient, position the patient in the supine position, expose his arms and legs, cleanse the sites for electrode placement), during electrocardiogram procedure in relation to (Place the limb lead electrodes, place the four limb leads, expose the patient's chest, place chest leads following appropriate directions, connect the lead wires to the electrodes, check to see that the paper speed selector is set to the standard 25 mm/second) and post-electrocardiogram procedure in relation to (Post procedure remove the electrodes, clean the patient's skin, perform hand washing & documentation).

As well, this study's findings agreed with those of an online Italian survey conducted by *Giannetta et al., (2020)*, which revealed that nurses' competence in electrocardiogram performance and bedside cardio-monitoring is restricted; specifically in the domains: of "identification, measurement, and correction of the QT interval," "AV block," "detection of myocardial ischemia," and "correct lead placement.

Considering the level of the studied nurses' practice, the study result identified that respectively, nearly three-thirds and more than four-fifths of the studied nurses gained a competent level of practice regarding ECG placement procedure and ECG interpretation at the post and follow-up application of the competency training program. This may reflect the improvement of the competency training program. Additionally, this could be credited to the competency training program making refreshments in nurses' knowledge, which in turn leads to nurses' practice getting better. Moreover, there was a slight decline in the follow-up phase as compared with post-application of the competency training program.

This is interpreted that the majority of the studied nurses have no time to refresh nurses' knowledge which in turn will reflect in ECG interpretation practice.

On the same line, the quasi-experimental research performed by *Shehab et al., (2019)*, who reported that the majority sector of the study group had a satisfactory level of skill in the electrocardiogram interpretation in most items post-test phase compared to pre-test phase and decreased in the follow-up phase. As well, a quasi-experimental study results executed in the coronary care unit at Beni-Suef University Hospital by *Malk et al., (2022)*, who evaluated "The defibrillation training program and its effects on acquisition of nurses' knowledge and practice", and found concluded that the majority of the nurses had unacceptable understanding knowledge and skills about defibrillation with an obvious significant improvement immediately post-program application while this significant improvement marginally diminished at the post-three-month check-in phase.

Regarding the total mean score of practice regarding ECG placement procedure and ECG interpretation, the study result discusses that, the studied nurses gained a higher mean score of practice regarding ECG placement procedure and ECG interpretation at immediately post-test followed by the phase of follow-up results up from pre-application test results. Moreover, a highly statistically significant difference presented between the total mean score of practice regarding ECG placement procedure and ECG interpretation across pre, post, and 3 months follow-up among the studied nurses at $P = 0.000$. Additionally, Shubra Hospital gained a higher mean score of practice regarding ECG placement procedure and ECG interpretation, followed by Embaba Hospital as compared Om-Elmasreen Hospital (throughout program implementation phases).

Additionally, the researchers interpreted the difference between hospitals may be reflected as percentage of nurses with bachelor's degree and number of older nurses were higher in Shubra hospital followed by Embaba Hospital as compared Om-Elmasreen. This section supported the 2nd hypothesis that, the mean post and follow-up test practice scores of the intensive care nurses' regarding the electrocardiogram application and interpretation will be statistically significantly higher than the mean pre-test practice scores.

As well, the quasi-experimental study result applied by *Ismail et al., (2020)*, who studied "The effect of implementing an educational program about electrocardiography interpretation on internship nursing students' performance in Intensive Care Units", and found that the total practice score (about patient preparation and the ECG machine, identify the location of limb electrode, identify the location of chest electrode, obtain a rhythm strip in the patient record, and identify immediately life-threatening abnormalities) was lower at the time of pre-program implementation, improved right away after program application,

and slightly decreased at the three-month follow-up phase with a statistically significant difference.

The study's findings also agreed with those of a quasi-experimental (pre/post-test) study conducted under the supervision of *Bdair (2022)* who "Analyzed electrocardiogram interpretation competency among undergraduate nurses", and confirmed that nurses who are enrolled in educational programmes had overall mean ECG competency ratings that were higher at the post-test than they were at the pre-test. The study emphasised the importance of nurses' training and education in ECG interpretation skills to ensure safe practice.

In relation to the effect size of the competency training program on nurses, the study result reveals that this program had a positive large effect size on total knowledge and practices regarding ECG placement procedure and interpretation throughout the studied nurses' competency training program phases. In the same vein, the study result carried out by *Subramaniam et al., (2022)*, who analyzed the impact of cardiac life support training on retention of knowledge measured by pre-test, immediate post-test, and 6-month post-test, concluded that the cardiac life support training had positive substantial influence or large effect size on retention of knowledge.

On the same line, the study results by *Awed et al., (2022)*, which evaluated "The effect of the nursing protocol of care on health-related outcomes for patients undergoing permanent pacemaker implants", and concluded that, the nursing protocol of care had a positive large effect size on health-related outcomes for patients. This section supported the 3rd hypothesis that there will be a substantial influence with a large effect size on nurses' knowledge and practice throughout the competency training program implementation.

From a statistical standpoint, a highly significant positive correlation presented between cumulative total knowledge and practice regarding ECG interpretation and ECG placement procedure during the phases of competency training program application among the studied nurses. This has been explained as knowledge and its implementation in clinical practice are most valuable for retention. So, knowledge alone without practice has no effect. So, improving nurses' knowledge through competency training programs could enhance their knowledge and consequently improve their practice.

Additionally, the study's findings were consistent with *Metwaly et al., (2021)*, who reviewed "The effect of training programs on nurses' knowledge and practice regarding patients with cardiac arrhythmias" in cardiac intensive care units at Zagazig University Hospitals, and discovered a highly statistically significant positive association between the overall cumulative knowledge of cardiac arrhythmias and practice..

As well, the current study results in the same direction as a descriptive research study carried out at cardiac and general intensive care units affiliated with Ain-Shams University Hospitals by **Fekry *et al.*, (2020)** which studied “Nurses' performance regarding life threatening ventricular dysrhythmias among critically ill patients”, and found a statistical significant relation between nurses' total practice and knowledge in emergency management of life threatening ventricular dysrhythmias with p-value at 0.03.

On the other hand, the quasi-experimental study result conducted by **Ismail *et al.*, (2020)** which reported that, before the start of the instructional program, no real association was seen. This portion backed up the 4th hypothesis, according to which there is a link between nurses' practice and understanding of ECG placement application interpretation.

Conclusion:

Based on the findings of the present study, the researchers found the study results reinforced the study hypothesis and concluded that the majority of the studied nurses gained a higher satisfaction level immediately at the post-test phase which decreased to four-fifth after three months follow-up tests up from the minority of nurses at pre-program implementation test. As well, the majority of the studied nurses had advanced competent levels immediately at the post-test phase which diminished to four-fifth after three months through follow-up tests paralleled with nearly one-quarter of nurses at the pre-program implementation test. Furthermore, the competency training program had a positive large effect size on total knowledge and practices regarding electrocardiogram interpretation and procedure with a highly statistically significant difference between the total mean score of the studied nurses' knowledge regarding electrocardiogram interpretation and practice regarding electrocardiogram placement procedure across the competency training program.

Recommendations:

The following suggestions can be made based on the current study's findings:

- Future researches are requisite to create the Public Hospital nurses competency regarding ECG skilful handling and interpretation.
- Establish and manage a diverse team strategy for providing continuous evaluation of ECG recording and interpretation.
- Create a generic self-instructional program on nursing interventions for expert placement and interpretation of electrocardiograms with various clinical cardiovascular problems.

- Design educational programs written in Arabic and implement regular updating of nurses' knowledge regarding common ECG abnormalities and prerequisite nursing intervention.

References

1. Ali, I.M., Ahmed, A. E. A., & Ebraheim, M.N. (2022). Nurses' Performance Regarding Electrocardiography Application and Its Interpretation: Suggested nursing Guideline. *Egyptian Journal of Health Care*, 13(4), 281-295.
2. Aljohani, M.S. (2022): Competency in ECG Interpretation and Arrhythmias Management among Critical Care Nurses in Saudi Arabia: A Cross Sectional Study. *Healthcare* 2022, 10, 2576. <https://doi.org/10.3390/healthcare10122576>
3. Amini, K., Mirzaei, A., Hosseini, M., Zandian, H., Azizpour, I., Haghi, Y. (2022): Assessment of Electrocardiogram Interpretation Competency among Healthcare Professionals and Students of Ardabil University of Medical Sciences: a multidisciplinary study. *BMC Med Educ.* Jun 9;22(1):448. doi: 10.1186/s12909-022-03518-0. PMID: 35681191; PMCID: PMC9179219.
4. Awad, W.H.A., El Gammal, W.E.A., Aly, A.A., & Abd Elrhman, S.H.M. (2022). Effect of the Nursing Protocol of Care on Health-Related Outcomes for Patients Undergoing Permanent Pacemaker Implant. *Egyptian Journal of Health Care*, 13(4), 815-833.
5. Baral, R., Murphy, D. C., Mahmood, A., & Vassiliou, V. S. (2020). The Effectiveness of A Nationwide Interactive ECG Teaching Workshop for UK Medical Students. *Journal of Electro cardiology*, 58, 74-79.
6. Batal, M. E., Mohammad, S. Y., & Sobeh, D. E. (2022). Effect of an Educational Program Regarding Cardiac Arrhythmias on Nurses' Knowledge and Practices in Critical Care Units. *Evidence-Based Nursing Research*, 5(2), 23-34.
7. Bdair, I.A. (2022). Electrocardiogram Interpretation Competency among Undergraduate Nursing Students: A Quasi-Experimental Study; Wiley online library; November/December; [Volume 57, Issue 6](#), Pages 1273-1280 available at <https://onlinelibrary.wiley.com/doi/full/10.1111/nuf.12790#nuf12790-bib-0006>
8. Bickerton, M., & Pooler, A. (2019). Misplaced ECG Electrodes and The Need for Continuing Training. *British Journal of Cardiac Nursing*, 14(3), 123-132.
9. Chen, Y., Kunst, E., Nasrawi, D., Massey, D., Johnston, A.N., and Keller, K. (2022). Nurses' Competency in Electrocardiogram Interpretation in Acute Care Settings: a systematic review. *J Adv Nurs.*; 00:1–22. <https://doi.org/10.1111/jan.15147>.
10. Fållun, N., Oterhals, K., Pettersen, T., Brørs, G., Olsen, S.S., Norekvål, T. M., & TELMON-NOR investigators. (2020). Cardiovascular Nurses' Adherence to Practice Standards in In-Hospital Telemetry Monitoring. *Nursing in Critical Care*, 25(1), 37-44.
11. Fekry, A.A.F., Taha, N.M., & Metwaly, E.A. (2020). Nurses' Performance Regarding Life Threatening Ventricular Dysrhythmias among Critically Ill Patients. *Egyptian Journal of Health Care*, 11(1), 101-114.
12. Giannetta, N., Campagna, G., Di Muzio, F., Di Simone, E., Dionisi, S., & Di Muzio, M. (2020). Accuracy and Knowledge in 12-Lead ECG Placement among Nursing Students and Nurses: A web-based Italian study. *Acta Bio Medica: Atenei Parmensis*, 91(Suppl 12).
13. Hadjiantoni, A.S. (2020). Is the Correct Anatomical Placement of the Electrocardiogram (ECG) Electrodes Essential to Diagnosis in the Clinical Setting A Systematic Review. DOI: <https://doi.org/10.21203/rs.3.rs-74147/v1>
14. Ho, J. K. M., Yau, C. H. Y., Wong, C. Y., & Tsui, J. S. S. (2021). Capability of Emergency Nurses for Electrocardiogram Interpretation. *International emergency nursing*, 54, 100953.

15. Ismail, A.J., Younis, G. A. & Ahmed, S. E. S. (2020). Effect of Implementing Educational Program about Electrocardiography Interpretation on Internship Nursing Students' Performance at Intensive Care Units. *International Journal of Novel Research in Healthcare and Nursing*. Vol. 7, Issue 1, pp: (361-374),
16. Kabeya, L. D. (2021). Nurses' Knowledge and Practice on Electrocardiogram Lead Placement and Interpretation at Three Consultant Hospitals in Dar Es Salaam, Tanzania (Doctoral dissertation, Muhimbili University of Health and Allied Sciences). @ <http://dspace.muhas.ac.tz:8080/xmlui/bitstream/handle/123456789/3096/Kabeya,%202021.pdf?sequence=1>
17. Kashou, A., May, A., DeSimone, C., and Noseworthy, P. (2020). The Essential Skill of ECG Interpretation: How Do We Define and Improve Competency? *Postgrad Med J.*;96(1133):125–127. <https://doi.org/10.1136/postgradmedj-2019-137191>.
18. Ko, Y., Issenberg, S.B., & Roh, Y.S. (2022). Effects of Peer Learning on Nursing Students' Learning Outcomes in Electrocardiogram Education. *Nurse education today*, 108, 105182.
19. Mahmood, D., Riaz, H.N., & Nisar, H. (2023). Introduction to Non-Invasive Biomedical Signals for Healthcare. In *Advances in Non-Invasive Biomedical Signal Sensing and Processing with Machine Learning* (pp. 1-24). Cham: Springer International Publishing. @ https://link.springer.com/chapter/10.1007/978-3-031-23239-8_1.
20. Malk R ,N (2018).Evaluation of Nurses Practice Regarding Electrocardiogram Procedure. *Sumerianz Journal of Medical and Healthcare*, Vol. 1, No. 1, pp. 24-30
21. Malk, R.N, Shrief, S.E., & Soutan, A.A.A. (2022). Defibrillation Training Program and Its Effects on Acquisition of Nurses Knowledge and Practice. *Egyptian Journal of Health Care*, 13(3), 795-808.
22. [McCombes](#), Sh. (2023). Sampling Methods | Types, Techniques & Examples; March 27, available at <https://www.scribbr.com/methodology/sampling-methods/>
23. [Melvin](#), E. (2018). Getting Started With Competency-Based Training (CBT); *E Learning Industry*; June 9, available at <https://elearningindustry.com/competency-based-training-cbt-getting-started>
24. Metwaly, E.A., Bayomi, R.R., & Taha, N.M. (2021). Effect of Training Program on Nurses' Knowledge and Practice Regarding Patients with Cardiac Arrhythmias. *Assiut Scientific Nursing Journal*, 9(26.), 52-61.
25. Mobrad, A. (2020). Electrocardiogram Interpretation Competency Among Paramedic Students. *J Multidiscip Healthc.* 2020 Aug 19;13:823-828. doi: 10.2147/JMDH.S273132. PMID: 32884280; PMCID: PMC7443414.
26. Nishiguchi, S., Sugaya, N., Saigusa, Y., Mayama, M., Moromizato, T., Inamori, M., & Watari, T. (2022). Effects of Electrocardiographic Monitoring Education on Nurses' Confidence and Psychological Stress: An Online Cross-Sectional Survey in Japan. *International Journal of Environmental Research and Public Health*, 19(8), 4742.
27. Penalo, L., Pusic, M., Friedman, J.L., Rosenzweig, B.P. and Lorin, J.D. (2021). Importance Ranking of Electrocardiogram Rhythms: a primer for curriculum development. *J Emerg Nurs.*; 47(2):313–20. <https://doi.org/10.1016/j.jen.2020.11.005>.
28. Pereira, L. (2021): Teaching Behavioural Competency with High Quality Content; June 21, available at <https://emtrain.com/blog/unconscious-bias/behavioral-competency>
29. Pueyo-Garrigues, M., Pardavila-Belio, M.I., Canga-Armayorb, A., Esandib, N., Alfaro-Díazb, C., Canga-Armayora, N. (2022). NURSES' Knowledge, Skills and Personal Attributes for Providing Competent Health Education Practice, and Its Influencing Factors: A cross-sectional study; [Nurse Education in Practice](#); [Volume 58](#), January 2022, 103277. Available at <https://www.sciencedirect.com/science/article/pii/S1471595321003139>
30. Rahimpour, M., Shahbazi, S., Ghafourifard, M., Gilani, N., Breen, C. (2021). Electrocardiogram Interpretation Competency among Emergency Nurses and Emergency Medical Service (EMS) Personnel: A Cross-Sectional And Comparative Descriptive Study. *Nursing Open*; 8(4):1712–9. <https://doi.org/10.1002/nop2.809>.
31. Ribeiro, A.H., Ribeiro, M.H., Paixão, G.M.M., (2020). Automatic Diagnosis of The 12-Lead ECG Using A Deep Neural Network. *Nat Commun.*; September 12; 11:1760. <https://doi.org/10.1038/s41467-020-15432-4>.

32. Ros, S.C., Isa, R., Fauzi, R., Isa, S.N., & Mansor, W.A.W. (2022). Critical Care Nurses' Competency in Electrocardiogram Interpretation: A Cross-Sectional Study. *Malaysian Journal of Medicine and Health Sciences*, 18(SUPP15): 124-131.
33. Rubbi, I., Carvello, M., Bassi, V., Triglia, C., Cremonini, V., Artioli, G., & Ferri, P. (2021). The skill of nursing students trained in the evaluation of electrocardiographic trace: a comparison with emergency nurses. *ACTA BIOMEDICA*, 92(Suppl 2), 1-8.
34. [Salcedo, J.](#) & [McCormick, K.](#) (2021). *SPSS Statistics for Dummies*; 4th Edition; Kindle Edition; Amazon.com Services LLC. Available at https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKewi39qb3oZn1AhXU5-www.amazon.com%2FSPSS-Beginners-Minutes-Interpretation-Statistical-ebook%2Fdp%2FB09K6VTDC3&usq=AOvVaw2Gtw9tzyTzuuiwb_az9o_3
35. [Sasikala, K.](#) (2019). Effect of Structured Teaching Programme on Knowledge, Interpretation of Electrocardiogram (ECG) Among Critical Care Nurses, at Selected Wards of Sri Ramakrishna Hospital, Coimbatore; *International Journal of Cardiovascular Nursing*; [Vol 5, No 1](#). DOI: <https://doi.org/10.37628/ijcn.v5i1.1011>
36. Shehab, M.S., Helmy, E.N.M., & Ali, M. R. (2019). Effect of an Educational Program of Electrocardiogram Interpretation on Medical and Maternity Nurses' Knowledge and Skills. *IOSR Journal of Nursing and Health Science*, 8(4), 69-78.
37. Sqalli M.T., Al-Thani, D., Elshazly M.B., Al-Hijji, M., Alahmadi, A., Houssaini, S.Y. (2022). Understanding Cardiology Practitioners' Interpretations of Electrocardiograms: An Eye-Tracking Study; *JMIR Hum Factors*; 9(1): e34058. doi: [10.2196/34058](https://doi.org/10.2196/34058) PMID: [35138258](https://pubmed.ncbi.nlm.nih.gov/35138258/) PMCID: [8867292](https://pubmed.ncbi.nlm.nih.gov/8867292/)
38. Subramaniam, T., Hassan, S., Tan, A.J., Rahman, A., Ramlah, S., & Tay, J.S. (2022). Impact of Cardiac Life Support Training on Retention of Knowledge Measured by Pre-test, Immediate Post-test, And 6-Months Post-test. *International E-Journal of Science, Medicine & Education*, 169(2).
39. Tahboub, O.Y. & Dal Yilmaz, U. (2019). Nurses' Knowledge and Practices of Electrocardiogram Interpretation. *International cardiovascular research journal*, 13(3).
40. Tahboub, O.Y.H. and Dal-Yilmaz, Ü. (2019). Nurses' Knowledge and Practices of Electrocardiogram Interpretation. *Int Cardiovasc Res J.*; July 23,; 13(3):80–4. Available at <https://brieflands.com/articles/ircrj-91025.html>
41. Wen, H., Hong, M., Chen, F., Jiang, X., Zhang, R., Zeng, J., & Chen, Y. (2022). CRISP Method with Flipped Classroom Approach in ECG Teaching of Arrhythmia for Trainee Nurses: A Randomized Controlled Study. *BMC Medical Education*, 22(1), 1-9.
42. World Health Organization (2022). Cardiovascular Diseases (CVDs); accessed December, 31 available at [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds))
43. World Health Ranking (2022): Pedal It out to Bring Egypt's Heart Beat Back, accessed December 31, available at <https://www.worldlifeexpectancy.com/egypt-coronary-heart-disease>.

الملخص العربي

فاعلية برنامج تدريب الكفاءة على أداء ترميز العناية المركزة فيما يتعلق بتحليل مخطط كهربية القلب.

المقدمة: من أهم المهارات العلاجية التي تساعد في الكشف السريع عن أمراض القلب والأوعية الدموية التي يمكن أن تكون قاتلة هو تحليل مخطط كهربية القلب. لذلك يجب أن يكون لدى الممرضات برنامج تدريبي للكفاءة مع محتوى عالي الجودة من المعرفة والمهارات لتقديم تحليل وإجراءات تخطيط كهربية القلب بشكل صحيح مما يؤدي إلى أحكام ذات تأثيرات إيجابية.

الهدف: تهدف الدراسة إلى تقييم فاعلية برنامج تدريب الكفاءات على أداء ممرضات العناية المركزة فيما يتعلق بتحليل مخطط كهربية القلب. **التصميم:** أجريت دراسة شبة تجريبية. **المكان:** أجريت الدراسة في ثلاثة مستشفيات عامة مرتبطة بوحدات العناية المركزة بوزارة الصحة. **العينة:** تم اختيار عينة هادفة تشمل 60 ممرضا تم توزيعهم في الموقع المذكور. **الأدوات:** (1) استبيان المعرفة المهيكلة للتمريض وقائمة ملاحظة الكفاءة العملية لمهارات تخطيط القلب. **النتائج:** أوضحت الدراسة أن 85% من معرفة التمريض الخاضعين للدراسة قد تحسنت إلى مستوى مرضي. والذي إنخفض إلى 80% في اختبار المتابعة، ومع ذلك كان مرتفعاً عن 13.3% في الاختبار الأولي، بالإضافة إلى ذلك، كان لدى مستشفى شبرا متوسط درجات أعلى من المعرفة (4.0 ± 13.9 ، 3.4 ± 22.6 ، 4.19 ± 22.0) يليها مستشفى امبابية (13.5 ± 21.2 ، 3.61 ± 22.0 & 4.1 ± 21.4) ارتفاعاً عن مستشفى أم المصريين (2.93 ± 12.9 ، 4.3 ± 21.8 ، 21.2 ± 4.8) خلال مراحل تنفيذ البرنامج.

الخلاصة: كان لبرنامج تدريب الكفاءات حجم تأثير إيجابي كبير على إجمالي المعرفة والممارسات المتعلقة بتحليل وإجراءات مخطط كهربية القلب خلال مراحل البرنامج بين التمريض الخاضعين للدراسة عند ($\eta^2 = 0.499$, & $r = 0.284$ ، مع وجود ارتباط إيجابي ذي دلالة إحصائية عالية بين المجموع التراكمي للمعرفة والممارسة عند قيمة $P = 0.000$ & 0.924).

التوصيات: إنشاء برنامج تعليمي ذاتي عام حول التدخلات التمريضية لإجراء مخطط كهربية القلب وتحليلها فيما يتعلق بمختلف اضطرابات القلب والأوعية الدموية.

مفاتيح الكلمات: برنامج تدريب الكفاءات، مخطط كهربية القلب، الإجراءات، التحليل، أداء الممرضات.