# Effect of Electronic Learning Package Application on Nurses' Knowledge and Practice Regarding Post Cardio Pulmonary Resuscitation for Critically Ill Neonates

**Rawia Abd El-ghany Mohamed [1] ,Ghada.A.Hassan [2] , Hanan Elsayed Metwally [3],**

[1]Assisstant Professor of Pediatric Nursing, Faculty of Nursing, Benha University, Egypt.
[2] Assisstant Professor of Pediatric Nursing, Faculty of Nursing,Menufia University,Egypt.
[3]Lecturer of Pediatric Nursing, Faculty of Nursing, Benha University, Egypt.

## Abstract

**Context:** Effective post cardiac arrest care results from successful resuscitation that can evolve in the days to weeks following the return of sustained circulation. So, electronic learning has grown tremendously and is now integrated into nursing education. **Aim:** Evaluate the effect of electronic learning package application on nurses' knowledge and practice regarding post cardio pulmonary resuscitation for critically ill neonates. **Methods:** The current study was conducted using a quasi-experimental design. **Setting:** This study was conducted at NICUs at Benha University Hospital in Benha city. **Sampling:** A convenient sample of 70 nurses from the previously mentioned settings was included in the current study regardless of their personal characteristics. **Study tools:** There were two tools used**,** Tool I: a structured interviewing questionnaire. Tool II: An observational checklist to assess nurses' practice regarding post cardio pulmonary resuscitation for critically ill neonates. **Results:** There was a positive correlation between total nurses' knowledge and practice scores post electronic learning package application. **Conclusion:** It can be concluded that, electronic learning package application had a positive effect on nurses' knowledge and practice level, which indicates that, the electronic learning package application is greatly effective. **Recommendation:** The study recommended that, an updated electronic learning and training programs should be periodically carried out with numerous teaching methods for nurses in NICUs for improving their performance regarding post cardio pulmonary resuscitation.

**Keywords***:* Critically ill neonates, Electronic learning package, Nurses' knowledge and practice, Post cardio pulmonary resuscitation.

## Introduction

Critically ill neonates who require cardiopulmonary resuscitation could deteriorate later. Once proper ventilation and circulation have been established, the neonate should be transferred to close monitoring, and proactive measures can be provided. Also, improving health post cardiac arrest is depends mainly on the quality of resuscitative care ***(Perkins et al., 2021*)**.

Post resuscitation care means optimization of ventilation and circulation, preserve organ, tissue function and maintain optimal blood glucose levels. Continuous cardiac monitoring and pulse oximetry should be introduced to recognize tissue oxygenation and perfusion and serve as a guide for extra resuscitative care. However, successful nursing care post cardio pulmonary resuscitation depends on the nurses' knowledge and skills ***(Starodub et al., 2020)*.**

Priorities post cardio pulmonary resuscitation includes constant assessment of the resuscitation and stabilization, defining and managing the etiology of arrest. Furthermore, a post-cardiac arrest reevaluation is very important for assessing the competence of pulse, perfusion, blood pressure, oxygenation and ventilation. Also, the

nurse has a vital role in post cardio pulmonary resuscitation monitoring such as constant cardiac monitoring, end tidal carbon dioxide measurement, and brain neurological monitoring ***(Aaron et al., 2021).***

The post cardio pulmonary resuscitation complications include systemic ischemia and myocardial dysfunction. In addition, post cardio pulmonary resuscitation brain injury is considered a prominent complication that causes morbidity and mortality in neonates because the brain has an imperfect tolerance for ischemia, or edema. So, neonatal post cardio pulmonary resuscitation care centers on expecting and recognizing this multifaceted physiology to increase survival and neurological outcomes ***(Topjian et al., 2019)*.**

Functional assessment for physical and non-physical injuries before hospital discharge is very important to detect the need for rehabilitation early and direct referral. Also, organizing follow-up care for cardiac arrest neonates within three months after hospital discharge, including screening for cognitive complications, and providing support for family ***(Nolan et al., 2021)***

E-learning package is a compilation of materials that contain guidance for the learner in numerous formats such as text, animation, image, and video to promote interaction with the scientific content being presented, create an interactive environment for learning, and facilitate active learning to generate novel knowledge and change the preceding attitudes ***(Abozed et al., 2020).***

Electronic learning is a training mode provided by a computer or other digital devices which allows technology to facilitate learning anytime and anywhere. Advantages of e-learning including; training can be delivered faster in a short period of time, easy simple updating of practice, objectives, assessment, feedback, and other positive features of a learning environment ***(Salema et al., 2021)***

Benefits of e-Learning for nurses include; interactive learning, innovative teaching, promoting self-directed learning, enjoying the expediency and flexibility to work on own time, reinforce virtual communication skills, access a wide variety of educational decisions, be a resource of up-to-date knowledge , safe time and place for learning, enable to enhance data-search by hyperlinks, self-paced learning, availability of help when needed, promote internet use; and building responsibility and self-confidence ***(Preventive Cardiovascular Nurses Association, 2018).***

Electronic learning refers to a learning system that can be attained via internet using an electronic device. The American Society of Training and Development defines electronic learning as a wide set of applications and processes, such as web-based learning, computer-based learning, virtual classrooms, and digital cooperation. Furthermore, digital learning represents opportunities to enhance resuscitation training, which may develop learning outcomes ***(Cheng et al., 2020).***

Electronic mail utilization in teaching and learning is considered one of electronic learning methods. The advantage of email is the simplicity of message storage and retrieval, which is used successfully in teaching. So, all course participants must be able to use it successfully and confidently ***(Barnes, 2021).***

Discussion board participation is very effective for encouraging meaningful discussion**.** However, discussion board is one of the most controversial basics of online learning. It should be designed and managed soundly, to help the learners complete the points and then not forget about it ***(Smith, 2021).***

All over the world, the internet has got vast connectivity growth. Online video learning is widely used in nursing education. Nurses in the online video training showed much more adaptability in their goals and intentions when engaging with video**.** Besides that, online video provides more benefits as compared to the traditional learning ***(Seo et al., 2021).***

A recorded PowerPoint slide contains pictures, graphs, diagrams, and bullet points. It increases the memory capacity of the mind. It also helps learners remember information for a long time. Also, it can enhance the intellect of them. Different fonts, visual effects, and highlighting can help students learn new information quicker. Using it is very simple and easy. The PowerPoint provides different audio and visual tools. Its

point-to-point explanation method makes difficult concepts easier ***(Liu et al., 2020).***

The most interactive, motivational, and self-deterministic form of e-learning for nurse education represents virtual lab training, which incorporate the narrative pedagogy framework and the real world, where they can hone their skills with standard procedures ***(Goceda, 2020).***

## 2. Significance of the Study

Mortality rates post-cardiac arrest remains high post initial resuscitation and a return of natural circulation. Several factors must be addressed to optimize survival and to prevent subsequent deterioration and organ dysfunction and neurologic sequelae. Continuing physiology that may lead to arrest must also be addressed as hypoxia, acidosis, hypo or hyperkalemia ***(Aaron et al., 2021).***

Recent studies have reported that the risk of poor neurodevelopmental outcomes remain high. Also, there are no studies that describe the incidence of common post-arrest morbidities in the neonatal population such as temperature instability, myocardial dysfunction, oxygenation and ventilation abnormalities, acute kidney injury, and how these affect outcomes ***(Haggerty et al., 2020).***

So, Several factors regarding pediatric post-cardiac arrest training need to be addressed in order to optimize neonatal survival and prevent organ dysfunction.

## Aim of the study

The present study aimed to evaluate the effect of electronic learning package application on nurses' knowledge and practice regarding post cardio pulmonary resuscitation for critically ill neonates through:

- Assessing nurses' knowledge and practice regarding post cardio pulmonary resuscitation for critically ill neonates.
- Designing and implementing electronic learning package application regarding post cardio pulmonary resuscitation for critically ill neonates based on the nurses' actual needs.
- Evaluating the effect of electronic learning package application on nurses' knowledge and practice regarding post cardio pulmonary resuscitation for critically ill neonates.

### 3.1. Research hypotheses

1- Nurses who will receive an electronic learning package application are expected to have improvement in their knowledge and practice regarding post cardiac arrest for critically ill neonates.

2- There will be a significant relationship between the nurses' knowledge, practice and their personal characteristics.

## Subject & Methods

### *Research design*

The current study was conducted using a quasi-experimental design.

### *Research settings*

The current study was carried out in Neonatal Intensive Care Units (NICUs) at Benha University Hospital in Benha city. The NICUs at Benha University Hospital placed on the fourth floor which composed of three rooms, the first room composed of (12) incubators, the second room has (7) incubators, and the third room contains (5) incubators.

### Subject

A convenient sample of 70 nurses who work in previously mentioned study setting were included in the study. The sample size was calculated by the following formula assumptions: Z1 (95% confidence interval) = 1.96, Z2 (80% test power) = 0.84, S = estimation of the standard deviation score for each variable and d = 0.70.

### 4.4. Tools of data collection

The following two tools were used to collect data required to the current study:

### Tool I: A structured interview questionnaire:

This tool was developed by the researchers after reviewing scientific and relevant literature as ***Korioth & Writer (2020) & Perkins et al.,***

***(2021) & Aaron et al., (2021).*** It was written in an Arabic language and composed of 3 parts:

***Part I:*** **Nurses' characteristics such as;** age, gender, academic qualifications, years of experience at NICU, and attendance of previous training courses about post cardio pulmonary resuscitation for critically ill neonates.

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***Part 2:*** **Neonates' characteristics** as; age, gender, the current weight, gestational age and medical diagnosis.

***Part 3:*** **Nurses' knowledge** concerning post cardio pulmonary resuscitation for critically ill neonates. It consisted of (37) questions in the form of multiple choice includes; neonatal life support concepts (5), the features of post cardio pulmonary resuscitation (1), new and updated neonatal algorithms (4), general monitoring (5), neurological monitoring (3), early hemodynamic monitoring (2), oxygenation and ventilation (2), post cardio pulmonary resuscitation treatment (3), glucose control after resuscitation (1), thermal care (1) neurophysiological and neuroimaging tests(2), frequency of post cardio pulmonary resuscitation reevaluation(2), the critical considerations in post cardio pulmonary resuscitation management (1), long term outcomes(2), post cardio pulmonary resuscitation transport(1), prognosis (2).

**The scoring system** for nurses' knowledge was evaluated post the fulfillment of the interview questionnaire sheet. The nurses' knowledge was checked with the predesigned model answer. Hence, the score is (1) for the correct answers and (0) for incorrect or do not know answers. The total score ranged from 0-37.

Nurses' total knowledge was categorized as ≥75% was considered a good level of knowledge, a score of 60>75% which considered an average level of knowledge, and nurses who had a score of <60% which was considered as a poor level of knowledge.

**Tool II: An observation checklist for nurses' practice**

It was designed by the researchers based on ***Pothiawala, (2017); Topjian et al., (2019) & Nolan et al., (2021)*** to assess nurses' practice regarding post cardio pulmonary resuscitation for critically ill neonates. It involved the procedure of post cardio pulmonary resuscitation including; immediate post cardio pulmonary resuscitation care (5 steps), airway management after restoring spontaneous circulation (6 steps), control of oxygenation (4 steps), and control of ventilation (5 steps), hemodynamic monitoring and management (8 steps) multimodal prognosis assessment with an exact clinical examination (2 steps), general intensive care management (7 steps), targeted temperature management (4 steps), recovery position (4 steps) and perform functional assessment of physical and non-physical injuries before hospital discharge (2 steps).

**Scoring system for nurses' practice:**

A score of (1) was given for correctly done, and not done was scored (0). The total score fluctuated from 0-43. Total practice are transformed into percentage scores, where a score of ≥ 90% was considered competent practice and a score < 90% was considered incompetent practice.

***Procedures***

**Preparatory phase:**

This phase included reviewing the local and international related literature and recent studies to get acquainted with the several aspects of the study and developing the study tools via using periodicals, books, and magazines of mark references. During this phase the researchers prepared the content of electronic learning package that used for nurses' teaching. This period started from the beginning of April 2021 to the end of May 2021.

**Content validity and reliability:**

The study tools validity was assessed and reviewed by a panel of three experts in field of pediatric nursing to test the clarity, sequence of items, relevance, and applicability of the tools. Modifications were accordingly done based on their judgement. Testing tools' reliability was done using Cronbach's alpha test. The reliability score was 0.78 for knowledge and 0.86 for practice. This phase expanded for one month in May 2022.

**Ethical considerations:**

The researchers received approval from the Ethical Research Committee at the Faculty of

Nursing, Benha University. A concise explanation of the study's aim, nature, and expected outcomes were given for nurses, along with the promise that the information obtained would be confidential and utilized only for the purpose of the study. Then, oral consent was obtained from each nurse to participate in the study.

**The pilot study**:

It was carried out on 10% of the studied subject (7 nurses) along one month (June 2022) to test the applicability and clarity of the tools and appraise the required time to fulfill the study tools. According to the results of the pilot study, no modification was carried out on tools as revealed from pilot study results. Therefore, the nurses enrolled in the pilot study were added to the study's sample.

**Field work:**

The field work was carried out to achieve the aim of the current study; through four phases:

Assessment, planning, implementation, and evaluation, which were completed from the beginning of July 2022 to the end of December 2022 covering 6 months.

***Assessment phase:***

Each nurse was interviewed individually by the researchers. Also, the aim and duration of the study were explained.

Before data collection, oral consent for participation in the study was acquired. The interviewing questionnaire sheet was given to each nurse; hence, the researchers compelete neonates' data from the medical sheet (tool I).

Following that, the researchers observed each nurses' practice while practicing post cardiopulmonary resuscitation care for critically ill neonates (tool II).

Through this phase, the researchers attended the study settings on the morning shift to collect data two days per week (Sunday & Wednesday).

The researchers interviewed an average of 4-5 nurses per day to fill out the tools (pre electronic learning package application) as following:

Firstly, distributing the questionnaire sheet to each nurse individually to assess their knowledge as regards post cardio pulmonary resuscitation, as researchers clarify any questions. The average time required ranged from 10 to 15 minutes.

After that, the researchers observed nurses' practice regarding post cardio pulmonary resuscitation during shifts using the observational checklist. The needed time for accomplishment of each direct observation was from 15 to 20 minutes.

**Planning phase:**

The researchers developed the electronic learning package after reviewing the related literature. The electronic learning package utilized in the current study included four methods as following:

1- ***Virtual lab training:*** in the current study, it is considered the best live streaming method for ease of use across multiple devices. The studied nurses are able to interact well with the researchers through Microsoft teams, getting practice sessions training wherever they can access internet. In this study the researchers using live videos from the pediatric clinical lab in the faculty of nursing, Benha University after taking approval letter from dean of the faculty.

2- ***Recorded PowerPoint slides:*** Recorded slides prepared by the researchers to help the studied nurses understand and remember because the presentation runs automatically with narration help the nurses better understand the presentation and are available at any time for repetition according to requirements. The researcher put one point or idea on a slide; objects on a slide were put in orderly manner. Content was logical, simple, and clear that no one will struggle to comprehend, the text color contrast highly with the background color, and main text larger, no much text on a slide. Furthermore, images in slides were high-quality; so, it helps the audience understand and remember the point. Also, objects on a slide were put in orderly manner.

*3-* ***Digital mind mapping:*** in the current study, the researchers used digital mind mapping as a tool for visual thinking that is used to capture information and thoughts to improve nurses' knowledge

regarding post cardio pulmonary resuscitation for critically ill neonates maintaining creativity and efficiency. Also, digital mind mapping allows varying levels of nurses to develop an understanding of critical thinking and share effective, safe, and quality clinical practices.

Also, it is a powerful graphic technique that works like the brain does and allows the nurses to organize and understand information faster and better.

Digital mind mapping was created in five steps; **First step,** create a central idea. The central idea is the starting point of the mind map and represents the topic that the researchers are going to explore. **Second step;** add branches to the map. **Third step;** add keywords. **Fourth step;** colour code the branches. **Last step;** include visual signifiers (e.g., images).

Additionally, the researchers use the following basic techniques to create digital mind mapping; *central theme* that placed in the center of a blank page, from the central theme *associations* radiate out. Curved lines, keywords, proximity, colour and pictures are commonly used to represent associations..

4- ***Discussion board assignment:*** Discussion assignments are prompts that the researchers can assign to nurses. By participating in discussions, nurses can reflect on their learning, share opinions and ideas, or ask and answer questions. Assigned discussions are available in nurses' assignments list and the discuss page. Ask questions and challenge nurses to think; respond to them with a question or feedback. Furthermore, the researchers ask nurses to read and sign the discussion guidelines document before posting to the discussion board, and provide a link to the document under each discussion question for easy reference.

Nurses are subsequently asked to read and reply to the introductions of two or three of other nurses. This allows them to get to know each other and become acquainted with the discussion board. For effective online discussions, the researchers convey clear expectations, provide feedback and coaching, and provide clear expectations for the number of entries and the number of replies.

**The general objectives** of the electronic learning package application were to update the studied nurses' knowledge and improve their practice regarding post cardio pulmonary resuscitation for critically ill neonates.

**Specific objectives:**

**At the end of the electronic learning package application the studied nurses were able to:**

- Define neonatal life support concepts.
- Enumerate the features of post cardiopulmonary resuscitation.
- Mention new and updated neonatal algorithms.
- Illustrate the general, neurological and early hemodynamic monitoring of neonate post cardiopulmonary resuscitation.
- Understand methods of oxygenation and ventilation.
- Explain post cardio pulmonary resuscitation treatment.
- Mention frequency of post cardio pulmonary resuscitation reevaluation.
- List the critical considerations in post cardio pulmonary resuscitation management.
- Discuss long term outcomes.
- List the post cardio pulmonary resuscitation transport.
- Demonstrate immediate post cardio pulmonary resuscitation care for critically ill neonates.
- Apply airway management after return of spontaneous circulation.
- Apply multimodal prognostication assessment with an accurate clinical examination

***Implementation phase:***

Six sessions were scheduled for completing the implementation phase. Moreover, sessions are carried out through (6) sessions [four sessions for

the theoretical part and two sessions for the practical part]. A timetable for nurses was established containing the date, time, topics and time period for each session.

Also, the studied nurses were attended online according to time selected for the online sessions according to the type of electronic learning method. The researchers take the nurses opinion in selecting the time for attending online sessions.

The studied nurses were classified into four groups for attendance online sessions according to the schedule time that estimated according to their available time they selected 2-3 session/week. The nurses were informed about the time of session and the used electronic learning method.

Each theoretical and practical session time ranged from 45 to 60 minutes. Each session began with a review of the previous session and the objectives of the present one, taking into account the usage of Arabic language. Each participant had the chance to ask questions accompanied by clear answers from researchers.

The practical sessions cover the procedures related to post cardiopulmonary resuscitation for critically ill neonates.

The researchers used recorded PowerPoint slides and digital mind mapping for theoretical sessions and OSCE virtual training for practical sessions. As regard discussion board assignment methods were used after all theoretical and practical sessions taken for online discussions, sharing ideas and opinions, asking or answering questions as mentioned above. All sessions were recorded and send to nurse as they view sessions at any time they want.

The electronic learning package application supports illumination of difficult information, using simple language for nurses. Additionally, providing information for nurses in an interactive format. Furthermore, it improves communication skills, enhanced information technology (IT) skills.

**Contents of each session:**

**- The first theoretical session focused on:**

- General and specific objectives.
- Introduction about CPR and its purpose.
- Neonatal life support concepts.
- The features of post cardiopulmonary resuscitation in neonates.

**- The second theoretical session focused on:**

- New and updated neonatal algorithms.
- The general, neurological and early hemodynamic monitoring of neonate post cardiopulmonary resuscitation.
- Methods of oxygenation and ventilation.

**- The third theoretical session focused on:**

- Glucose control after resuscitation and thermal care
- Post cardio pulmonary resuscitation treatment.
- Frequency of post cardio pulmonary resuscitation reevaluation.

**- The fourth theoretical session focused on:**

- The critical considerations in post cardio pulmonary resuscitation management and long term outcomes.
- The post cardio pulmonary resuscitation transport and prognosis.

**- The fifth practical session concentrated on:**

- Measures of infection control.
- Steps of immediate post cardio pulmonary resuscitation care for critically ill neonates.
- Application of airway management after return of spontaneous circulation.
- Control of oxygenation and ventilation
- Hemodynamic monitoring

**- The six practical session focused on:**

- Multimodal prognostication assessment with an accurate clinical examination.
- General intensive care management.
- Recovery position.
- Functional assessments of physical and non-physical impairments prior hospital discharge.

All sessions advertised formally through email for each nurse.

***Evaluation Phase:***

After the application of the electronic learning package, the nurses' knowledge and practice were evaluated immediately. The post-test was done using the same pretest tools for data collection.

***Data analysis***

The collected data were classified, organized, analyzed, and tabulated using the Statistical Package for Social Sciences (Version 22). Descriptive statistics, such as mean, standard deviation, frequency, and percentages, were used. The Chi-square was used to assess the study's hypothesis. For correlation analysis, Pearson correlation coefficients were utilized, and the degree of significance was determined.

A highly statistically significant difference was done at P-value ≤ 0.001, while a statistically significant difference at P-value < 0.05, and no statistically significant difference at P-value > 0.05.

**Results**

Table (1) clarifies that the mean age of the studied nurses was 30.11±4.70 years, and more than two-fifths (41.5%) of them graduated from the Technical Institute of Nursing. Also, the majority (92.9%) of the studied nurses are females, and more than one third (37.1%) of them had experience 5->8 years.

Figure (1) shows that less than three-quarters (71.7%) of the studied nurses did not participate in training courses regarding post cardio pulmonary resuscitation for critically ill neonates.

Table (2) portrays that the mean age of neonates was 10.56±9.24 days and that more than half (53.7%) were females. In addition, the majority (80.5%) of neonates were born before 37 weeks of gestation.

Table (3) mentions that less than half (44.3 %) of the studied nurses had a poor level of knowledge pre the electronic learning package application; while more than two-thirds (67.1%) of them had a good level of knowledge post the electronic learning package application.

Table (4) reveals that there were highly statistically significant differences (P≤0.001) between nurses' total practice level pre and post the electronic learning package application.

Table (5) demonstrates that the majority (81.4%) of the studied nurses had incompetent level of practice pre the electronic learning package application; in addition the majority (88.6%) of them had competent level of practice post the electronic learning package application.

Table (6) shows that there is a statistically significant relation between the total knowledge scores of the studied nurses and their age, gender, academic qualification, and years of experience (P<0.05).

Table (7) illustrates that there is a highly statistically significant relation between the total practice scores of studied nurses and their age, gender, academic qualification, and years of experience (P<0.05).

Table (8) portrays that there is a statistically significant positive correlation between total knowledge scores and total practice scores of the studied nurses post electronic learning package application (p≤0.001).

Table (9) clarifies the nurses' experience as regards the effectiveness of each method used in the electronic learning package. It was determined that the majority (88.6%) of the studied nurses experiences that the electronic learning package was highly effective

Figure (2) clarifies the distribution of the studied nurses according to level of benefits of the electronic learning package application. It was determined that half (50.0%) of the studied nurses agreed that the electronic learning package was completely beneficial.

Table (10) portrays nurses' agreement about the effectiveness of the electronic learning package application. It was noticed that the majority (95.7%) of the studied nurses agreed that the electronic learning package was effective.

**Table (1): Percentage distribution of the studied nurses according to their characteristics [n=70].**

| Nurses' characteristics | No. | % |
|---|---|---|
| **Age/years** | | |
| >20 | 10 | 14.3 |
| 20>25 | 18 | 25.7 |
| 25>30 | 13 | 18.5 |
| 30>35 | 10 | 14.3 |
| 35≥40 | 19 | 27.2 |
| Mean ±SD | 30.11±4.70 | |
| **Gender** | | |
| Male | 5 | 7.1 |
| Female | 65 | 92.9 |
| **Academic qualification** | | |
| Diploma of Secondary Nursing School | 26 | 37.1 |
| Technical Institute of Nursing | 29 | 41.5 |
| Bachelor in Nursing Science | 15 | 21.4 |
| **Years of experience at NICU** | | |
| > 2 | 8 | 11.4 |
| 2 >5 | 21 | 30.0 |
| 5 >8 | 26 | 37.1 |
| ≥ 8 | 15 | 21.5 |

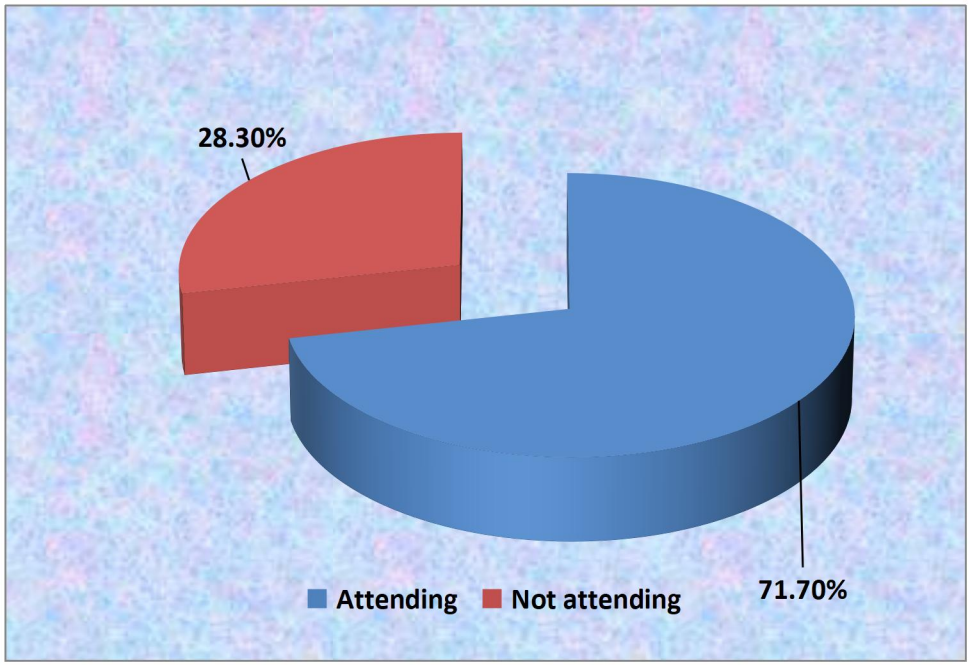


**Figure (1): Percentage distribution of the studied nurses according to their attendance to training courses regarding post cardio pulmonary resuscitation for critically ill neonates [n=70].**

**Table (2): Percentage distribution of neonates according to their characteristics [n=41].**

| Neonate's characteristics | No | % |
|---|---|---|
| **Age/days** | | |
| 1 >7 | 15 | 36.6 |
| 7 > 14 | 11 | 26.8 |
| 14 > 21 | 9 | 21.9 |
| ≥ 21 | 6 | 14.7 |
| Mean ±SD | 10.57±9.14 | |
| **Gender** | | |
| Male | 19 | 46.3 |
| Female | 22 | 53.7 |
| **Current weight in grams** | | |
| 1000->1500 | 17 | 41.5 |
| 1500->2000 | 10 | 24.3 |
| 2000->2500 | 8 | 19.5 |
| ≥2500 | 6 | 14.7 |
| **Medical diagnosis** | | |
| Respiratory distress syndrome | 35 | 85.4 |
| Heart muscle disease | 4 | 9.7 |
| Infant of diabetic mother | 2 | 4.9 |
| **Gestational age in weeks** | | |
| <37 | 33 | 80.5 |
| ≥ 37 | 8 | 19.5 |

**Table (3): Percentage distribution of nurses' total knowledge regarding post cardio pulmonary resuscitation for critically ill neonates pre and post the electronic learning package application [n=70].**

| Items | Pre electronic learning package application [n=70] | | Post electronic learning package application [n=70] | | $X^2$ | P-value |
|---|---|---|---|---|---|---|
| | No | % | No | % | | |
| **Total knowledge level** | | | | | 36.856 | P<0.05* |
| Good (≥75 %) | 12 | 17.1 | 47 | 67.1 | | |
| Average (60 >75%) | 27 | 38.6 | 17 | 24.3 | | |
| Poor (<60%) | 31 | 44.3 | 6 | 8.6 | | |

***A statistical significant at P value p<0.05.**

**Table (4): Percentage distribution of nurses' practice regarding post cardio pulmonary resuscitation for critically ill neonates pre and post the electronic learning package application [n=70].**

| Practice items | Pre electronic learning package application [n=70] | | | | Post electronic learning package application [n=70] | | | | $X^2$ | P-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Competent practice | | Incompetent practice | | Competent practice | | Incompetent practice | | | |
| | No | % | No | % | No | % | No | % | | |
| **Key elements of practice** | | | | | | | | | | |
| Immediate post CPR care | 15 | 21.4 | 55 | 78.6 | 66 | 94.3 | 4 | 5.7 | | |
| Airway management after return of spontaneous circulation | 13 | 18.6 | 57 | 81.4 | 63 | 90.0 | 7 | 10.0 | | |
| Control of oxygenation and control of ventilation | 23 | 32.8 | 47 | 67.2 | 68 | 97.2 | 2 | 2.8 | | |
| Hemodynamic monitoring and management | 19 | 27.2 | 51 | 72.8 | 65 | 92.8 | 5 | 7.2 | | |
| Multimodal prognostication assessment with an accurate clinical examination | 10 | 14.3 | 60 | 85.7 | 53 | 75.7 | 17 | 24.3 | 49.372 | 0.000** |
| General intensive care management | 12 | 17.1 | 58 | 82.9 | 60 | 85.7 | 10 | 14.3 | | |
| Targeted temperature management | 15 | 21.4 | 55 | 78.6 | 63 | 90.0 | 7 | 10.0 | | |
| Recovery position | 10 | 14.3 | 60 | 85.7 | 70 | 100.0 | 0 | 0.0 | | |
| Perform functional assessments before discharge | 8 | 11.4 | 62 | 88.6 | 58 | 82.9 | 12 | 17.1 | | |
| **Total** | **13** | **18.6** | **57** | **81.4** | **62** | **88.6** | **8** | **11.4** | | |

****Highly statistically significant at P value p≤0.001.**

**Table (5): Percentage distribution of nurses' total practice regarding post cardio pulmonary resuscitation for critically ill neonates pre and post the electronic learning package application [n=70].**

| Items | Pre electronic learning package application [n=70] | | Post electronic learning package application [n=70] | | $X^2$ | P-value |
|---|---|---|---|---|---|---|
| | No | % | No | % | | |
| **Total practice level** | | | | | | |
| Competent practice (≥ 90) | 13 | 18.6 | 62 | 88.6 | 48.139 | 0.000** |
| Incompetent practice (< 90) | 57 | 81.4 | 8 | 11.4 | | |

****Highly statistically significant at P value p≤0.001.**

**Table (6): Relation between nurses' total knowledge scores and their personal characteristics pre and post the electronic learning package application [n=70].**

| The total score of knowledge and Characteristics of nurses | Pre electronic learning package application [n=70] | | | | | | Post electronic learning package application [n=70] | | | | | | $X^2$ | P-Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Good (n=12) | | Average (n=27) | | Poor (n=31) | | Good (n=47) | | Average (n=17) | | Poor (n=6) | | | |
| | No | % | No | % | No | % | No | % | No | % | No | % | | |
| **Age/ Years:** | | | | | | | | | | | | | | |
| >20 | 0 | 0.0 | 0 | 0.0 | 10 | 32.2 | 0 | 0.0 | 6 | 35.3 | 4 | 66.6 | 38.8 | P<0.05* |
| 20>25 | 4 | 33.3 | 9 | 33.4 | 5 | 16.1 | 10 | 21.3 | 7 | 41.2 | 1 | 16.7 | | |
| 25>30 | 1 | 8.3 | 5 | 18.5 | 7 | 22.7 | 9 | 19.1 | 3 | 17.6 | 1 | 16.7 | | |
| 30≥35 | 1 | 8.3 | 5 | 18.5 | 4 | 12.9 | 9 | 19.1 | 1 | 5.9 | 0 | 0.0 | | |
| 35≥40 | 6 | 50.0 | 8 | 29.6 | 5 | 16.1 | 19 | 40.5 | 0 | 0.0 | 0 | 0.0 | | |
| **Gender** | | | | | | | | | | | | | | |
| Male | 0 | 0.0 | 3 | 11.1 | 2 | 6.5 | 3 | 6.4 | 1 | 5.9 | 1 | 16.7 | 40.9 | P<0.05* |
| Female | 12 | 100.0 | 24 | 88.9 | 29 | 93.5 | 44 | 93.6 | 16 | 94.1 | 5 | 83.3 | | |
| **Academic qualifications** | | | | | | | | | | | | | | |
| Diploma of Secondary Nursing School | 3 | 25.0 | 5 | 18.5 | 18 | 58.1 | 10 | 21.3 | 12 | 70.6 | 4 | 66.6 | 35.4 | P<0.05* |
| Technical Institute of Nursing | 4 | 33.3 | 15 | 55.6 | 10 | 32.2 | 22 | 46,8 | 5 | 29.4 | 2 | 33.3 | | |
| Bachelor in Nursing Science | 5 | 41.7 | 7 | 25.9 | 3 | 9.7 | 15 | 31.9 | 0 | 0.0 | 0 | 0.0 | | |
| **Years of experience at NICU** | | | | | | | | | | | | | | |
| > 2 | 0 | 0.0 | 0 | 0.0 | 8 | 25.8 | 5 | 10.6 | 1 | 5.9 | 2 | 33.3 | 36.3 | P<0.05* |
| 2 >5 | 1 | 8.3 | 8 | 29.6 | 12 | 38.7 | 12 | 25.5 | 6 | 35.2 | 3 | 50.0 | | |
| 5 >8 | 5 | 41.7 | 10 | 37.0 | 11 | 35.5 | 17 | 36.2 | 8 | 47.1 | 1 | 16.7 | | |
| ≥ 8 | 6 | 50.0 | 9 | 33.4 | 0 | 0.0 | 13 | 27.7 | 2 | 11.8 | 0 | 0.0 | | |

***A statistically significant at P value p<0.05**

**Table (7): Relation between nurses' total practice scores and their personal characteristics pre and post the electronic learning package application [n=70].**

| The total score of practices and Characteristics of nurses | Pre electronic learning package application [n=70] | | | | Post electronic learning package application [n=70] | | | | $X^2$ | P-Value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Competent (n=13) | | Incompetent (n=57) | | Competent (n=62) | | Incompetent (n=8) | | | |
| | No | % | No | % | No | % | No | % | | |
| **Age/ Years** | | | | | | | | | | |
| >20 | 0 | 0.0 | 10 | 17.5 | 6 | 9.7 | 4 | 50.0 | 38.91 | P<0.05* |
| 20>25 | 0 | 0.0 | 18 | 31.6 | 17 | 27.5 | 1 | 12.5 | | |
| 25>30 | 2 | 15.4 | 11 | 19.3 | 12 | 19.3 | 1 | 12.5 | | |
| 30≥35 | 3 | 23.1 | 7 | 12.3 | 8 | 12.9 | 2 | 25.0 | | |
| 35≥40 | 8 | 61.5 | 11 | 19.3 | 19 | 30.6 | 0 | 0.0 | | |
| **Gender** | | | | | | | | | | |
| Male | 0 | 0.0 | 5 | 8,7 | 3 | 4.8 | 2 | 25.0 | 40.18 | P<0.05* |
| Female | 13 | 100.0 | 52 | 91.3 | 59 | 95.2 | 6 | 75.0 | | |
| **Academic qualifications** | | | | | | | | | | |
| Diploma of Secondary Nursing School | 2 | 15.4 | 24 | 42.1 | 22 | 35.5 | 4 | 50.0 | 39.25 | P<0.05* |
| Technical Institute of Nursing | 3 | 23.1 | 26 | 45.6 | 25 | 40.3 | 4 | 50.0 | | |
| Bachelor in Nursing Science | 8 | 61.5 | 7 | 12.3 | 15 | 24.2 | 0 | 0.0 | | |
| **Years of experience at NICU** | | | | | | | | | | |
| > 2 | 0 | 0.0 | 8 | 14.0 | 3 | 4.8 | 5 | 62.5 | 38.62 | P<0.05* |
| 2 >5 | 1 | 7.7 | 20 | 35.1 | 18 | 29.0 | 3 | 37.5 | | |
| 5 >8 | 4 | 30.7 | 22 | 38.6 | 26 | 42.0 | 0 | 0.0 | | |
| ≥ 8 | 8 | 61.6 | 7 | 12.3 | 15 | 24.2 | 0 | 0.0 | | |

***A statistically significant at P value p<0.05**

**Table (8): Correlation between nurses' total knowledge score and total practice score pre and post the electronic learning package application [n=70].**

| Variables | Pearson correlation coefficient Total knowledge score | | | |
|---|---|---|---|---|
| | Pre electronic learning package application [n=70] | | Post electronic learning package application [n=70] | |
| | r | P | r | P |
| Total practice score | .473 | .000** | .619 | .000** |

**** Correlation is significant at the 0.01 level**

**Table (9): Percentage distribution of nurses' experience regarding the effectiveness of each method used in electronic learning package [n=70].**

| Electronic learning package | Minor effective | | Moderate effective | | Highly effective | |
|---|---|---|---|---|---|---|
| | No | % | No | % | No | % |
| - Virtual lab training | 0 | 0.0 | 5 | 7.1 | 65 | 92.8 |
| - Recorded PowerPoint slides | 2 | 2.9 | 7 | 10.0 | 61 | 87.1 |
| - Digital mind mapping | 0 | 0.0 | 0 | 0.0 | 70 | 100.0 |
| - Discussion board assignment | 6 | 8.5 | 10 | 14.2 | 54 | 77.1 |
| **Total** | **2** | **2.9** | **6** | **8.5** | **62** | **88.6** |

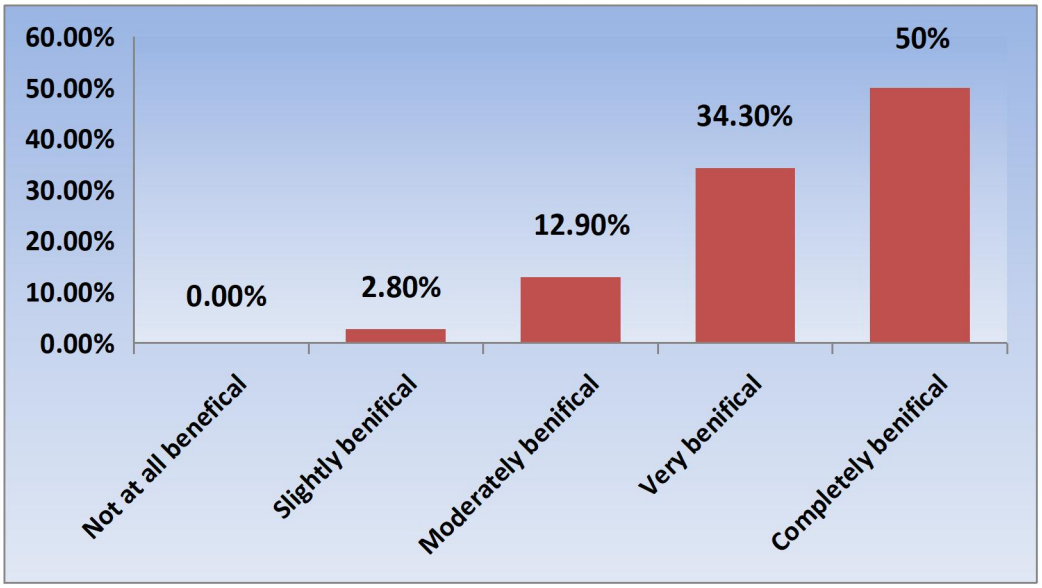


**Figure (2): Percentage distribution of nurses according to level of benefits of the electronic learning package application [n=70].**

**Table (10): Percentage distribution of the studied nurses regarding their agreement about the effectiveness of the electronic learning package application [n=70].**

| Items | Agree | | To some extent | | disagree | |
|---|---|---|---|---|---|---|
| | No | % | No | % | No | % |
| The training objectives were clear | 70 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| The content was clear and related to training objectives | 70 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| The content presented in a logical sequence | 65 | 92.8 | 4 | 5.7 | 1 | 1.4 |
| The content was appropriate for everyone level of experience | 66 | 94.3 | 2 | 2.8 | 2 | 2.8 |
| The explanations provided were clear | 68 | 97.1 | 2 | 2.8 | 0 | 0.0 |
| The activities were easily engaged and relevant | 70 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| The content enhance the learning experience | 70 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| I was capable to navigate easily through the program | 61 | 87.1 | 7 | 10.0 | 2 | 2.8 |
| The package was effectively presented | 70 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| The e-learning package has increased my understanding of the topic area | 65 | 92.8 | 3 | 4.3 | 2 | 2.8 |
| The researcher contact and respond questions if I had any technical or content issues with the package | 61 | 87.1 | 5 | 7.1 | 4 | 5.7 |
| The e-learning package was an efficient means of obtaining knowledge | 67 | 95.7 | 1 | 1.4 | 2 | 2.8 |
| The e-learning package improved my ability to reflect on my practice | 70 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| Generally, nurse was satisfied with the e-learning package | 70 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| **Total** | **67** | **95.7** | **2** | **2.8** | **1** | **1.4** |

## Discussion

Electronic learning is a mixture of instructional methods applied to assist in the development of knowledge and skills for nurses. It supports the attainment and understanding of knowledge by both online and offline interactive technologies. E-learning involves the use of a variety of technologies, such as online learning, virtual classrooms and web-based education ***(Barnes, 2021).***

E-learning increasing nurses' interest and motivation allowing for active engagement, and participation. Although, peak success comes from consistent commitment. Many advantages of e-learning including enhancement of accessibility, cost-effectiveness and reducing administrative burden. Additional advantage is that, trainers are able to choose content, order, pace, location and timing of the instruction with the ability to update content any time ***(Salema et al., 2021)***

The current study aimed to evaluate the effect of electronic learning package application on knowledge and practice of nurses regarding post cardio pulmonary resuscitation for critically ill neonates. Also, the findings of the present study support the study hypothesis.

Regarding the characteristics of the studied nurses, the present study found that the mean age of the studied nurses was 30.11±4.70 years. This finding disagrees with ***Tsaloukidis et al., (2017)*** in a study about the "Evaluation of Nurses' Perceptions on Cardiopulmonary Resuscitation (CPR) Education " who found that the mean age of the participants was 36.21 years. From the viewpoint of the researchers; young age nurses

currently experience a stressful transition into the workforce.

The current study revealed that less than one third of the studied nurses aged between 35-≥40 and majority of studied nurses were females. This result agreed with ***Narayan et al., (2018)*** in a study about "Evaluation of an E-learning Training Package by Nurses for Various Designations for Developing Clinical Skills and Knowledge" Who found that less than one third (30.2%) of participants aged between 36 and 45 years the majority of staff nurses were female.

Concerning academic qualifications of the studied nurses, the ongoing study illustrated that more than one-fifths of them had Bachelor in nursing science. This finding contrary to***, Bylow et al., (2019***) in a study about" Effectiveness of Web Based Education Addition to Basic Life Support Learning Activities: A cluster Randomized Controlled Trial" who found that 42,4% college/ university education. Also, ***Narayan et al., (2018)*** who found that, the highest level of education were (83.3%) and Diploma in Enrolled Nursing were 10.5%,

As regard years of experience for studied nurses, the current study found that more than one third of the studied nurses had 5 > 8 of experience. The study finding agrees with ***Dalhem & Saleh, (2014)*** who studied "The Impact of E-learning on Nurses' Professional Knowledge and Practice in HMC" who found that 40% of nurses had 6-10 years of experience.

The current study found that less than three-quarters of nurses didn't attain training courses regarding post cardiopulmonary resuscitation. This finding disagreed with ***Bylow et al., (2019***) who revealed that 35% no previous training on post resuscitation procedure. From the view point of the researcher this finding could be due to lack of training program in the place work and lack professional team.

Regarding the nurses' total knowledge about post cardiopulmonary resuscitation, the finding of the current study viewed that more than two-thirds of the studied nurses had good knowledge after electronic learning package application compared to less than half who had poor knowledge pre electronic learning package application with a statistically significant difference pre and post electronic learning package application. These findings were parallel to ***Abuatiq et al., (2017),*** who mentioned that the use of virtual e-learning and other various platforms in e-learning leads to a wide range of knowledge. Additionally, ***Yangoz, (2017)*** stated that e-learning programs are more effective learning methods than lecture programs. Also, it is characterized by flexibility in terms of completion time and is accessible to complete without too much disruption to the workload.

On the same circumstances, these results were confirmed by ***Goceda, (2020),*** who stated that the use of e-learning improved nurses' knowledge and clarified the theoretical base.

Also, this finding was consistent with ***Abdullah et al., (2019)*** who carried out a study about "E-learning in Advanced Cardiac Life Support: Outcome and Attitude among Healthcare Professionals, Hong Kong" and found that e-learning advanced cardiac life support courses confirmed better results of knowledge level compared to conservative advanced cardiac life support.

As regards nurses' total practice regarding post cardiopulmonary resuscitation, the ongoing study illustrated that the majority of the studied nurses had competent level post electronic learning package application compared to a minority of them had competent level pre electronic learning package application. This finding may be due to the applicable technological and scientific advancements that lead to improving professional skills in a short period of time.

These findings were matched with ***Salema et al., (2021)*** in a study about "The Evaluation of e-learning Prescribing Course for General Practice, Education for Primary Care" who showed that e-learning is a common tool used in motivating and stimulating training. The majority of participants mentioned that, the e-learning course had a positive impact on their skills and attitudes.

On the same line ***Bylow et al., (2019***) found that, web-based education achieved a significant higher total score for practical skills**.**

Also, this finding is in the same line with ***Beckett, (2020***) in a study about "Effect of E-

Learning on Nurses' Continuing Professional Development" who portrayed that E-learning can provide nurses with the opportunity to assume permanent learning and continuing professional development in a flexible, practical and attractive manner.

On the same context ***Abdullah et al., (2019)*** clarified that, the advantage of having e-learning modules helped critical care nurses in performing enhanced skills.

In other study done by ***García et al., (2020)*** about "Standard Basic Life Support Training of the European Resuscitation Council Versus Blended Training: A randomized Trial of A new Teaching Method" who found that, the blended training group scored better on certain skill markers.

It was evident from the current study that, the majority of the studied nurses able to easily navigate through the program. This finding was supported by ***Salema et al., (2021)*** who found that more than 90% of the participants confirmed that the e-learning course was simple to use and a valuable aspect of their continuous professional development.

The present study portrayed that, the majority of the studied nurses agreed that the e-learning package was an efficient means of obtaining knowledge, this finding run in the same line with ***Hersey& McAleer (2017),*** in astudy about " Developing an E-learning Resource for Nurse Airway Assistants in the Emergency Department", who found that all nurses agreed that they had increased their knowledge and found the e-learning beneficial.

In the same context, this result was in an agreement with ***Moon & Hyun, (2019)*** in a study about "Nursing Students' Knowledge, Attitude, Self-efficacy in Blended Learning of Cardiopulmonary Resuscitation: A randomized Controlled Trial" who found that a blended learning CPR program that included videos and lectures was shown to be successful in enhancing nurses' knowledge and attitudes towards CPR practical demonstration.

Finally, the current study clarified that, all of the studied nurses agreed that the e-learning training package improved their ability to reflect on their practice contradictory with ***Beckett, (2020***), who found that more than half of respondents agreed that e-learning aids their ongoing professional development.

## Conclusion

Based on the findings of the current study, it can be concluded that, there was an improvement in knowledge and practice of studied nurses which emphasize that electronic learning package application effective.

## Recommendations

Based on the current study results, the following recommendations can be proposed:

- An update electronic learning and training programs should be periodically conducted with numerous teaching methods for nurses in NICUs to improve their performance regarding post Cardio Pulmonary resuscitation.
- Guideline booklet should be accessible for NICUs nurses in an Arabic language to guide them in dealing with neonates post cardio pulmonary resuscitation.
- Establish optimal standardized care protocols for the introducing and managing bundled post resuscitation care which will eventually lead to improved neonatal outcomes.

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