# EFFECTS OF DIGITAL APPLICATION AND TRAINING INTERVENTIONS ON SKILLS OF CARDIO PULMONARY RESUSCITATION AMONG UNDERGRADUATE NURSES IN SOUTH-WEST NIGERIA

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**Abstract**

Cardiac arrest is one of the leading causes of mortality and a growing public health problem across the world. The study aimed to investigate the effects of digital application and physical training interventions on the skills of cardiopulmonary resuscitation (CPR) among undergraduate nursing students in Southwest Nigeria. A quasi-experimental research design was used for this study, two experimental groups and a control group. The quasi-experimental component involved two experimental groups (one using a digital application for CPR training and the other using physical training) and a control group, with data collected at baseline, immediate post-intervention, and end-line evaluation points. The study was conducted at three state public universities in Southwest Nigeria, selected via multistage sampling procedure, and involved 400 level undergraduate nursing students. An adapted NMCN checklist on CPR skills was the instrument used to collect data. Validity and reliability of the instruments were ensured through expert reviews and pilot testing. Data collection procedures involved trained research assistants, and data was analyzed using SPSS version 28. Post-intervention results showed significant improvement in skills for EG1 and EG2 compared to the Control Group. EG1 and EG2 exhibited substantial increase in skill levels (95.7% and 95.1%, respectively), while the Control Group showed minimal improvement. The results showed significant improvements in both immediate and 12-week post-intervention skills for participants in the intervention groups compared to the control group. Analysis of Variance (ANOVA) and Post-hoc Scheffe tests indicated that both intervention methods—digital applications and physical training—were effective, with digital applications showing the highest mean scores. It was recommended that Nursing schools and training centers should incorporate hands-on physical CPR training sessions alongside digital applications to provide a comprehensive learning experience for undergraduate nurses among several others.

**Keywords:** Digital Application, Physical Training, Skills, Cardiopulmonary Resuscitation, Nurses

## Introduction

Cardiac arrest, commonly referred to as CA, is a significant contributor to global mortality rates and is increasingly becoming a public health concern. The survival rate of patients who are discharged from the hospital after experiencing an out-of-hospital cardiac arrest (OHCA) remains quite low, ranging from 5 to 10% (Nishiyama, et al., 2019; Grasner, et al., 2016). Adewale, et al. (2020) argue that numerous African countries suffer from deficient emergency medical response systems, resulting in unfavourable outcomes for individuals experiencing cardiac arrest. Cardiopulmonary resuscitation (CPR), also referred to as CPR, is widely recognised as an essential element of initial medical assistance for cardiac arrest (Craig-Brangan & Day, 2019). The latest global recommendations highlight the importance of performing high-quality cardiopulmonary resuscitation (CPR) along with prompt defibrillation as a primary objective in reviving adult and paediatric patients experiencing cardiac arrest.

Despite extensive endeavours made in the last 50 years to enhance understanding of CPR, the efficacy of CPR still falls considerably short of expectations (Hasselqvist, et al., 2018). According to Zheng et al. (2022), the survival rates for patients who suffered cardiac arrest outside of a hospital and those who encountered cardiac arrest inside a hospital were only 11.4% and 23.8%, respectively, even after receiving CPR assistance. Cardiopulmonary resuscitation (CPR) aims to maintain the flow of oxygenated blood to vital organs, particularly the brain. Prolonged deprivation of oxygen can lead to irreversible damage or death (Alsharari, et al., 2018). Panchal, et al.'s (2020) study reveals that the American Heart Association's criteria for survival consist of five significant components. The links mentioned include early access, prompt and correct CPR initiation, rapid defibrillation, primary and secondary emergency healthcare services, enhanced life support, and post-cardiac arrest therapy (Panchal, et al., 2020; Craig-Brangman & Day, 2019).

The education sector is currently experiencing an unprecedented growth in innovation in digital technologies. This is expected to offer significant benefits, especially in the domain of resuscitation instruction. The digital resuscitation technique is being widely utilised as an alternative to the traditional face-to-face teaching method. This enhances the flexibility and transportability of training. Training in digital resuscitation encompasses the use of digital technology, including blended learning, online games, computer assistance, and mobile or virtual learning environments, to facilitate training (Creutzfeldt, et al., 2020). The trainers engaged in digital learning activities using a combination of synchronous and asynchronous features, leading to a high degree of clarity and efficiency. When comparing digital resuscitation training to traditional CPR instruction, it is evident that the former yields similar outcomes in terms of pass rate, increased independence, less manpower needs, and cost-effectiveness. Nevertheless, the extent to which digital resuscitation training is beneficial in terms of information acquisition and achieving the correct compression rate remains questionable.

International resuscitation standards advocate the incorporation of technology in cardiopulmonary resuscitation (CPR) training as a substitute for traditional training methods (Creutzfeldt, et al., 2021). In order to enhance overall performance, enhance the training for cardiopulmonary resuscitation (CPR), and provide immediate guidance during resuscitation efforts, digital application interventions for CPR utilise technology such as mobile applications, web platforms, and virtual reality. These

digital interventions have the capacity to provide numerous advantages and advancements in the education and implementation of CPR. Thanks to digital technologies, CPR teaching and training can now be conducted on easily accessible platforms that are actively engaged in. These platforms provide various instructional resources such as video demonstrations, interactive modules, and step-by-step guidelines to effectively train students in the proper CPR procedures (Cortegiani, et al., 2019). People may learn at their own pace and reinforce their comprehension due to the availability of these programmes, which can be accessed anytime and from anywhere.

The utilisation of digital resources, such as mobile applications, e-learning platforms, virtual simulations, and interactive training modules, has the potential to enhance the learning experience and effectiveness for nursing students. However, it is imperative to examine the efficacy of these digital interventions and physical training in improving cardiopulmonary resuscitation (CPR) skills among undergraduate nurses in Southwest Nigeria which is what spur the researcher to undergo this study.

The study specifically assessed;

i.   assessed the skill of cardiopulmonary resuscitation among undergraduate nursing students in the intervention and control groups;

ii.  assessed the immediate and 12th week post-intervention follow-up and skill knowledge of cardiopulmonary resuscitation among undergraduate nursing students in the intervention and control groups.

The following research questions were raised for this study;

1.   What is the baseline skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups?

2.   What is the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups?

3.   What is the 12th week post-intervention follow-up skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups?

The following research hypotheses were formulated for this study;

**Ho1:**  There is no significant difference in the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups

**Ho2:**  There is no significant difference in the 12th week post-intervention follow-up skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups

**Ho3:** There is no significant effect in the skill mean scores of undergraduate Nurses exposed to digital application, physical training and control method before and after intervention.

## Methodology

The study adopted a quasi-experimental research design, it implemented a three main phase namely baseline assessment, intervention with follow-up and end-line evaluation. The target population were undergraduate Nurses selected from the six state public institutions in South-West Nigeria. The sample size for the study was the intact class size in the three selected public universities. Multi stage sampling procedure was used to select the respondents in the three states while simple random sampling was used to assign the selected institutions to groups. The experimental group 1 was tagged as EG1 while experimental group 2 was tagged EG2 and control group was tagged CG.

Baseline assessment on skills of CPR was done among the three groups. EG1 were exposed to digital application training via a purposely- built digital based cardiopulmonary resuscitation, while EG2 were exposed to 6 weeks curriculum based physical training on CPR. The participants in the two (2) experimental groups were followed up for a period of 12 weeks. The control group did not receive any form of cardiopulmonary related intervention. The skill of cardiopulmonary resuscitation of the participants were assessed at 3 phases: baseline, immediate post-intervention; and end line for the 3 groups. The control group did not receive any form of cardiopulmonary related intervention. The intact class size for EG1 was 104 students, EG2 44 students and CG 75 students.

The instrument, a 22-item adapted statement on skills of cardiopulmonary resuscitation was used for data collection. The total obtainable mark was 22. Scores of 16 and above was regarded as good skill, scores between 11 to 15 was regarded as intermediate skill and ≤11 as poor skill. The instrument was reviewed by experts in the field of basic life support (BLS), Public health and Tests and Measurement to ensure the face and content validity of the instruments. A team of 3 trained Research Assistants were assigned to each treatment arm of the study to assist the researcher in data collection.

The data was collected at each phase across the 2 experimental and control groups using the checklist. It was firstly collected at baseline, after six weeks training (immediate post intervention) and also after 12th week of intervention. The collected data was gathered, checked for completeness and analysed using SPSS software 28. Variables were summarized using descriptive statistics including mean, median, standard deviation, ranges, frequencies, and proportions. Difference in mean of three groups was compared using the one way Analysis of Variance (ANOVA) while Post Hoc test was used where necessary. Analysis of Covariance and Multiple Classification Analysis was used to analysed the effect of the intervention on skill of CPR.

Ethical approval was sought from Afe Babalola University Research and Ethic Committee and the Institutional Review Board of the three universities where the study were conducted prior to commencement of study. Informed consent was sought from each participants, there was no coercion to participate and confidentiality was maintained throughout the study.

**Results**

**Research Question 1:** What is the baseline skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups?

**Table 1: Summary of baseline skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups**

| Skill of CPR at baseline | EG 1: F (%) | EG 2: F (%) | CG: F (%) |
|---|---|---|---|
| Poor Skill (0-10) | 93 (100.0) | 41 (100.0) | 68 (100.0) |
| Intermediate Skill (11-15) | - | - | - |
| Good Skill (16-22) | - | - | - |
| Mean ±SD | **2.99±0.68** | **3.05±0.55** | **3.06±0.69** |

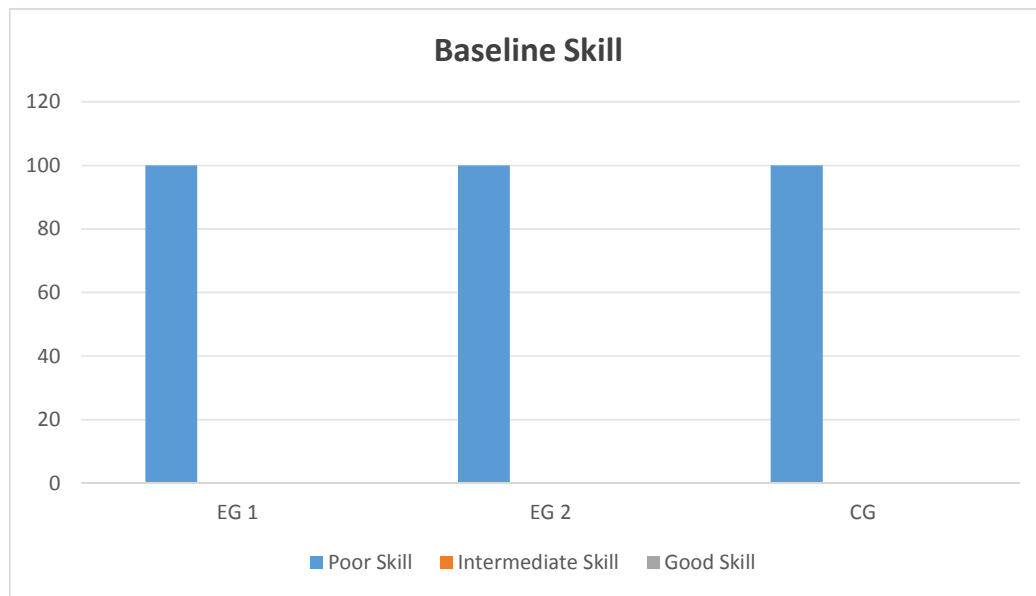*EG1: Digital Application, EG2: Physical Training, CG: Control Group*



**Figure 1:** Bar Chart showing baseline skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups

The summary of baseline skill in cardiopulmonary resuscitation (CPR) among undergraduate nurses, as presented in Table 1 and figure 1, indicates that prior to any intervention, all groups - Experimental Group One (EG1), Experimental Group Two (EG2), and the Control Group (CG) - displayed similarly poor levels of CPR skill. In each group, 100% of respondents fell into the category of poor skill, indicating a uniform lack of proficiency in CPR skills among participants before any interventions were introduced. This underscores the universal need for enhancement in CPR skills across all groups, with no initial discrepancies among the groups in terms of baseline skill levels. When examining the mean skill scores, there are minor differences among the groups. EG1 shows a slightly lower mean score of 2.99 compared to EG2's mean

score of 3.05, while the Control Group's mean score is slightly higher at 3.06. Despite these slight variations, all groups still fall within the category of poor skill, indicating a consistent lack of proficiency across the board. In conclusion, the baseline data suggests a uniform lack of CPR skill among undergraduate nurses across all groups, with no discernible differences in skill levels before the interventions.

**Research Question 2:** What is the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups?

**Table 2: Summary of immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups**

| Skill of CPR at Immediate Post-Intervention | EG 1: F (%) | EG 2: F (%) | CG: F (%) |
|---|---|---|---|
| Poor Skill (0-10) | 0 (0.0) | 0 (0.0) | 68 (100.0) |
| Intermediate  Skill (11-15) | 4 (4.3) | 2 (4.9) | - |
| Good Skill (16-22) | 89 (95.7) | 39 (95.1) | - |
| Mean ±SD | **18.95±2.18** | **18.54±1.98** | **4.96±1.23** |

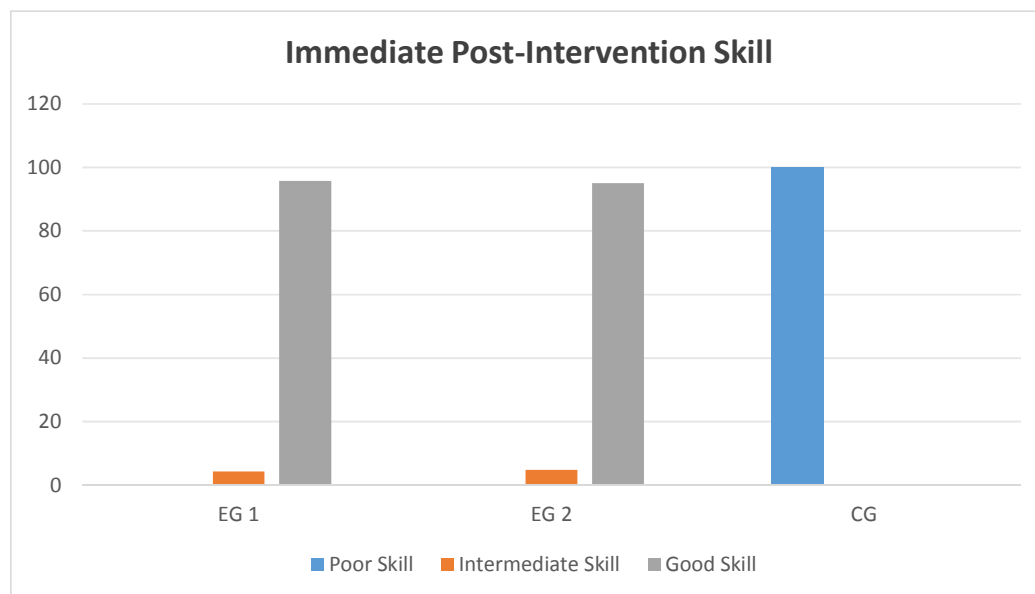*EG1: Digital Application, EG2: Physical Training, CG: Control Group*



**Figure 2:** Bar Chart showing immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups

The table presents a summarized overview of the immediate post-intervention skill levels in cardiopulmonary resuscitation (CPR) among undergraduate nurses, segmented into three skill categories: Poor, Intermediate, and Good Skill levels. It compares the distribution of skill levels across the intervention groups (EG 1: Digital Application and EG 2: Physical Training) and the control group (CG). In terms of Poor Skill (0-10), none of the participants in either intervention group or the control group exhibited poor skill levels immediately after the intervention. However, all participants in the control group (100.0%) fell into this category.

For Intermediate Skill (11-15), a small percentage of participants in both intervention groups demonstrated intermediate skill levels, with 4.3% in EG 1 and 4.9% in EG 2. Skill levels for the control group were not reported in this category. In the Good Skill category (16-22), the majority of participants in both intervention groups displayed good skill levels, with 95.7% in EG 1 and 95.1% in EG 2. None of the participants in the control group achieved good skill levels. Overall, the table underscores the efficacy of the intervention strategies, highlighting that both the digital application and physical training were effective in enhancing CPR skill levels among undergraduate nurses, when compared to the control group which did not receive specific interventions.

**Research Question 3:** What is the 12th week post-intervention follow-up skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups?

**Table 3: Summary of 12th week post intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups**

| Skill of CPR at 12th week Post-Intervention | EG 1: F (%) | EG 2: F (%) | CG: F (%) |
|---|---|---|---|
| Poor Skill (0-10) | 0 (0.0) | 0 (0.0) | 68 (100.0) |
| Intermediate Skill (11-15) | 8 (8.6) | 2 (4.9) | - |
| Good Skill (16-22) | 85 (91.4) | 39 (95.1) | - |
| Mean ±SD | **19.19±2.23** | **18.37±1.98** | **4.91±1.10** |

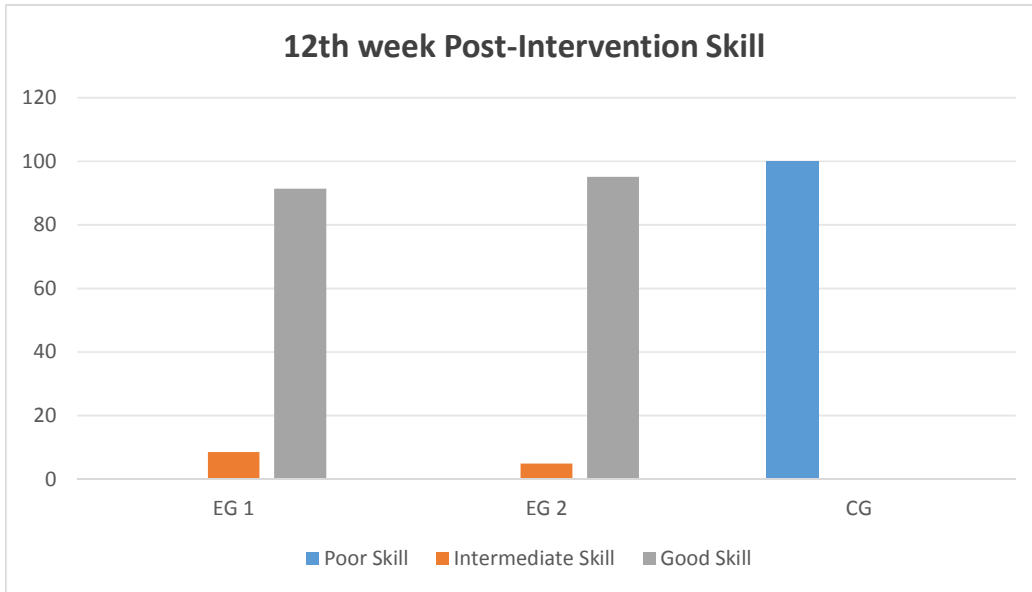*EG1: Digital Application, EG2: Physical Training, CG: Control Group*

**Figure 3:** Bar Chart showing 12th week post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention and control groups

*Test of Hypotheses*

**Ho1:** There is no significant difference in the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups

In order to test the hypothesis, performance of participants after treatment were collected. Analysis of Variance (ANOVA) was used to compute difference in the immediate post-intervention skill of cardiopulmonary resuscitation. The result is presented in Table 4

**Table 4:** Difference in the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| 8639.697 | 2 | 4319.849 |  |  |  |
| 693.912 | 199 | 3.487 | 1238.846* | .000 | 0.926 (0.907 - 0.937) |
| 9333.609 | 201 |  |  |  |  |

*P < 0.05

The result presented in table 4 showed that F-cal value of 1238.846 is significant because the P value (0.000) < 0.05 at 0.05 level of significance. Hence, the null

hypothesis is rejected. This implies that there was significant difference in the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups. The effect size (Eta-Squared) reported in Table 4 is 0.926, with a confidence interval of 0.907 to 0.937. This extremely large effect size indicates that the intervention (digital app and physical training) had a profound impact on the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses. It implies that a very high proportion of the variance in skill scores can be attributed to the intervention, demonstrating its exceptional effectiveness.

In order to determine the source of the significant differences observed, Post – hoc (Scheffe) analysis with mean difference was carried out in Table 5.

**Table 5:** Scheffe Post – hoc multiple range test of the immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses in the intervention and control groups

| Groups | | N | Mean | A | B | C |
|---|---|---|---|---|---|---|
| | | | | 18.95 | 18.54 | 4.99 |
| Digital Application | **(A)** | 93 | 18.95 | | | |
| Physical Training | **(B)** | 41 | 18.54 | | | |
| Control | **(C)** | 68 | 4.99 | * | * | |

* $P < 0.05$

In Table 5, significant differences were found between immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses in the digital application group and control group in favour of digital application group; and physical training group and control group in favour of physical training group. However, there was no significant difference between immediate post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses in the digital application group and physical training group. It can be deduced through the mean mark in table 5 that undergraduate nurses exposed to digital application strategy performed best in skill of cardiopulmonary resuscitation, followed by undergraduate nurses exposed to physical training while undergraduate nurses in the control group performed least.

**Ho2:** There is no significant difference in the 12th week post-intervention follow-up skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups.

In order to test the hypothesis, performance of participants after treatment were collected. Analysis of Variance (ANOVA) was used to compute difference in the 12th week post-intervention follow-up skill of cardiopulmonary resuscitation. The result is presented in Table 6

**Table 6:** Difference in the 12<sup>th</sup> week post-intervention skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups

| | | | | | | |
|---|---|---|---|---|---|---|
| 8896.917 | 2 | 4448.458 | | | | |
| 697.499 | 199 | 3.505 | 1269.168* | .000 | 0.927 (0.909 - 0.939) | |
| 9594.416 | 201 | | | | | |

*P < 0.05

The result presented in table 6 showed that F-cal value of 1269.168 is significant because the P value (0.000) < 0.05 at 0.05 level of significance. Hence, the null hypothesis is rejected. This implies that there was significant difference in the 12th week post-intervention follow-up skill of cardiopulmonary resuscitation among undergraduate Nurses in the intervention (digital app and physical training) and control groups. The effect size (Eta-Squared) is 0.927, with a confidence interval of 0.909 to 0.939. An effect size (Eta-Squared) of 0.927 indicates an extremely large effect, suggesting that the intervention (digital app and physical training) had a profound impact on the 12th week post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses. This substantial effect size implies that the intervention was highly effective, accounting for a major portion of the variance in CPR skill levels.

In order to determine the source of the significant differences observed, Post – hoc (Scheffe) analysis with mean difference was carried out in Table 7.

**Table 7:** Scheffe Post – hoc multiple range test of the 12th week post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses in the intervention and control groups

| Groups | | N | Mean | A | B | C |
|---|---|---|---|---|---|---|
| | | | | 19.19 | 18.37 | 4.91 |
| Digital Application | **(A)** | 93 | 19.19 | | | |
| Physical Training | **(B)** | 41 | 18.37 | | | |
| Control | **(C)** | 68 | 4.91 | * | * | |

* P < 0.05

In Table 7, significant differences were found between 12th week post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses in the digital application group and control group in favour of digital application group; and

physical training group and control group in favour of physical training group. However, there was no significant difference between 12th week post-intervention skill of cardiopulmonary resuscitation among undergraduate nurses in the digital application group and physical training group. It can be deduced through the mean mark in table 7 that undergraduate nurses exposed to digital application strategy performed best in 12th week post-intervention skill of cardiopulmonary resuscitation, followed by undergraduate nurses exposed to physical training while undergraduate nurses in the control group performed least.

**Research Hypothesis 3:** There is no significant effect in the skill mean scores of undergraduate Nurses exposed to digital application, physical training and control method before and after intervention.

**Table 8:** Analysis of Covariance for skill difference before and after intervention in the intervention and control groups

| Source | Sum of Square | df | Mean Square | F | Sig. | Partial Eta-Square | Observe Power |
|---|---|---|---|---|---|---|---|
| Corrected Mode | 8660.120ᵃ | 3 | 2886.707 | 848.667 | <.001 | .928 | 1.000 |
| Intercept | 2187.631 | 1 | 2187.631 | 643.145 | <.001 | .765 | 1.000 |
| Pre-Test | 20.422 | 1 | 20.422 | 6.004 | .015 | .029 | .684 |
| Groups | 8595.688 | 2 | 4297.844 | 1263.529 | <.001 | .927 | 1.000 |
| Error | 673.489 | 198 | 3.401 | | | | |
| Total | 49855.000 | 202 | | | | | |
| Corrected Total | 9333.609 | 201 | | | | | |

a.  R Squared = .928 (Adjusted R Squared = .927)

The result presented in table 8 shows that there is a significant effect in the skill mean scores of undergraduate Nurses exposed to digital application, physical training and control method before and after intervention. The high F-values and significant p-values (< .001) for the corrected model and groups indicate that the digital application and physical training interventions significantly improved CPR skills compared to the control group. The large Partial Eta-Squared values for both the corrected model (0.928) and groups (0.927) highlight that these interventions explain a substantial portion of the variance in skill scores, demonstrating their effectiveness.The R Squared (0.928) and Adjusted R Squared (0.927) values suggest that the model is robust and highly predictive, accounting for about 92.7% of the variance in post-intervention skill scores. The observed power of 1.000 for the significant predictors confirms the model's reliability and sensitivity in detecting true effects. This implies that educational programs incorporating these interventions can expect significant and reliable improvements in CPR skills among nursing students.

In order to find out the most probable effective strategy, Multiple Classification Analysis (MCA) was carried out. The result is shown in Table 9

**Table 9:** Multiple Classification Analysis (MCA) of undergraduate nurses' skill of CPR by treatment

| Grand Mean = 14.16 | | | | | |
|---|---|---|---|---|---|
| **Variable + Category** | **N** | **Unadjusted Dev'n** | **Eta²** | **Adjusted for Independ + Covariate** | |
| Digital Application | 93 | 4.79 | .927 | 4.72 | |
| Physical Training | 41 | 4.38 | | 4.29 | |
| Control | 68 | -9.17 | | -9.22 | |
| **Multiple R** **Multiple R²** | | | | | .963 .928 |

The result in Table 9 shows the Multiple Classification Analysis (MCA) of undergraduate nurses' skill of CPR by treatment. It reveals that, with a grand mean of 15.32, students exposed to digital application strategy had the highest adjusted mean score of 18.95(14.16+4.79). The unadjusted deviation from the grand mean is 4.79, indicating that participants in the digital application group scored, on average, 4.79 points higher than the grand mean. This was followed by the undergraduate nurses exposed to physical training with adjusted mean score of 18.54(14.16+4.38). The unadjusted deviation from the grand mean is 4.38, indicating an average increase of 4.38 points above the grand mean for this group. Lastly, control group had adjusted mean score of 4.99(14.16+(-9.17)). The unadjusted deviation from the grand mean is -9.17, indicating that control group participants scored, on average, 9.17 points below the grand mean. This means that undergraduate nurses exposed to digital application performed better than undergraduate nurses exposed to physical training and control method.

**Discussion**

The findings of the results indicated that there was no statistically significant difference in the entry skill of CPR among participants in the experimental and control groups, as evidenced by the non-significant F-cal value and the P value greater than 0.05. This suggests that the participants were homogeneous in terms of CPR skill level at the beginning of the study. This finding is crucial as it ensures the validity of subsequent statistical analyses, as mentioned in the conclusion. This aligns with the findings of Munezero et al. (2018), who concluded that participants had inadequate CPR skills at the pretest stage. This suggests that initial homogeneity in CPR skills, as observed in the current study, is not uncommon and underscores the importance of targeted training interventions to improve these skills.

*Immediate Post-Intervention*

The findings presented in the results indicate a significant difference in the immediate post-intervention skill of cardiopulmonary resuscitation (CPR) among undergraduate nurses across intervention (digital app and physical training) and control groups. The effect size, as indicated by Eta-Squared, is reported to be 0.926, demonstrating a profound impact of the intervention on CPR skills among undergraduate nurses. The exceptionally large effect size suggests that a substantial proportion of the variance in skill scores can be attributed to the intervention, highlighting its remarkable

effectiveness. This finding aligns with existing literature on CPR training effectiveness. For instance, Onyeaso (2016) demonstrated that CPR skills retained by secondary school students were statistically significant six weeks after training, emphasizing the potential for effective CPR training even among young learners. Additionally, Munezero et al. (2018) found a significant improvement in CPR skills among nurses following training, indicating the efficacy of structured CPR programs in enhancing healthcare professionals' skills.

This finding suggests that both interventions may be equally effective in improving CPR skills among undergraduate nurses, challenging the notion that one method may yield significantly better outcomes than the other.

### 12th Week Post-Intervention

The findings indicated a significant difference in the 12th week post-intervention skill of cardiopulmonary resuscitation (CPR) among undergraduate nurses in the intervention (digital app and physical training) and control groups. The effect size (Eta-Squared) of 0.927 suggests an extremely large effect, indicating that the intervention had a profound impact on CPR skill levels. This aligns with Munezero et al. (2018) supporting the effectiveness of CPR training interventions in improving skill levels among healthcare professionals after several weeks of intervention

Similarly, the findings reveal significant differences in the 12th week post-intervention CPR skill levels among undergraduate nurses in the digital application group and control group, as well as the physical training group and control group. However, there was no significant difference between the digital application group and physical training group. This is consistent with Onyeaso (2016) indicating that both digital applications and physical training methods can effectively improve CPR skills.

The mean marks suggest that undergraduate nurses exposed to the digital application strategy performed best, followed by those exposed to physical training, while those in the control group performed least. This supports the recommendation for incorporating CPR training into healthcare education curricula to enhance skill levels among students (Gebremedhn et al., 2017; Okonta & Okoh, 2015).

### Conclusion

The study aimed to examine the effects of various interventions on undergraduate nurses' skills in cardiopulmonary resuscitation (CPR). The findings indicate that the interventions significantly improved CPR skills among the participants, with substantial effect sizes ($\eta^2 = .919$ for skills). This consistency suggests that the interventions are equally effective for both male and female participants, highlighting the robust nature of the training methods employed. The Digital Application intervention is the most effective, closely followed by physical training. These results indicate that the Digital Application provides the best outcomes for enhancing CPR knowledge and skills among undergraduate nurses.

**Recommendations**

1. Healthcare institutions should implement digital CPR training applications as part of undergraduate nursing education programs to enhance CPR knowledge and skills among students.

2. Nursing schools and training centers should incorporate hands-on physical CPR training sessions alongside digital applications to provide a comprehensive learning experience for undergraduate nurses.

3. Nursing educators and administrators should encourage continuous professional development opportunities, including refresher courses and workshops, to ensure ongoing competence in CPR among practicing nurses.

4. Institutions should tailor CPR training programs to meet the specific needs of different groups, such as undergraduate nursing students, experienced nurses, and healthcare professionals in non-clinical roles.

5. CPR training programs should be designed to be gender-neutral, considering the non-significant impact of gender on CPR knowledge and skills, to ensure inclusivity and effectiveness for all learners.

6. Healthcare organizations should establish mechanisms for regular monitoring and evaluation of CPR training programs to assess their effectiveness and make necessary adjustments based on feedback and outcomes.

# REFERENCES

Adewale, B. A., Aigbonoga, D. E., Akintayo, A. D., Aremu, P. S., Azeez, O. A., Olawuwo, S. D., ... & Oguntoye, R. A. (2020). Awareness and attitude of final year students towards the learning and practice of cardiopulmonary resuscitation at the University of Ibadan in Nigeria. *African Journal of Emergency Medicine*, 11(1), 182-187.

Alsharari, A.O, Alduraywish, A., Ali-Zarea, E., Ibrahim Salmon, N., & Ali Sheikh, M. S. (2018). Current status of knowledge about cardiopulmonary resuscitation among University students in the northern region of Saudi Arabia. *Cardiology research and practice,* 2(2), 23-28.

Cortegiani, A., Russotto, V., Montalto, F., Iozzo, P., Meschis, R., Pugliesi, M., et al., (2019). Use of a Real-Time Training Software compared to instructor-based feedback for high-quality chest Compressions Acquisition in secondary School students: a Randomized Trial. *PLoS ONE*. 12(1):e0169591

Craig-Brangan, K.J., & Day, M.P. (2019). Update. 2017/2018 AHA BLS, ACLS, and PALS guidelines. *Nursing*; 49(2), 46–54.

Creutzfeldt, J., Hedman, L., & Felländer-Tsai, L. (2021). Effects of pre-training using serious game technology on CPR performance: an exploratory quasi-experimental transfer study. *Scand J Trauma Resusc Emerg Med.*, 20(1), 79.

Creutzfeldt, J., Hedman, L., Medin, C., Heinrichs, W.L. & Felländer-Tsai, L. (2020). Exploring virtual worlds for scenario-based repeated team training of cardiopulmonary resuscitation in medical students. *J Med Internet Res.,* 12(3), e38-e41.

Gebremedhn, E.G., Gebregergs, G.B., Anderson, B.B., & Nagaratnam, V. (2017). Attitude and skill levels of graduate health professionals in performing cardiopulmonary resuscitation. *Advances in Medical Education and Practice,* 8, 43-50.

Grasner, J.T., Lefering, R., Koster, R.W., Masterson, S., Böttiger, B.W., Herlitz, J., et al., (2016). EuReCa ONE-27 nations, ONE Europe, ONE registry: a prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. *Resuscitation*.105,188–95. https://doi.org/10.1016/j.resuscitation.2016.06.004

Hasselqvist, A.I., Riva, G. & Herlitz, J. (2018).Early cardiopulmonary resuscitation in out-of- hospital cardiac arrest. *N Engl J MedOverseas Ed.* 372, 2307–2315

Munezero, J.B.T., Atuhaire, C., Groves, S., & Cumber, S.N. (2018). Assessment of nurses knowledge and skills following cardiopulmonary resuscitation training at Mbarara Regional Referral Hospital, Uganda. *The Pan African Medical Journal*, 30,108-112

Niles, D. E., Nishisaki, A., Sutton, R. M., Elci, O. U., Meaney, P. A., O'Connor, K. A., & Berg, R. A. (2019). Improved retention of chest compression

psychomotor skills with brief "rolling refresher" training. *Simulation in healthcare: journal of the Society for Simulation in Healthcare,* 7(4), 213-219.

Nishiyama, C., Brown, S.P., May, S., Iwami, T., Koster, R.W. & Beesems, S.G. (2019) Apples to apples or apples to oranges? International variation in reporting of process and outcome of care for out-of-hospital cardiac arrest. *Resuscitation.* 85(1), 1599–1609

Okonta, K.E & Okoh, B.A. (2015). Theoretical knowledge of cardiopulmonary resuscitation among clinical medical students in the University of Port Harcourt, Nigeria. *Afr J Med Health Sci*, 14: 42-6.

Onyeaso, A.O., & Achalu, E.I. (2014). Knowledge of Cardiopulmonary Resuscitation among Some Secondary School Students in Nigeria. *Journal of Education and Practice*; 5(15), 1-5.

Panchal, A. R., Bartos, J. A., Cabañas, J. G., Donnino, M. W., Drennan, I. R., Hirsch, K. G., ... & Berg, K. M. (2020). Part 3: adult basic and advanced life support: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation,* 142(16_Suppl_2), S366-S468

Zheng, J., Du, L., Deng, X., Zhang, L., Wang, J & Chen, G (2022). Efficacy of virtual reality techniques in cardiopulmonary resuscitation training: protocol for a meta-analysis of randomised controlled trials and trial sequential analysis *BMJ* 12:e058827. http://dx.doi.org/10.1136/bmjopen-2021-058827).