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Effectiveness of application technology-based basic life support training method on cardiopulmonary resuscitation accuracy: A Systematic Review

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Abstract

Background: Professionals' knowledge and abilities can be enhanced by the effective and efficient use of technology in BHD training. In order to better study and assess the impact of application-technology based basic life support training techniques on the precision of cardiopulmonary resuscitation procedures, we plan to assess the existing research, which was published between 2014 and 2024.
Purpose: To examine application-technology-based basic life support training approaches affected the precision of cardiac resuscitation techniques.
Method: A systematic review with article selection guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The systematic review process begins with the formulation of clinical questions relevant to the topic. Before this, the authors establish PICOS criteria, which stand for: P (problem, patient, or population), I (intervention, prognostic factor, or exposure), C (comparison or control), O (outcome), and S (study design). For this article, P: Individuals who received Basic Life Support (BLS) training, I: Technology application-based BLS training method, C: Conventional BLS training method or no app-based training, O: Accuracy in performing cardiopulmonary resuscitation (CPR), and S: Randomized controlled trial. The article search was conducted systematically using the keywords: Basic Support" AND "Cardiopulmonary Resuscitation" AND "CPR training with application guideline" AND "Conventional CPR training" AND "Accuracy of CPR performance.
Results: Basic Life Support (BLS) instruction shows varying effects on knowledge and skills in administering Cardiopulmonary Resuscitation (CPR). Training using applications presents both advantages and disadvantages. One notable advantage is the use of digital platforms to deliver learning materials in a more interactive and dynamic way, thereby increasing trainees' accessibility to relevant and up-to-date information.
Conclusion: That technology-based Basic Life Support (BLS) training applications are effective in improving the accuracy of Cardiopulmonary Resuscitation (CPR). Applications featuring real-time feedback, Virtual Reality (VR) simulations, and interactive smartphone guides significantly improve the standard of CPR techniques and chest compressions in comparison to traditional approaches.

Keywords: Application Technology; Basic Life Support; CPR Accuracy; Training Method.

INTRODUCTION

One of the main causes of death worldwide, including in Indonesia, is cardiac arrest. Blood flow to the brain and the body as a whole is stopped when the heart stops beating. The American Heart Association (AHA) reports that over 350.000 cases of out-of-hospital cardiac arrest (OHCA) occur annually, with a just 10% probability of survival. Globally, cardiac arrest incidents occur in approximately 10 out of 10.000 individuals under the age of 35, totaling 300.000–350.000 cases per year. Cardiovascular

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diseases contribute to 17.8 million deaths annually, accounting for one-third of global deaths, with a national prevalence in Indonesia reaching 1.010.290 cases in 2018 (Hollenberg, Claesson, Ringh, Nordberg, Hasselqvist, & Nord, 2019).

Cardiac arrest, often triggered by electrical disturbances in the heart causing arrhythmia, is a medical emergency that requires immediate intervention. Without prompt treatment, it can result in death; however, it is reversible with timely and appropriate measure. A crucial intervention in such emergencies is Basic Life Support (BLS), a series of actions designed to restore and sustain vital organ functions, with The primary factor influencing a patient's survival during cardiac arrest is cardiopulmonary resuscitation, or CPR. Studies indicate that patients receiving high-quality CPR have significantly better survival outcomes, with a hospital discharge rate of 25.5% (Atkins, Berger, Duff, Gonzales, Hunt, Joyner, & Schexnayder, 2015).

Cardiopulmonary resuscitation (CPR) plays a critical role in maintaining circulatory flow and oxygenation to vital organs during cardiac arrest, especially before advanced medical help arrives. The effectiveness of CPR is influenced by several factors, including the depth and rate of chest compressions, minimal interruptions, and proper hand placement. According to the American Heart Association (AHA), chest compressions should be performed at a rate of 100–120 compressions per minute with a depth of at least 5 cm in adults, ensuring full chest recoil between compressions (Gabisa, & Wakuma, 2023). In recent years, the integration of technology into Basic Life Support (BLS) training such as mobile applications, virtual reality simulations, and feedback-equipped manikins has shown promising results in improving the quality and retention of CPR skills. These tools provide real-time feedback, visual guidance, and accessible learning platforms, making CPR training more interactive and effective for both healthcare providers and laypersons. Furthermore, increasing public access to CPR training and awareness campaigns can significantly enhance bystander response, ultimately improving survival rates in out-of-hospital cardiac arrest cases (Tuma, 2021).

Therefore, both healthcare providers and the general public, who may act as first responders, must understand and perform CPR effectively. BLS training plays a pivotal role in equipping individuals with the skills necessary for emergency cardiac arrest management, particularly in out-of-hospital settings. Cardiopulmonary resuscitation (CPR), activating emergency response systems, using an automated external defibrillator (AED), and recognizing the warning signs of cardiac arrest are all covered in this course (Syaripudin, Purbasari, & Marisa, 2022).

However, conventional training methods, such as lecture-based instruction, are often inadequate for developing critical thinking and practical skills. These traditional methods are inconsistent and insufficient for delivering high-quality training to participants. To address these limitations, innovative training approaches, including the use of technology-based applications, are essential. Technological advancements enable transformative educational approaches, including CPR training. Mobile application-based procedure guides offer adaptive and responsive training solutions tailored to participants' needs. These platforms enhance knowledge retention, facilitate individual progress monitoring, and provide interactive and personalized learning experiences. Consequently, integrating technology into BLS training holds significant potential to improve training quality, although attention must be given to content delivery and instructional design (Astuti, Sari, & Azizah, 2019).

RESEARCH METHOD

A systematic review with article selection guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The systematic review process begins with the formulation of clinical questions relevant to the topic. Before this, the authors establish PICOS criteria, which stand for: P (problem, patient, or population), I (intervention, prognostic factor, or exposure), C (comparison or control), O (outcome), and S (study design). For this article, P: Individuals who received Basic Life Support (BLS) training, I: Technology application-based BLS training method, C: Conventional BLS training method or no app-based training, O: Accuracy in performing cardiopulmonary resuscitation (CPR), and S: Randomized controlled trial.

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The article search was conducted systematically using the keywords: Basic Support" AND "Cardiopulmonary Resuscitation" AND "CPR training with application guideline" AND "Conventional CPR training" AND "Accuracy of CPR performance. The inclusion criteria required full-text articles, international publications, studies using cardiopulmonary resuscitation training interventions, randomized control trials or random clinical trial design methods, or quasi-experimental designs with control groups. The exclusion criteria studies that do not directly evaluate CPR accuracy or skills, articles that do not use experimental or quasi-experimental research designs (e.g. opinion, editorial, or literature review), publications in languages other than English or Bahasa Indonesia, studies that are not available in full-text.

The initial search resulted in 20 article from Science Direct, 26 from Pubmed and 60 from Pro Quest. After screening and filtering based on the predefined criteria, 10 articles met the inclusion criteria and were selected for further analysis.

RESEARCH RESULTS

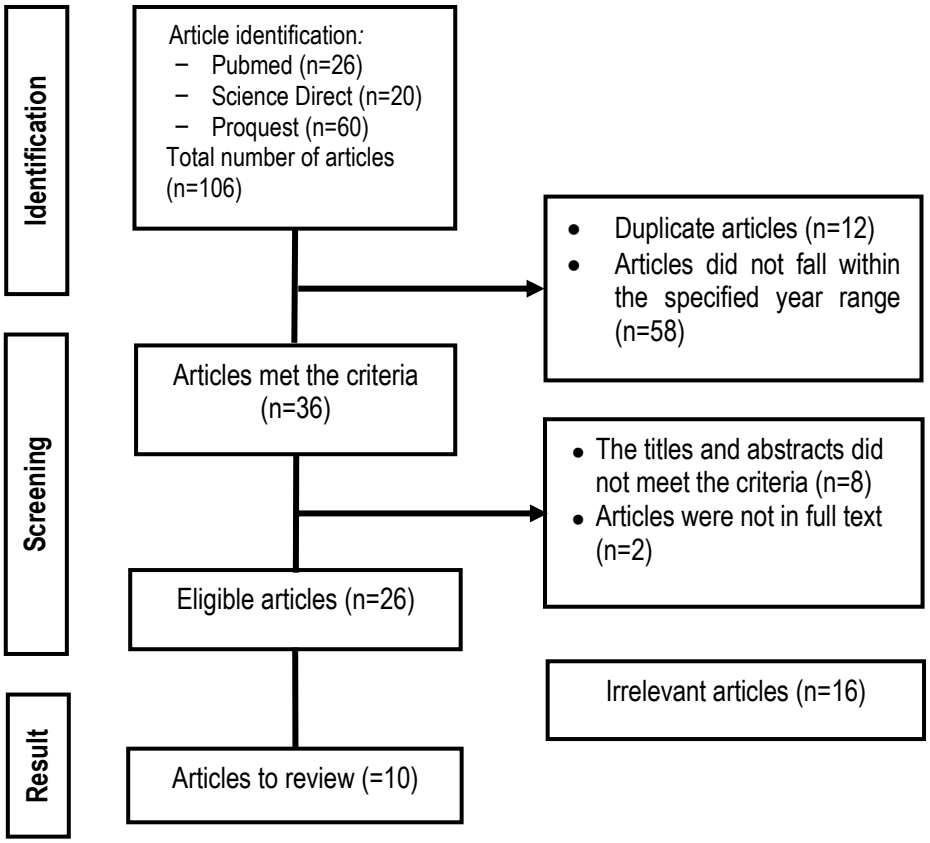


Figure 1. PRISMA Flow Diagram

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Table The Main Characteristics of Included Studies

Author (Year) (Country)	Purpose	Method	Results
(Moll-Khosrawi et al., 2022) (Germany)	Examine the relative efficacy of web-based and virtual reality (VR) training for Basic Life Support (BHD) during the COVID-19 pandemic.	The design used was Randomized Double Blinded Controlled Study, the sample was 97 first-year students who did not have symptoms of the disease during the Covid-19 pandemic. The sample collection technique used was purposive sampling.	According to the findings, the cardiopulmonary resuscitation (CPR) action interruption time for the intervention group was less than that of the control group (M = 6.46 s, SD = 3.49) (M = 11.05 s, SD = 14.89). In terms of learning outcomes, the intervention group felt more at ease completing the task than the control group did.
(González-Santano et al., 2020) (Spain)	Examine three different approaches to cardiopulmonary resuscitation (CPR) instruction: feedback manikins (FT), mobile phone applications (AP), and traditional training (TT).	The design used is Randomized Trial Study, the sample in this study were 30 lifeguards.	The results revealed a significant difference in the proportion of compressions with correct depth between the traditional manikin and the manikin with real-time feedback (30.8% (30.4) vs. 68.2% (32.6); p = 0.042). In terms of pressing quality, hand posture, and appropriate chest recoil, each group's percentage was above 70% of correct performance; the proportion for FT was greater (TT vs. FT; p < 0.05).
(Sakai et al., 2015) (Japan)	Examine the effectiveness of cardiopulmonary resuscitation (CPR) both with and without a recently created smartphone app that supports CPR.	The design used was Randomized controlled trial. The sample consisted of 84 participants aged ≥18 years	The results demonstrated that the intervention group using the CPR help app conducted considerably more chest compressions overall than the control group among those who performed chest compressions throughout the 2-minute test period (211.6 ± 29.5 vs. 77.0 ± 43.3, P<0.001). The intervention group using the CPR help app conducted more correct chest compressions than the control group (30.3±57.3 vs. 17.2±28.7, P=0.246), but the difference was not statistically significant.

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Author (Year) (Country)	Purpose	Method	Results
(Nord et al., 2016) (Swedia)	Comparing students' practical cardiopulmonary resuscitation (CPR) skills and willingness to perform bystander CPR, following mobile app-based training compared to DVD-based training	The research design used was a cluster randomized trial. The sample was 63 classes or 1232 seventh grade students aged (13 years).	At six months, the CPR abilities of the DVD-using group were superior than those of the app-using group; their respective total scores were 33 (30-36) and 31 (28-34) ($p<0.001$), and 36 (33-38) vs. 33 (30-36) right after training ($p<0.001$). In eight of the twelve CPR skill components, the DVD group's performance at six months was significantly better. Between baseline and follow-up, both groups experienced an increase in compression depth. Only 31 (DVD) against 32% (app) would provide basic CPR if the victim was a stranger, compared to 78% (DVD) versus 75% (app) who would perform compressions and breathing if a friend experienced cardiac arrest.
(Kitapcioglu et al., 2024) (Turkey)	In a metaverse setting, this study compares the learning results of educator-guided and machine-guided virtual reality (VR)-based training.	The research design used was Randomized controlled trial. A total of 62 volunteer students from the Vocational School of Anesthesiology of Acibadem Mehmet Ali Aydinlar University were randomly divided into 2 groups of 31 participants each: one group received machine-guided VR-based training (MG), and the other received educator-guided VR-based training (EG) in the metaverse.	The VR test results for the MG and EG groups did not differ statistically significantly. The EG group's VR exam results ranged from 11 to 100, with a median of 86. The median score for the MG group, on the other hand, was 66 (range 13-100; P=.08). The correlation between the amount of time spent training under machine or educator guidance and the outcomes of VR-based exams was determined to be =0.569 and P=.005 for the MG group. This correlation was determined to be =0.298 and P=.10 for the EG group.

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Author (Year) (Country)	Purpose	Method	Results
(Tanaka et al., 2019) (Japan)	To test whether the new QCPR Class training can produce higher quality chest compressions than standard CPR training	This study used a cluster randomized controlled trial methodology. 642 participants who were older than 15 made up the study sample.	The results of the study showed that 259 individuals in the control group and 238 participants in the QCPR Classroom Group were eligible for analysis. The QCPR Class group's average compression depth and speed after training were 59.5±7.9 mm and 116.8±5.5 cpm, while the control group's were 56.1±9.8 mm and 119.2±7.3 cpm. The QCPR Class group showed significantly more adequate depth than the control group (p=0.001). There was a 39.0% (95% CI 33.8 to 44.2; p<0.0001) increase in the QCPR Class group and a 20.0% (95% CI 15.4 to 24.7; p<0.0001) increase in the control group. The difference between adequate recoil before and after training in the control group and QCPR Class group was 22.6% (95% CI17.8-27.3; before 64.8±37.5% vs after 87.4%±22.9%; p<0.0001) and 2.7% (95% CI -1.7 to 7.1; before 64.2±36.5% vs after 66.9%±34.6%; p=0.23).
(Dong et al., 2020) (China)	Assess the impact of TCPRLink, a free smartphone software that offers audiovisual feedback and real-time monitoring while performing chest compressions (CC).	A randomized controlled trial design was employed in this investigation. The 186 adult study participants (ages 18–65) who had previously received T-CPR training were randomly assigned to the TCPRLink (n=94) and T-CPR (n=92) groups using age stratification.	Compared to the T-CPR group, participants in the TCPRLink feedback group needed fewer rhythm counts (21.3% vs 41.3%, p=0.003%, and 7% vs 22.6%, p=0.004) and CCed at a higher rate both at baseline and three months later (median 111 (IQR 109-113) vs 108 (103-112) min-1, p=0.002 and 111 (109-113) vs 108 (105-112) min-1, p<0.001). The hands-off time, CC complete release ratio, and CC start time did not change much. The TCPRLink group showed a deeper CC depth than the TCPR group in the 55–65 age range (47.1±9.6 vs. 38.5±8.7 mm, p=0.001 and 44.7±10.1 vs. 39.3±10.8 mm, p=0.07).

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Author (Year) (Country)	Purpose	Method	Results
(Peek et al., 2023) (Netherland)	Comparing CPR training using VR Simulation with CPR training using conventional methods.	A randomized controlled study is the type of research strategy used here. VR group (n = 15) and control group (n = 16) are the research samples.	According to the study's findings, the VR group made 11 mistakes overall, while the group that received traditional instruction made 15. The VR simulator was deemed practical and user-friendly by the participants. The results showed the VR simulator's ability to deliver adequate CSU-ALS training. Additionally, during VR training, less errors were produced, suggesting that skills can be improved through repeated practice in an immersive environment.
(Márquez-Hernández et al., 2020) (Spain)	Evaluating how well CPR simulation works with mobile phone-based apps versus phone operator support	The design used was RCT with Comparative study with two intervention groups. The sample involved was 128 nursing students at the University of Spain. The sampling technique used was simple random sampling.	The mobile app group was more proficient in 3A (X2 (1) ¼ 26.812; P < 0.05), asking for help (X2 (1) ¼ 66.074; P < 0.05), opening the airway (X2 (1) ¼ 12.025; P < 0.05), checking breathing (X2 (1) ¼ 6.104; P < 0.05), and summoning emergency services (X2 (1) ¼ 12.405; P < 0.05). While there was no difference in CPR proficiency, the mobile phone app group's compression quality differed significantly (U ¼ 1.593.000; Z ¼ 2,161; P < 0.05).
(Ratanarojanakul et al., 2022) (Thailand)	Comparing traditional classroom teaching techniques with tele-education for CPR knowledge and skills	A randomized controlled trial design was employed in this investigation. The sample for this study consisted of 45 individuals, ages 18 to 60.	Both groups' competence scores were similar in terms of evaluation, activation, and application of AED abilities. The conventional group outperformed the distance education group in terms of compression rate and compression for high-quality CPR performance parameters. Other measures of the high ventilation ratio showed similar results (p = 0.042 and p = 0.017).

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DISCUSSION

Technology-based and traditional CPR training methods have varied impacts on CPR accuracy and effectiveness. Recent trends emphasize the use of mobile applications and VR simulations that provide real-time feedback on compression depth and rate, improving BLS training outcomes. Studies across diverse participant groups including students, lifeguards, and healthcare professionals demonstrated the effectiveness of apps and VR tools compared to conventional methods. These technologies enhance accessibility, engagement, and personalized feedback, addressing limitations of instructor-led training (Wider, Ahmad, & Kadir, 2024).

The integration of advanced tools like AI, VR, and tele-education is crucial for improving CPR skills and increasing survival rates in cardiac arrest cases. The sequence and duration of CPR training varied across ten studies, each highlighting different methods and approaches. The first article compared web-based training with Virtual Reality (VR) based training. The control group attended a 60 minute BLS seminar and a 120 minute online demonstration, while the intervention group underwent VR training consisting of a 20-minute module introduction and a 35 minute training unit. Evaluations were conducted through structured clinical assessments under the supervision of the same instructor (Baharudin, Hartono, Hasan, Hasyati, & Grefti, 2022).

The reviewed articles compare various CPR training methods traditional, mobile app-based, feedback mannequins, VR simulations, and tele-education across different participant groups. Training durations ranged from 5 to 45 minutes, with evaluation tools like Resusci Anne QCPR and skill reporting mannequins used to assess chest compression accuracy and CPR performance. Methods incorporating real-time feedback, visual guidance, and simulations showed improved skill retention and performance. Overall, the studies highlight that training effectiveness is influenced by the method, duration, and feedback mechanism used, emphasizing the value of tailored, technology-enhanced CPR education (Ahmad, Musa, Kadir, Sharizman, Hidrus, Hassan, & Baddri, 2024).

Moreover, the integration of adaptive learning technologies such as artificial intelligence (AI) and augmented reality (AR) in CPR training holds great promise. These innovations allow for personalized feedback, scenario-based simulations, and real-time performance analysis, which can lead to more effective skill acquisition and retention. Future research is encouraged to explore long-term outcomes of these technology-based methods, including their impact on actual clinical performance and patient survival. In conclusion, while no single method fits all, a blended approach that combines the strengths of traditional and technology-driven training can maximize the effectiveness of CPR education and better prepare both laypersons and healthcare professionals in responding to cardiac emergencies (Li, Yi, Chi, Wang, & Chan, 2018).

The results of numerous research on Basic Life Support (BLS) training show the varied effects of technology-assisted treatments on the development of cardiopulmonary resuscitation (CPR) knowledge and abilities. The first study highlights that Virtual Reality (VR)-based BLS training significantly enhances CPR performance. By immersing participants in realistic scenarios, VR provides a safe and interactive learning environment that improves contextualization and learning outcomes. Its audiovisual features create an immersive experience, encouraging users to engage deeply with the environment and respond actively, thus optimizing skill development (Xie, Liu, Alghofaili, Zhang, Jiang, Lobo, & Yu, 2021).

The second study shows that feedback mannequins (FT) significantly enhance CPR quality by improving chest compression depth, hand placement, and recoil through realtime feedback. The third study highlights smartphone apps as effective tools in guiding users through the chain of survival, improving compression performance and training accessibility. In contrast, the fourth study finds DVD based training more effective than apps in teaching specific skills like airway management and ventilation ratios. Lastly, the fifth study on VR training in the metaverse finds no significant outcome differences between machine and instructor guided sessions but emphasizes the vital role of instructors in delivering personalized and adaptive training (Abdulzahra, & Shawq, 2024).

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QCPR Classroom, a system that provides real-time visual feedback during group training sessions, is introduced in the sixth research. When compared to traditional training, participants in the QCPR Classroom demonstrated notable improvements in chest compression depth and recoil. Real-time feedback enhanced overall CPR quality, aligning with the American Heart Association's (AHA) recommendations for integrating audiovisual feedback in training (Kong, Shin, Song, Ro, Hong, Park, & Myklebust, 2018).

The seventh study demonstrates that the TCPRLink app improves chest compression consistency by providing real time feedback during telephone assisted CPR, enhancing bystander performance. The eighth study highlights a VR simulator for post-cardiac surgery CPR, offering immersive, guideline based ALS training. The ninth study finds both mobile app and telephone operator guidance effective for initiating CPR, though with no significant differences in CPR metrics. The tenth study shows that tele-education is a practical alternative to conventional training, with comparable outcomes, particularly valuable in remote or emergency situations like the COVID-19 pandemic (Mishna, Milne, Bogo, & Pereira, 2021).

Overall, technological advancements have diversified BLS training methods, integrating interactive applications, VR simulations, and feedback systems to enhance learning. Nevertheless, traditional instructor led training remains a gold standard, offering unmatched guidance and skill refinement opportunities. Future efforts must ensure that digital tools are effectively designed and paired with high quality content to optimize learning outcomes while addressing limitations like reduced physical interaction and overreliance on digital instructions (Shahu, Kinzer, & Michaelles, 2023).

CONCLUSION

This systematic review finds that technology-based BLS training applications effectively improve CPR accuracy, especially through features like real-time feedback, VR simulations, and interactive smartphone guides. However, traditional instructor-led training still offers valuable personalized instruction. To optimize outcomes, a hybrid approach combining both methods is recommended, with improvements in app content, accessibility, and the integration of AI and AR for enhanced personalization and effectiveness.

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