MINH
MALAHAYATI INTERNATIONAL JOURNAL OF NURSING AND HEALTH SCIENCE
ISSN 2620-9152 (Print)
ISSN 2621-4083 (Online)
DOI: 10.33024
Nomor: 79/E/KPT/2023

ARTICLE INFORMATION
Received: December, 21, 2024
Revised: April, 27, 2025
Available online: April, 28, 2025
at : https://e-jurnal.iphorr.com/index.php/minh

Use of technology in efforts to improve cardiac arrest management: A systematic review

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

Abstract

Background: Cardiac arrest is a critical medical condition that occurs when the heart suddenly stops beating, causing the blood circulation to the entire body, including the brain, to stop. This can lead to brain damage or death. Basic Life Support (BLS) training is an essential element in creating a community that is responsive to medical emergencies. The implementation of BLS has been shown to increase the chance of Return of Spontaneous Circulation (ROSC) in patients experiencing Out-of-Hospital Cardiac Arrest (OHCA) by 40% each year.
Purpose: To review and evaluate studies on the use of technology in efforts to improve cardiac arrest management.
Method: A systematic literature review study to review and evaluate previous studies on the use of technology to improve cardiac arrest management skills, especially in Basic Life Support (BLS) training. The analysis focused on improving knowledge and skills among health workers and health students. The search for scientific articles was conducted from October-November 2024 using the PICO framework as a guide for article selection.
Results: Based on the 6 articles reviewed, the technologies used in BLS training include applications/software, virtual reality (VR), educational games, and video-based learning. Virtual reality with realistic simulations was identified as the most effective medium for improving participants' cognitive and psychomotor skills.
Conclusion: Technology plays a significant role in supporting the BLS learning process and improving the quality of medical actions, especially in cardiac arrest management.

Keywords: Cardiac Arrest; Management; Technology.

INTRODUCTION

Cardiac arrest is a critical medical condition that occurs when the heart suddenly stops functioning, causing a cessation of blood circulation throughout the body, including the brain. This can lead to brain damage or death (Perkins, Callaway, Haywood, Neumar, Lilja, Rowland, & Nolan, 2021). It is classified as a medical emergency with an extremely high mortality rate. Globally, more than 7 million deaths annually are attributed to cardiac arrest, making it one of the leading causes of death worldwide (Gaidai, Cao, & Loginov, 2023). In the United States alone, approximately 325,000 deaths per year are caused by cardiac arrest, accounting for 0.1–0.2% of all adult deaths (Karatasakis, Sarikaya, Liu, Gunn, Kudenchuk, Gatewood, & Branch, 2022).

Cardiac arrest can occur both in-hospital (In-Hospital Cardiac Arrest/IHCA) and outside the hospital (Out-of-Hospital Cardiac Arrest/OHCA). Approximately 50% of deaths related to coronary artery disease are associated with cardiac arrest (American Heart Association, 2022). Given the high incidence of this condition, comprehensive measures are essential to improve the quality of care for cardiac arrest patients, including Basic Life Support (BLS) training for healthcare providers, students, and the general public. BLS training is an integral part of preparing the public for medical emergencies, including cardiac arrest (Cheng, Magid, Auerbach, Bhanji, Bigham, Blewer, & Donoghue, 2020).

DOI: https://doi.org/10.33024/minh.v8i2.503

This training aims to provide basic knowledge and skills in life-saving interventions such as Cardiopulmonary Resuscitation (CPR), recognizing signs of cardiac arrest, and using tools such as Automated External Defibrillators (AEDs) (Berg, Cheng, Panchal, Topjian, Aziz, & Bhanji, 2020). With adequate training, the community, especially health workers, can provide high-quality BLS interventions to reduce mortality from cardiac arrest. According to previous research results, performing CPR and artificial respiration through BLS training can increase the chance of return of spontaneous circulation (ROSC) in OHCA patients by up to 40% per year (Yan, Gan, Jiang, Wang, Chen, Luo, & Lv, 2020),

Technology plays a vital role in enhancing the efficiency and effectiveness of BLS training. Advances in technology have enabled various innovations, such as computer-based simulations, Virtual Reality (VR) devices, and interactive CPR training applications, which provide participants with realistic training experiences without risk to patients (Demiray & Kiziltepe, 2022; Shatpattananunt, Petpichetchian, Pinsuwan, Chaloempong, Waraphok, & Wongwatkit, 2023). These technologies not only enrich participants' experience with real-life scenarios but also allow for direct skills evaluation and personalized training adjustments based on individual progress. During the COVID-19 pandemic, technologies like VR and online applications became critical solutions to ensure the continuity of training despite activity restrictions (Moll-Khosrawi, Falb, Pinnschmidt, Zöllner, & Issleib, 2022). VR has even been proven more effective in improving participant competence compared to traditional methods such as blended learning. Thus, integrating technology into BLS training enhances participants' cognitive and psychomotor skills, benefitting both healthcare professionals and the general public.

Several studies have documented the benefits of technology in health education. Previous research found that 3D simulation improved nursing students' knowledge and confidence in administering nasogastric tube feedings (Chao, Hu, Chiu, Huang, Tsai, & Chuang, 2021). Similarly, previous research reported that VR had a significant impact on nursing practice knowledge (Chen, Leng, Ge, Wang, Li, Chen, & Sun, 2020). However, despite the proven benefits of technology in nursing education, there has been limited in-depth evaluation of its effectiveness in BLS intervention training, a critical aspect of emergency care.

RESEARCH METHOD

A systematic literature review study to review and evaluate previous studies on the use of technology to improve cardiac arrest management skills, especially in Basic Life Support (BLS) training. The analysis focused on improving knowledge and skills among health workers and health students. The search for scientific articles was conducted from October-November 2024 using the PICO framework as a guide for article selection. Population/Problem (P) focuses on cardiac arrest management skills. Intervention (I) involves the use of advanced technologies such as software, websites, apps, computer-based simulations, and virtual reality (VR). Comparison (C) includes other methods used in the control group, while Outcome (O) describes improvements in cardiac arrest management skills, including knowledge and skills.

The article search was conducted using the Publish or Perish application. The publication period of the articles was limited to between 2018-2024, using keywords such as "software," "games," "nurses," "resuscitation," and "heart." Online databases used in this study include PubMed, Scopus, Crossref, Semantic Scholar, and Google Scholar. The inclusion criteria for article selection required respondents to be health workers or health students, the use of advanced technology in the education or training process, and research methods such as Randomized Controlled Trials (RCTs), experiments, or research and development (R&D). In addition, articles must be written in Indonesian or English.

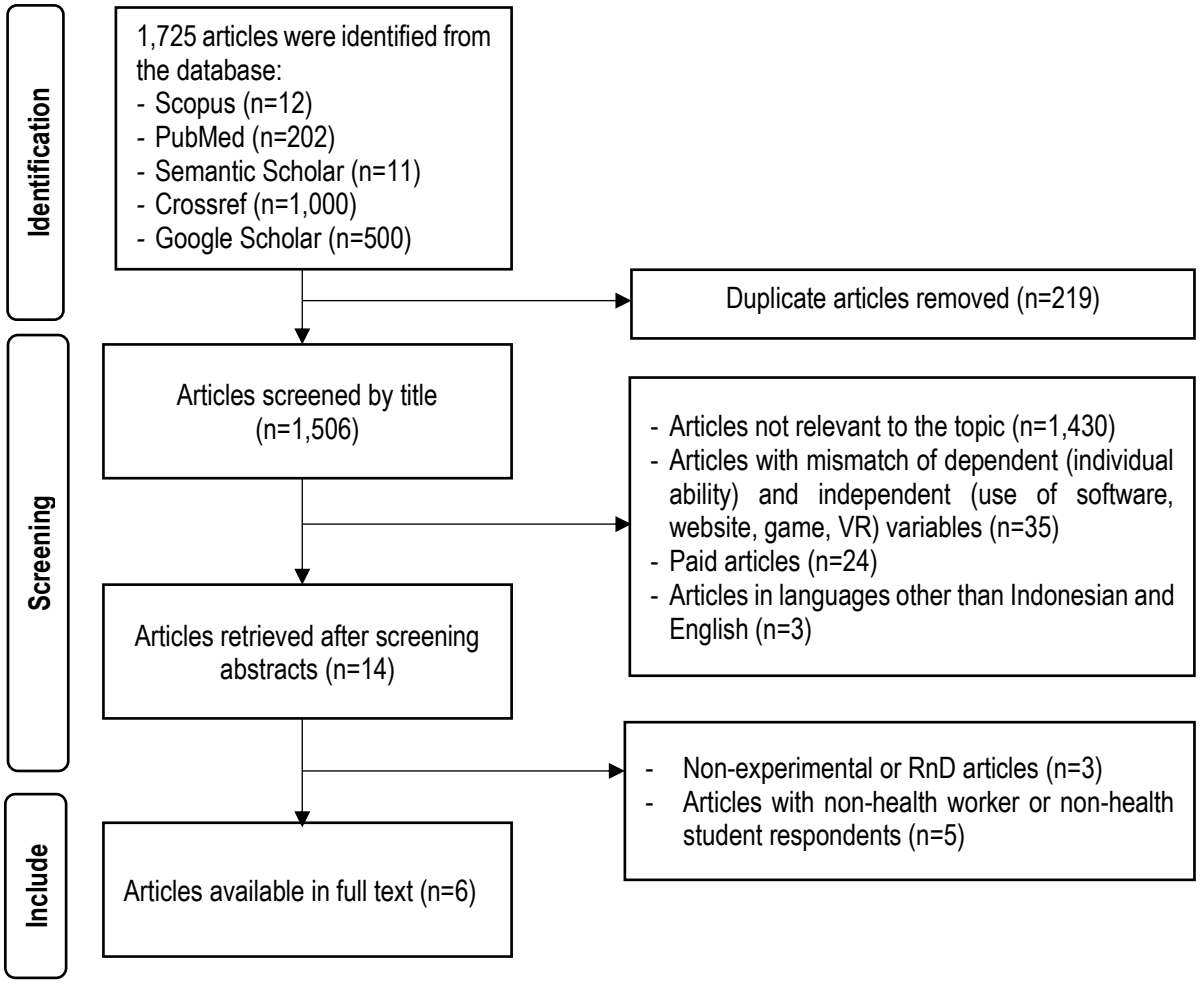
On the other hand, the exclusion criteria excluded articles that were inaccessible or not available in full-text format. The eligibility assessment focused on articles with experimental designs. Of the 1,725 articles identified, 6 articles met the inclusion and exclusion criteria. These articles were evaluated using the Joanna Briggs Institute (JBI) critical appraisal tool, adapted for quasi-experimental studies and RCTs. Based on the evaluation results, all six articles were deemed suitable for inclusion in this review.

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

RESEARCH RESULTS



Prisma Flow Diagram Figure

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

Article Data Mapping Results Table

(Author, Year) (Country)	Purpose	Method	Results
(Khayudin & Sugiyarto, 2024) (Indonesia)	To determine the influence of cardiac arrest management application media on the level of knowledge of nursing students.	This study uses a quasi-experimental pre- and post-test approach without control group. The sample used was 40 respondents with a questionnaire instrument.	Knowledge during the pre-test showed a category of less than 30%, sufficient 50% and good 20%, while during the post-test the category was sufficient 20% and good 80%. The Wilcoxon test results showed a p value of .000. Based on these results, there is an influence of the cardiac arrest handling application media on the level of knowledge.
(Wirawan & Arsa, 2020) (Indonesia)	To determine the effect of implementing Basic Life Support (BLS) based guidelines in handling Out Cardiac Arrest (OHCA) by Emergency Nurses in Health Centers.	Research and development (RnD) design with a sample size of 50 nurses, randomly divided into two groups, namely, the control group was given the Basic Life Support (BLS) module and the intervention group was given the Guide BLS application for 2 weeks. The instrument used was a questionnaire that evaluated the performance of Basic Life Support (BLS).	The intervention group showed precision variables (p = 0.000) and speed (p = 0.000) for the Wilcoxon Test and precision variables (p = 0.000) and speed (p = 0.000) for the Mann U Whitney Test. The basic android application can improve the accuracy and speed of nurses in performing BLS.
(de Sena et al., 2019) (Brazil)	To estimate the effect size of a serious game for cardiopulmonary resuscitation (CPR) training compared to a video-based online course on learning outcomes among medical students prior to	A randomized controlled trial using a sample of 45 randomly selected medical students. The instrument used was a CPR and AED evaluation questionnaire. Each participant was evaluated on a written multiple-choice test (theory test) and then on a cardiac arrest scenario (practice test) before and after exposure to the self-paced learning method.	Both groups experienced an increase in scores after exposure. The video group performed better on both the theory test (7.56±0.21 vs. 6.51±0.21 for the game group; p = 0.001) and the practical test (9.67±0.21 vs. 8.40±0.21 for the game group; p < 0.001). However, students showed a preference for using games, as indicated by the length of time they

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

(Author, Year) (Country)	Purpose	Method	Results
	simulation-based CPR using a manikin.		remained engaged in the method (18.57±0.66 minutes for the game group vs. 7.41±0.43 for the video group; p < 0.001).
(Fijačko et al., 2024) (California)	To investigate whether playing a serious smartphone game called MOBICPR at home can improve and maintain nursing students' theoretical knowledge and practical skills in adult BLS.	This study used a randomized, wait-list controlled design. Nursing students were randomly assigned in a 1:1 ratio to either the MOBICPR intervention group (MOBICPR-IG) or the wait-list control group (WL-CG), with the wait-list control group receiving the MOBICPR game 2 weeks after MOBICPR-IG. Participants' theoretical knowledge of adult BLS was assessed using a questionnaire, while their practical skills were evaluated on cardiopulmonary resuscitation quality parameters using a manikin and checklist.	There was a difference between MOBICPR-IG and WL-CG in theoretical knowledge (P=.04), but not in practical skills (P=.45) after playing the MOBICPR game at home. No differences were noted in retention of theoretical knowledge and practical skills of adult BLS participants after a 2-week break from playing the MOBICPR game (P=.13).
(Issleib et al., 2021) (Germany)	To compare conventional cardiopulmonary resuscitation (CPR) training with Virtual Reality (VR) training.	A randomized controlled trial using a sample of 160 medical students divided into two groups, namely the intervention group and the control group. The intervention group received a 35-minute VR Basic Life Support (BLS) course and basic skills training, while the control group received a "classic" BLS course with seminars and basic skills training. The instrument used was the Comparative Self-Assessment (CSA).	Time without flow was significantly shorter in the control group (Mean value: control group 82 seconds vs. intervention group 93 seconds; p = 0.000). On CSA, intervention group participants had higher learning gains on 6 of the 11 questionnaire items (p < 0.05).

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

(Author, Year) (Country)	Purpose	Method	Results
(Moll-Khosrawi et al., 2022) (Germany)	To explore the effectiveness of VR Basic Life Support (BLS) training compared to web-based training during the Covid-19 pandemic.	This randomized, double-blind, controlled study involved medical students. The control group received web-based BLS training, while the intervention group received additional individual VR BLS training. The primary endpoint was flow-free time, an indicator of BLS quality, assessed during the structural clinical examination, which also assessed overall BLS quality (secondary outcome). The tertiary outcome was undergraduate students' learning gains, assessed by comparative self-assessment (CSA).	The intervention group had significantly lower time without flow (p=.009) with a between-group difference of 28% (95%-CI [8%;43%]). The intervention group's overall BLS performance was also significantly better than the control group with a mean difference of 15.44 points (95%-CI [21,049.83]), p<.001. In the CSA, undergraduate students in the intervention group reported significantly higher learning gains.

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

DISCUSSION

A variety of technologies have been applied to improve cardiac arrest management skills, particularly in Basic Life Support (BLS), as discussed in this article. A Virtual Reality (VR)-based BLS course was applied individually (Issleib et al., 2021; Moll-Khosrawi et al., 2022). Another study used a smartphone-based game, MOBICPR, for nursing students' practice (Fijačko et al., 2024). In addition, previous studies, another simulation game developed in a 3D environment is known as the BLS-CPR Game Teaser (de Sena et al., 2019). In Indonesia, an Android-based application was used to improve the accuracy of compression and ventilation rhythms during BLS to improve nursing students' knowledge in managing cardiac arrest (Wirawan & Arsa, 2020; Khayudin & Sugiyarto, 2024).

The review article in this study used various processes to improve the ability of health workers to handle cardiac emergencies. Respondents were instructed to use specific application media, followed by an assessment of their knowledge and skills before and after the intervention (Wirawan & Arsa, 2020; Khayudin & Sugiyarto, 2024). The research process involved comparing the effectiveness of learning videos and simulation games. The intervention group was given 20 minutes to learn cardiac arrest management using a simulation game, while the control group only received a learning video (de Sena et al., 2019). Similarly, in a similar study, respondents were allowed to use the simulation game for two weeks before evaluating the results (Fijačko et al., 2024). In another study, the intervention group was trained using Virtual Reality (VR), while the control group received standard learning methods, such as seminars and practicums (Issleib et al., 2021; Moll-Khosrawi et al., 2022). However, VR was given to respondents for three days after completing online learning (Moll-Khosrawi et al., 2022).

Overall, the reviewed articles revealed various objectives and outcomes achieved. The use of application-based media showed a significant increase in knowledge and skills, especially in compression rhythm and ventilation accuracy with a p value of 0.00 (Wirawan & Arsa, 2020; Khayudin & Sugiyarto, 2024). In a comparison between video-based learning and simulation games, respondents who used videos showed better theoretical and practical results during the evaluation. However, they preferred the learning process using simulation games (de Sena et al., 2019). Meanwhile, in another study, simulation games significantly improved respondents' knowledge but had no significant effect on practical skills (Fijačko et al., 2024). Regarding the use of Virtual Reality (VR), two studies found no significant difference in "flowless time" between the intervention and control groups. However, in terms of performance and learning outcomes, VR has been shown to have a greater positive impact compared to standard learning methods (Issleib et al., 202; Moll-Khosrawi et al., 2022).

The utilization of advanced technology in health education has emerged as a significant innovation. These technologies offer a more interactive, flexible, and customizable approach to learning, enhancing the effectiveness of knowledge transfer and practical skill development (Elendu, Amaechi, Okatta, Amaechi, Elendu, Ezeh, & Elendu, 2024). For instance, mobile-based applications allow users to access information and training anytime and anywhere (Mitra & Gupta, 2020). Similarly, Virtual Reality (VR) creates realistic simulations that provide deep training experiences without direct risk to patients (Aiello, Cochrane, & Sevigny, 2023). Additionally, the use of educational games with gamification elements can boost motivation and engagement among learners (Yu, Gao, & Wang, 2021). While video-based learning delivers educational materials that can be revisited to reinforce understanding (Wong, Hosshan, Hanafi, & Mudiono, 2024). Overall, integrating these technologies not only facilitates the learning process but also holds the potential to improve the quality of healthcare personnel in a more efficient and measurable manner.

Advanced technologies, including applications/software, VR, educational games, and video-based learning, collectively play complementary roles in enhancing cognitive and psychomotor skills in cardiac arrest management. Applications and software provide interactive learning modules and algorithmic guides that can be accessed at any time, supporting cognitive skill improvement through mastery of theory and case-based scenarios (Tuma, 2021). In the psychomotor domain, some applications are equipped with real-time simulation features that enable users to practice fundamental skills such as chest compressions (Lim, Liao, Wang,

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

& Seah, 2022). VR offers realistic simulation-based training, allowing participants to practice cardiac arrest management in scenarios resembling real-life conditions without clinical risk. This strengthens psychomotor skills and aids in understanding the context of actions taken (Shorey & Ng, 2021). Educational games incorporate gamification elements to enhance participant engagement through challenge-based exercises, which not only reinforce theoretical knowledge but also encourage the repetitive practice of technical skills in an enjoyable manner (Feng, González, Mutch, Amor, Rahouti, Baghouz, & Cabrera-Guerrero, 2020). Video-based learning is vital in delivering educational content visually, including both theoretical concepts and practical demonstrations. These materials can be revisited to reinforce cognitive understanding while providing a visual reference for practicing technical skills (Olivier, 2021). The combination of these technologies creates a comprehensive and effective learning approach, significantly improving the competence of healthcare personnel in cardiac arrest management.

The effectiveness of using technology to improve cardiac arrest management skills shows mixed results. The application used in the first article only focuses on improving the cognitive aspect or knowledge of its users (Khayudin & Sugiyarto, 2024). In contrast, the second review article targets psychomotor learning, specifically improving skills in BLS compression and ventilation techniques (Wirawan & Arsa, 2020). This difference is related to the features provided by each application. Applications designed for cognitive learning often lack simulation features or real-time feedback that support skill development. Likewise, educational games and videos have shown significant results in improving cognitive aspects during the learning process (Olivier, 2021). However, VR stands out by offering a realistic simulation experience, allowing users to practice actions directly in scenarios that closely resemble real-world conditions. This makes VR very effective in improving cognitive and psychomotor skills (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020).

The use of technology in cardiac arrest training has both advantages and disadvantages that must be carefully considered. The primary advantage lies in its ability to provide interactive, flexible, and iterative learning methods, which enhance cognitive understanding and psychomotor skills (Krishnamurthy, Selvaraj, Gupta, Cyriac, Dhurairaj, Abdullah, & Ang, 2022). Applications and software offer instant access to step-by-step guides for cardiac arrest management. VR creates realistic simulations that closely replicate clinical conditions, educational games motivate participants through gamification, and video-based learning enables the repetition of materials to reinforce memory and practical skills (Krishnamurthy et al., 2022; Pallavicini, Pepe, Clerici, & Mantovani, 2022; Shorey & Ng, 2021). However, these technologies also have limitations. High procurement and maintenance costs, along with the need for adequate infrastructure, such as advanced hardware and stable internet connections, can be significant barriers. Additionally, technological gaps may exist in areas with limited resources. Technologies like VR and educational games often require initial adaptation by users, which can affect training effectiveness if not accompanied by additional training or support. Despite these challenges, with proper management and planning, advanced technologies hold significant potential to complement traditional learning methods in enhancing competence in cardiac arrest management (Baniasadi, Ayyoubzadeh, & Mohammadzadeh, 2020).

The limitations of this study primarily stem from restricted access to certain databases, which limited the scope of articles that could be analyzed. Additionally, the study focused exclusively on experimental articles involving healthcare professionals and health students with relevant backgrounds that supported successful learning outcomes. Despite these limitations, this research is expected to provide insights into the effectiveness of using technology in cardiac arrest management training. The findings aim to contribute to broader perspectives on implementing these technologies in wider public contexts, ultimately fostering a safer and more prepared community.

CONCLUSION

The use of technology to enhance cardiac arrest management skills has been widely implemented. The effectiveness of these technologies in improving individuals' knowledge and skills largely depends on the type of technology used and the learning process applied. Technologies such as applications/software,

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

VR, educational games, and learning videos have all been utilized. Among these, VR has proven to be one of the most effective tools in enhancing both theoretical knowledge and practical skills in cardiac arrest management.

REFERENCES

Aiello, S., Cochrane, T., & Sevigny, C. (2023). The affordances of clinical simulation immersive technology within healthcare education: a scoping review. *Virtual Reality*, *27*(4), 3485-3503.

American Heart Association. (2022). *Heart and Stroke Statistics: 2022 Update.* Retrieved from: https://cpr.heart.org/en/resources/cpr-facts-and-stats

Baniasadi, T., Ayyoubzadeh, S. M., & Mohammadzadeh, N. (2020). Challenges and practical considerations in applying virtual reality in medical education and treatment. *Oman medical journal*, *35*(3), e125.

Berg, K. M., Cheng, A., Panchal, A. R., Topjian, A. A., Aziz, K., & Bhanji, F. (2020). Part 7: systems of care: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*, *142*(16_Suppl_2), S580-S604.

Chao, Y. C., Hu, S. H., Chiu, H. Y., Huang, P. H., Tsai, H. T., & Chuang, Y. H. (2021). The effects of an immersive 3d interactive video program on improving student nurses' nursing skill competence: A randomized controlled trial study. *Nurse education today*, *103*, 104979.

Chen, F. Q., Leng, Y. F., Ge, J. F., Wang, D. W., Li, C., Chen, B., & Sun, Z. L. (2020). Effectiveness of virtual reality in nursing education: meta-analysis. *Journal of medical Internet research*, *22*(9), e18290.

Cheng, A., Magid, D. J., Auerbach, M., Bhanji, F., Bigham, B. L., Blewer, A. L., & Donoghue, A. (2020). Part 6: resuscitation education science: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*, *142*(16_Suppl_2), S551-S579.

de Sena, D. P., Fabrício, D. D., da Silva, V. D., Bodanese, L. C., & Franco, A. R. (2019). Comparative evaluation of video-based on-line course versus serious game for training medical students in cardiopulmonary resuscitation: a randomised trial. *PloS one*, *14*(4), e0214722.

Demiray, A., & Kiziltepe, S. K. (2022). The Effect of Computer Based Game on Improving Nursing Students' Basic Life Support Application Skills: Experimental Study. *Turkiye Klinikleri Journal of Nursing Sciences*, *14*(1).

Elendu, C., Amaechi, D. C., Okatta, A. U., Amaechi, E. C., Elendu, T. C., Ezeh, C. P., & Elendu, I. D. (2024). The impact of simulation-based training in medical education: A review. *Medicine*, *103*(27), e38813.

Feng, Z., González, V. A., Mutch, C., Amor, R., Rahouti, A., Baghouz, A., & Cabrera-Guerrero, G. (2020). Towards a customizable immersive virtual reality serious game for earthquake emergency training. *Advanced Engineering Informatics*, *46*, 101134.

Fijačko, N., Creber, R. M., Metličar, Š., Strnad, M., Greif, R., Štiglic, G., & Skok, P. (2024). Effects of a Serious Smartphone Game on Nursing Students' Theoretical Knowledge and Practical Skills in Adult Basic Life Support: Randomized Wait List–Controlled Trial. *JMIR serious games*, *12*(1), e56037.

Gaidai, O., Cao, Y., & Loginov, S. (2023). Global cardiovascular diseases death rate prediction. *Current problems in cardiology*, *48*(5), 101–114.

Issleib, M., Kromer, A., Pinnschmidt, H. O., Süss-Havemann, C., & Kubitz, J. C. (2021). Virtual reality as a teaching method for resuscitation training in undergraduate first year medical students: a randomized controlled trial. *Scandinavian journal of trauma, resuscitation and emergency medicine*, *29*, 1-9.

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503

Karatasakis, A., Sarikaya, B., Liu, L., Gunn, M. L., Kudenchuk, P. J., Gatewood, M. O., & Branch, K. R. (2022). Prevalence and patterns of resuscitation-associated injury detected by head-to-pelvis computed tomography after successful out-of-hospital cardiac arrest resuscitation. *Journal of the American Heart Association*, *11*(3), e023949.

Khayudin, B. A., & Sugiyarto, S. (2024). Pengaruh media aplikasi penanganan henti jantung terhadap tingkat pengetahuan mahasiswa keperawatan Poltekkes Kemenkes Surakarta. *Journal of Health Sciences Leksia (JHSL)*, *2*(5), 12-21.

Krishnamurthy, K., Selvaraj, N., Gupta, P., Cyriac, B., Dhurairaj, P., Abdullah, A., & Ang, E. T. (2022). Benefits of gamification in medical education. *Clinical Anatomy*, *35*(6), 795-807.

Lim, X. M. A., Liao, W. A., Wang, W., & Seah, B. (2022). The effectiveness of technology-based cardiopulmonary resuscitation training on the skills and knowledge of adolescents: systematic review and meta-analysis. *Journal of Medical Internet Research*, *24*(12), e36423.

Mitra, S., & Gupta, S. (2020). Mobile learning under personal cloud with a virtualization framework for outcome based education. *Education and Information Technologies*, *25*(3), 2129-2156.

Moll-Khosrawi, P., Falb, A., Pinnschmidt, H., Zöllner, C., & Issleib, M. (2022). Virtual reality as a teaching method for resuscitation training in undergraduate first year medical students during COVID-19 pandemic: a randomised controlled trial. *BMC Medical Education*, *22*(1), 483.

Olivier, M. (2021). *Utilizing a Deliberate Practice Model to Improve Quality Cardiopulmonary Resuscitation Knowledge, Psychomotor Skills, and Confidence* (Doctoral dissertation, Northwestern State University of Louisiana).

Pallavicini, F., Pepe, A., Clerici, M., & Mantovani, F. (2022). Virtual reality applications in medicine during the COVID-19 pandemic: systematic review. *JMIR Serious Games*, *10*(4), e35000.

Perkins, G. D., Callaway, C. W., Haywood, K., Neumar, R. W., Lilja, G., Rowland, M. J., & Nolan, J. P. (2021). Brain injury after cardiac arrest. *The Lancet*, *398*(10307), 1269-1278.

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & education*, *147*, 103778.

Shatpattananunt, B., Petpichetchian, W., Pinsuwan, S., Chaloempong, T., Waraphok, S., & Wongwatkit, C. (2023). Development and evaluation of a virtual reality basic life support for undergraduate students in Thailand: a project by Mae Fah Luang University (MFU BLiS VR). *BMC medical education*, *23*(1), 782.

Shorey, S., & Ng, E. D. (2021). The use of virtual reality simulation among nursing students and registered nurses: A systematic review. *Nurse education today*, *98*, 104662.

Tuma, F. (2021). The use of educational technology for interactive teaching in lectures. *Annals of Medicine and Surgery*, *62*, 231-235.

Wirawan, C. A., & Arsa, S. A. W. (2020). Development of Guide Basic Life Support (BLS) Application based on android to increase accuracy compression ritme and ventilation to handling of out hospital cardiac arrest. *Babali Nursing Research*, *1*(1), 18-30.

Wong, K. T., Hosshan, H., Hanafi, H. F., & Mudiono, A. (2024). Augmented reality (AR): An assistive technology for special education needs. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *35*(1), 97-105.

Yan, S., Gan, Y., Jiang, N., Wang, R., Chen, Y., Luo, Z., & Lv, C. (2020). The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. *Critical care*, *24*, 1-13.

Yu, Z., Gao, M., & Wang, L. (2021). The effect of educational games on learning outcomes, student motivation, engagement and satisfaction. *Journal of Educational Computing Research*, *59*(3), 522-546.

Erna Tri Andini*, Ridlwan Kamaluddin

Jurusan Keperawatan Fakultas Ilmu Kesehatan Universitas Jenderal Soedirman
Corresponding author: *E-mail: erna.kemkes@gmail.com

DOI: https://doi.org/10.33024/minh.v8i2.503