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Short paper

Resuscitation education science meets virtual and augmented reality: Evolution from potential concept to recommendations

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Abstract

Aim of the study: This study aims to examine the evolution of recommendations for integrating Virtual Reality (VR) and Augmented Reality (AR) into adult Basic Life Support (BLS) education over time.

Data sources: In December 2024, we conducted a two-phase search. First, we identified and reviewed publications available on the International Liaison Committee on Resuscitation (ILCOR) webpage, focusing on resuscitation education science, specifically addressing VR and/or AR in adult BLS education. In the second phase, we reviewed the references and citations of the included publication to identify relevant publications from the American Heart Association (AHA), European Resuscitation Council (ERC), and ILCOR.

Results: Across both phases, we included 29 AHA, ERC, and ILCOR publications on resuscitation education. These comprised 16 ILCOR CoSTRs, seven AHA/ERC guidelines (four ERC, three AHA), three ILCOR scientific statements, two AHA scientific statements, and one ILCOR review. The first mention of VR appeared in 2003, but the first recommendation was provided in 2020 AHA guidelines, suggesting its use for adult BLS training based on very low-quality evidence. In 2024, the ILCOR CoSTRs issued a weak recommendation supporting AR and a weak recommendation against VR for adult BLS training, both based on very low-quality evidence.

Conclusion: While VR/AR is gaining traction in resuscitation training, its effectiveness remains debated. Initially focused on professionals, it now extends to laypersons and schoolchildren. However, strong evidence is lacking. Future research should assess learning outcomes, guideline adherence, and patient impact to support stronger ILCOR recommendations.

Keywords: Extended reality, Virtual reality, Augmented reality, Adult basic life support, Review

Introduction

Basic Life Support (BLS) is a critical life-saving skill widely taught to improve survival rates in cardiac emergencies. The practice has been recommended for healthcare professionals since the 1960s and extended to the lay public in the 1970s.[1] These recommendations have driven the development of diverse adult BLS programs, utilizing various training methodologies, including instructor-led approaches and emerging alternatives like immersive technology.[2]

Immersive technology is increasingly utilized in healthcare to enhance and facilitate learning.[3] The most prominent examples are virtual reality (VR) and augmented reality (AR), now collectively known as extended reality or xReality (XR).[4] By 2024, the most widely used XR approach to teaching adult BLS content was VR in various forms,[5] immersing users in a fully digital environment. On the other hand, AR enhances the real world by overlaying digital elements.

While the International Liaison Committee on Resuscitation (ILCOR) endorses instructor-led adult BLS training and remains cautious about alternative methods such as XR, research has highlighted significant gaps in traditional training. Studies indicate that even certified instructor-led BLS courses often exhibit suboptimal adherence to guidelines, variability in instructor effectiveness, and inconsistencies in skill retention over time.[6,7] These limitations highlight the need to explore more standardized, scalable, and engaging

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training methods. Given these challenges, XR-based training has the potential to bridge these gaps by offering data-driven, immersive, and interactive learning experiences that reinforce adherence to resuscitation guidelines while ensuring consistency and accessibility in training.[5]

This review explores recommendations for or against integration of VR and AR into adult BLS education over the years.

Methods

In December 2024, we conducted the search in two phases. In the first phase, we identified and conducted a review of publications available on ILCOR webpage. Publications were included if they were published by American Heart Association (AHA), European Resuscitation Council (ERC), and/or ILCOR publication, with no specific time frame. Additionally, they were included if they addressed resuscitation education science and/or mentioned "immersive technology", "virtual reality", and/or "augmented reality" in adult BLS education, were conducted by ILCOR Education, Implementation, and Teams (EIT) Task forces, and were published in journals Circulation (AHA) and/or Resuscitation (ERC).[8] ILCOR EIT Task Force, establish in 2007,[†] reviews resuscitation education and implementation science, prioritizing questions based on literature, practices, and council submissions. Evidence updates ensure recommendations remain current, focusing on training populations, faculty development, instructional design, and knowledge transfer.

In the second phase, a references and citations review of included AHA, ERC and/or ILCOR publications was performed to identify additional relevant publications. Citations review was done by using Google Scholar (Google LLC, USA). These two methodological approaches were intentionally selected over other types of reviews, such as scoping or systematic reviews, because the latter would include all research records meeting specific search criteria. In contrast, this review focuses exclusively on literature relevant to resuscitation education recommendations, guidelines, and statements. References and citations were initially screened by title and included if they were published by the AHA, ERC and/or ILCOR, with no specific time frame. Additionally, they were included if they addressed resuscitation education science and/or mentioned "immersive technology", "virtual reality", and/or "augmented reality" in adult BLS education, were conducted by ILCOR EIT Task forces, and were published in journals Circulation and/or Resuscitation. Publications as ILCOR International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) that did not involve ILCOR EIT Task Forces and were not published in Circulation and/or Resuscitation journal were excluded.[8] Additionally, AHA/ERC guideline summaries were excluded because of duplication of included AHA/ERC guidelines chapters.

No information specialist was involved, as we did not use a predefined search strategy with keywords and Boolean operators. Instead, studies were selected based on predefined inclusion/exclusion criteria. Conflicts were resolved in consultation with RG both before and during the search. For example, CoSTR publications that also found in Pediatrics (American Academy of Pediatrics) journal were excluded.

Results

At the start of the first phase, we identified 61 publications, of which 45 were initially excluded for not meeting the criteria of being AHA, ERC, or ILCOR publications. From the remaining, we included ten ILCOR CoSTRs[9–17] and two ILCOR statements[18,19] after review. However, four ILCOR CoSTRs were excluded because they did not address resuscitation education science.[20–23] In the second phase, we identified 3,474 publications through references and citations from the first-phase publications. We excluded 3,445 publications for not meeting the criteria. Across both phases, we included a total of twenty-nine AHA, ERC, and ILCOR publications focusing on resuscitation education science.[5,9–19,24–39] These comprise sixteen ILCOR CoSTRs (10 from Phase 1 and 6 from Phase 2),[9–17,26,27,30,33,38,39] seven AHA/ERC guidelines[25,28,29,32,33,35,36]—four from the ERC,[25,29,32,36] and three from the AHA,[28,33,35] three ILCOR scientific statements (2 from Phase 1 and 1 from Phase 2),[18,19,24] two AHA scientific statements,[34,37] and one ILCOR review (Fig. 1).[5]

Fourteen of the twenty-nine AHA, ERC, and ILCOR publications did not address the evolving role of VR and AR in adult BLS education.[9,10,14–17,26–33] The first mention of VR appeared in 2003,[24] but the first recommendation appeared in the 2020 AHA guidelines for resuscitation education science, suggesting that **VR** may be considered for adult BLS training for both laypersons and healthcare providers, albeit based on very low-quality evidence.[35] In 2024, the ILCOR EIT Task Force conducted its first review,[5] and based on this, the 2024 ILCOR CoSTR[38,39] concluded that the use of **AR** for adult BLS training of laypersons and healthcare providers evolved from unreferenced concept to a weak recommendation based on very low-quality evidence. Conversely, the use of **VR** for adult BLS training of laypersons and healthcare providers evolved from unreferenced concept to a weak recommendation against its use, supported by very low-quality evidence (Fig. 2).[35,38,39]

Discussion

The journey of VR and AR in adult BLS education continues to evolve alongside advancements in technology and their application. In 2003, VR was recommended primarily for duty-to-respond personnel and healthcare professionals rather than laypersons. For these groups, the technology needed to be straightforward and cost-effective to ensure practical application and accessibility.[24] The 2023 ILCOR statement further emphasizes XR's potential to engage, motivate, and educate schoolchildren in adult BLS.[18,19] However, research involving this group should consider age restrictions, as most head-mounted displays are recommended for older users, and ensure that XR is designed to minimize risks such as cybersickness through careful testing.[5]

While ILCOR endorses instructor-led adult BLS training, research highlights gaps, including suboptimal guideline adherence, instructor variability, and inconsistent skill retention.[6,7] XR-based training can bridge these gaps with data-driven, immersive learning that enhances guideline adherence, consistency, and accessibility. However, XR is also highly heterogeneous, much like traditional

[†] Personal communication: Dr. Jasmeet Soar, Bath, UK (Co-chair if the ILCOR Task Force Education and Implementation at that time).

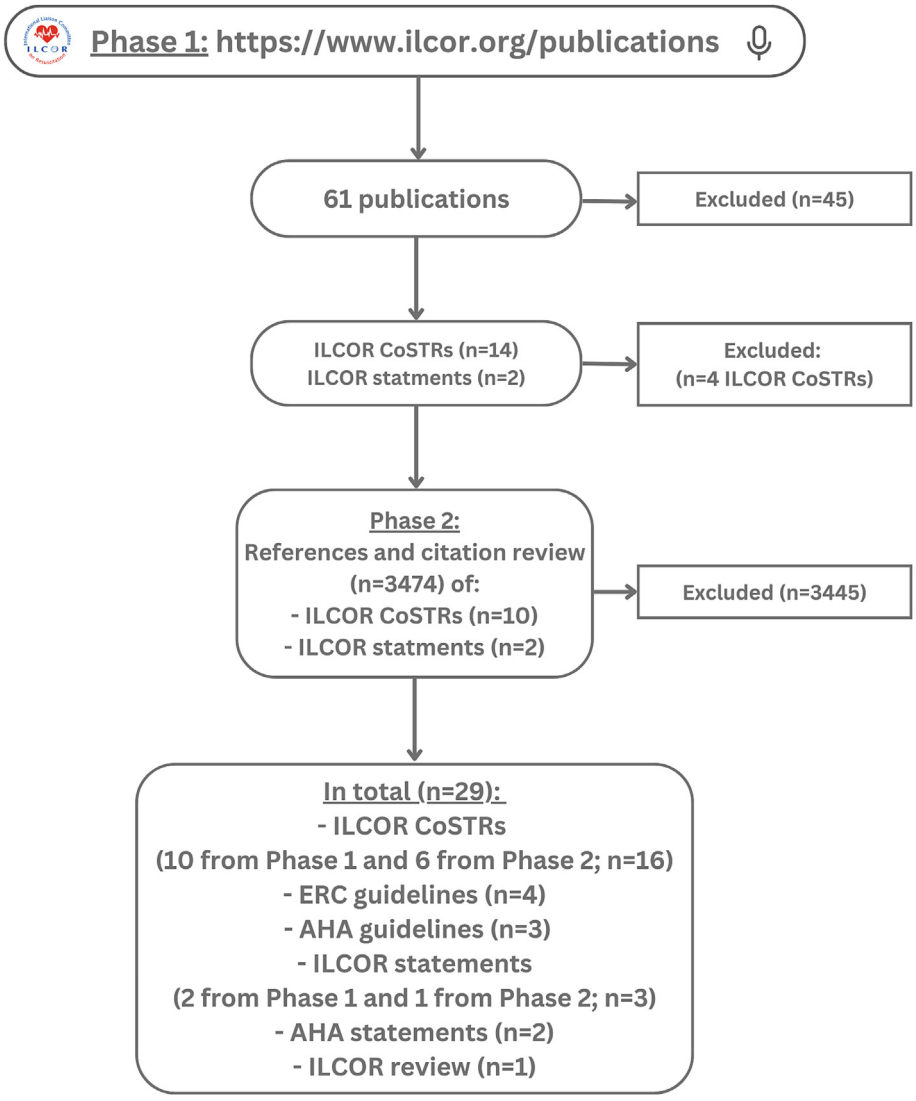

Fig. 1 – Flow diagram of inclusion of the AHA, ERC, and ILCOR publications.

instructor-led education, varying in content quality, instructional design, and delivery methods. To maximize its educational impact, XR solutions must be evidence-based, incorporating validated content and instructional best practices that align with established adult BLS guidelines.

Future XR studies could focus on investigating the relative and synergistic effects of immersive technology when integrated with other educational strategies to enhance learning outcomes. Additionally, they could assess the impact on both short-term and long-term retention of knowledge and skills, providing evidence for the sustained effectiveness of XR in training scenarios.[5] XR education should evaluate not only its impact on learning outcomes but also its effect on patient and population outcomes, determining whether this educational strategy contributes to improved prevention and treatment of cardiac arrest. To issue stronger ILCOR recommendations, more high-quality, high-stakes high level evidence is needed.

Limitations

This review has several limitations. It is restricted to adult BLS and only considers two ILCOR Council Guidelines—the AHA and ERC. Due to the chosen methodology, some AHA/ERC/ILCOR publications may have been overlooked. Notably, the Google Scholar citation review retrieved only ILCOR CoSTRs published in Circulation, with none from Resuscitation. However, this is unlikely to impact the results, as both journals reference the same source material.

Conclusions

While XR have gained traction as educational tools, their role in resuscitation training remains subject to ongoing debate. Early adoption focused on professional training, but recent advancements have expanded their applicability to laypersons and schoolchildren. How-

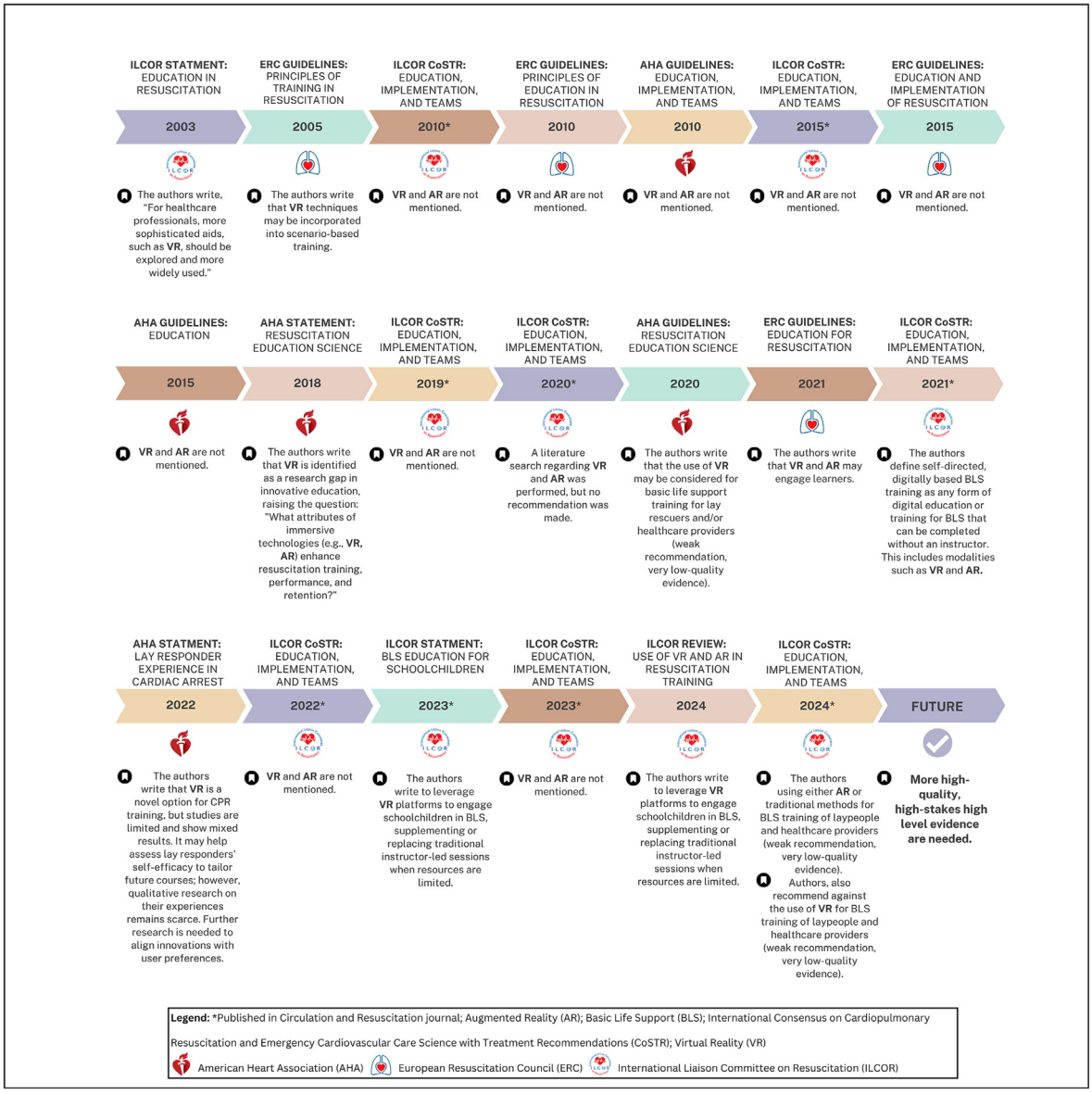

Fig. 2 – Timeline of virtual and augmented reality integration in resuscitation education guidelines and recommendations.

ever, strong evidence supporting their effectiveness compared to traditional methods is still limited. Future research should prioritize rigorous studies evaluating learning outcomes, guideline adherence, and patient impact. To strengthen ILCOR recommendations, high-quality evidence is needed to determine the optimal role of VR and AR in adult BLS education.

CRediT authorship contribution statement

Nino Fijačko: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Manuel Pardo Rios:** Writing – review & editing, Methodology. **Federico Semeraro:** Writing – review & editing, Data curation. **Vinay M Nadkarni:** Writing – review & editing, Supervision, Methodology, Data curation. **Robert Greif:** Writing – review & editing, Supervision, Methodology, Data curation.

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Conflict of interest

NF is a member of the ERC BLS Science and Education Committee. MPR is a member of the ERC and the Spanish Society of Emergency Medicine. FS is the Chair of the European Resuscitation Council, an Emeritus member of the ILCOR BLS Working Group, and a member of the Italian Resuscitation Council Foundation. VN is the past-board chair of ILCOR, an emeritus member of the ILCOR Pediatric Task Force, editorial board of Resuscitation journal and Pediatric Critical Care Medicine journal. RG is ERC Director of Guidelines and ILCOR, and ILCOR Task Force chair for Education Implementation and Team; and member of the editorial board of Resuscitation Plus.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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