[h1] European Resuscitation Council Guidelines 2025: Systems Saving Lives

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[h1] Abstract

The European Resuscitation Council (ERC) developed the Systems Saving Lives guidelines, based on the 2025 ILCOR Consensus on Science with Treatment Recommendations (CoSTR). These guidelines address various topics including the chain of survival, advocacy, CPR awareness campaigns, Kids Save Lives, resuscitation in low-resource settings, social media, first responders, EMS organisation for cardiac arrest, in-hospital cardiac arrest management, cardiac arrest centres, system performance improvement, survivors, and new technologies and artificial intelligence.

[h1] Keywords: cardiac arrest, systems saving lives, emergency medical service, first responders, awareness campaign, advocacy, survivors, co-survivors, kids save lives, world restart a heart, low resource settings, in-hospital cardiac arrest, cardiac arrest centres, social media, artificial intelligence.

[h1] Introduction

This ERC Guideline 2025 on Systems Saving Lives explains how various factors can work together to improve the care of cardiac arrest patients, not through isolated actions, but via a comprehensive, system-level strategy. This chapter aims to present the best practice based on the highest quality evidence available, regarding interventions that healthcare systems can implement to improve outcomes from cardiac arrests occurring both outside and inside hospital settings.
The intended audience includes governments, stakeholders in health and education systems, healthcare professionals, educators, students, laypeople, and communities affected by cardiac arrest.

The importance of the Systems Saving Lives approach to cardiac arrest is highlighted within the chain of survival. Key components include cardiac arrest centres, rapid response teams to prevent in-hospital cardiac arrest (IHCA), and the collaboration among community, emergency medical services (EMS), and hospital healthcare professionals. This system involves everyone, from schoolchildren learning CPR to community members ready to initiate resuscitation after receiving alerts on their mobile phones. The latest ERC guidelines extend their relevance to low-resource settings, recognising the need for adaptable solutions beyond high-resource healthcare environments.

These guidelines are derived from the previous Consensus on Science with Treatment Recommendations (CoSTR) provided by the International Liaison Committee on Resuscitation (ILCOR).[1] The ERC Systems Saving Lives writing group has used published systematic reviews and scoping reviews, alongside the CoSTR document. This process includes thorough consideration of evidence-to-decision tables, narrative reviews, task force discussions, and justifications during the development of these guidelines. For topics not reviewed by ILCOR, other reviews, single studies, surveys, or expert consensus from the writing group members have been used to inform this guideline.

The methodology used for guideline development is presented in the executive summary.[2] The guidelines were posted for public comment on dd.mm.yyyyy. A total of [INSERT NUMBER] individuals from [INSERT COUNTRIES] submitted [INSERT NUMBER] comments, leading to [INSERT CHANGES] in the final version. Feedback was reviewed by the writing group and updates were made where relevant. The Guidelines were presented to the ERC Board and approved by the ERC General Assembly on dd.mm.yyyyy.

The executive summary outlines the methodology used in developing the guideline. The term cardiopulmonary resuscitation (CPR) in this Systems Saving Lives guideline refers to the entire resuscitation procedure, not just chest compression and ventilation. The term 'co-survivors' includes family members, significant others, close friends, or next of kin.

Table 1. Key messages of Systems Saving Lives
1. A simple, four-link Chain of Survival is an effective model to help everyone involved in resuscitation understand life-saving systems.
2. Survival depends on the interaction between science, education and implementation, guided by the 'Formula for Survival'.
3. Government leadership is essential – through policy, public campaigns, mandatory CPR training and stakeholder coordination.
4. School-based CPR education must be mandatory, beginning from age 4 and progressing in complexity, supported by legislation and innovative tools.
5. Community engagement is critical, including CPR training at public events and participation in global campaigns such as *World Restart a Heart (WRAH)*.
6. Social media and digital tools can support CPR education and community mobilisation.
7. First responder systems should be integrated with dispatch centres, prioritising AED accessibility, responder safety and psychological support.
8. Early EMS recognition of cardiac arrest and guidance on public AED use are vital for timely intervention.
9. AEDs must be accessible, and all ambulances attending out-of-hospital cardiac arrest (OHCA) must carry defibrillators.
10. Hospitals must be prepared for OHCA, including supporting family presence during CPR and establishing referral pathways to cardiac arrest centres.
11. Guidelines must be adaptable to context and resource settings, using local data and cultural insight while clearly reporting the respective setting in research and publications.
12. All organisations managing cardiac arrest should implement continuous quality improvement strategies.
13. Resuscitation systems must be tailored to local contexts, using local data and reflecting available resources.

14.	Collaboration among national resuscitation councils, survivor organisations and healthcare systems is key to strengthening the Chain of Survival.
15.	Artificial intelligence and digital health tools show promise but are not yet ready for routine use – restrict them to controlled research settings.

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[h1] Summary of key changes or new evidence

Table 1. The major changes in the 2025 guidelines for title of the chapter.

ERC Guidelines 2021	ERC Guidelines 2025
The chain of survival and formula of survival Both describe a series of actions linking a person who experienced sudden cardiac arrest to survival. Emphasis was placed on combining high-quality science with effective education for both laypeople and healthcare professionals. The guidelines highlighted the importance of implementing resource-efficient systems of care that could improve survival rates following cardiac arrest within healthcare systems.	**The chain of survival and formula of survival** Expansion of the concept, presenting the chain of survival as part of a broader Systems Saving Lives approach. It is designed for all stakeholders, laypersons, healthcare professionals, educators, and policymakers. The preservation of a four-link chain format provides consistency, while also enabling an expanded, multifaceted concept tailored to specific situations or target audiences. The focus is on integrating the chain into public awareness, education, and system-wide resuscitation efforts.
	Advocacy This new recommendation emphasises advocacy by encouraging governments, local authorities, and national resuscitation councils (NRCs) to promote policies that improve survival and quality of life following cardiac arrest. Key actions include public awareness campaigns (e.g., World Restart a Heart - WRAH), mandatory CPR training in schools and for drivers (e.g., Kids Save Lives), and enhancing workplace emergency preparedness (e.g., Alliance for Workplace Awareness & Response to Emergencies -AWARE). Collaboration with stakeholders aims to promote engagement with EU legislative bodies and local governments to support cardiovascular health and harmonise CPR policies (e.g., the European Alliance for Cardiovascular Health). Major sporting events and public gatherings

	serve as key platforms for promoting CPR training to diverse and large audiences.
Community initiatives to promote CPR implementation European Restart a Heart Day (ERHD) & World Restart a Heart (WRAH). Awareness efforts were divided into two distinct areas: European Restart a Heart Day (ERHD) and World Restart a Heart (WRAH), and community initiatives. National resuscitation councils, governments, and local authorities were encouraged to engage in WRAH, raise public awareness about bystander CPR and automated external defibrillator (AED) use, train large numbers of citizens, and develop life-saving systems and policies. Separately, healthcare systems were urged to implement widespread community CPR training programmes at various levels, from local neighbourhoods to entire nations.	**Awareness campaigns and initiatives to promote CPR** The former topics were merged under a unified focus. NRCs, governments, and local authorities are encouraged to support community basic life support (BLS) training initiatives and actively participate in WRAH. The aim is to raise public awareness of bystander CPR and the use of automated external defibrillators (AEDs) to efficiently train as many people as possible, and to develop innovative policies and systems to improve survival outcomes.
Kids Save Lives The Kids Save Lives initiative recommended annual CPR training for all schoolchildren, focusing on the Check–Call–Compress method. It encouraged children to teach at least ten others within two weeks, creating a multiplier effect. CPR training was also promoted for students in higher education, particularly those in healthcare and teaching fields. The guidelines called for Ministries of Education and political leaders to implement mandatory CPR education by law across Europe and beyond.	**Kids Save Lives** The initiative has been expanded and made more structured. Basic life support (BLS) training is to start as early as age four. Training progresses gradually, introducing more complex skills as children mature. Children are encouraged to train family and friends using take-home training CPR kits. Technology-enhanced learning (e.g. virtual reality, serious games, apps) has been introduced to complement traditional education. Mandatory BLS education is reinforced through legislation, funding, and national public awareness campaigns.
Low-resource settings The focus was on the need for more research into cardiac arrest in low-resource settings, emphasising the importance of understanding different populations,	**Resuscitation in low-resource settings** The approach is now more streamlined and practical. It continues to promote research on populations, causes, and outcomes of cardiac arrest, with

aetiologies, and outcomes while following the Utstein guidelines, and of considering psychological and sociocultural factors. Experts from diverse settings were to be consulted to ensure that guidelines were acceptable and applicable locally. Additionally, the development of a list of essential resuscitation resources specifically tailored for low-resource environments was recommended, in collaboration with local stakeholders.	adherence to reporting standards (e.g. Utstein style), and highlights the importance of including information about the respective resource setting (e.g., income classification) in publications. Cultural considerations should ensure that guidelines are regionally acceptable and implementable. Adaptations of the guidelines for specific resource settings—such as remote areas or alpine regions—are suggested when standard guidelines are not feasible.
	Social media New recommendations highlight social media platforms to be used to enhance public awareness, education, and community engagement in basic life support (BLS) and sudden cardiac arrest. Schools, universities, and healthcare institutions are encouraged to integrate short videos, interactive content, and live sessions into BLS training programmes. Such content should be validated by experts to ensure alignment with international guidelines. Additionally, the effectiveness of social media initiatives should be continuously monitored to assess their impact on BLS training outcomes, bystander CPR rates, and hopefully patient survival.
Social media and smartphones apps for engaging the community The focus was on encouraging European countries to implement smartphone applications or text alert systems to notify trained and untrained first responders—including laypersons, police, firefighters, and off-duty healthcare professionals—of nearby out-of-hospital cardiac arrests (OHCA). The goals were to increase bystander CPR rates, reduce the time to first	**First Responders** The approach is now more structured and comprehensive. All healthcare systems are advised to implement first responder programmes dispatched by EMS and linked to AED registries, covering both public places and private residences. New emphasis is placed on ensuring the physical safety and psychological support of first responders. Additionally, cardiac arrest events should be

chest compressions and shock delivery, and improve survival with good neurological outcomes.	reported using standardised methods to monitor system performance and drive continuous quality improvement.
Role of dispatcher The focus was primarily on the role of dispatchers in the early recognition of cardiac arrest and the delivery of dispatcher-assisted CPR instructions. Dispatch centres were encouraged to use standardised algorithms to quickly identify cardiac arrest during emergency calls and to continuously monitor and improve their ability to recognise these cases. There was a strong emphasis on ensuring that call handlers provided clear instructions for chest compression-only CPR to callers dealing with unresponsive adults who were not breathing normally, reinforcing the importance of immediate bystander intervention guided by dispatchers.	**EMS organisation in response to cardiac arrest** The scope has expanded beyond dispatcher roles to encompass a more comprehensive approach involving the entire EMS system. Standardised algorithms for cardiac arrest recognition remain important, but there is an added focus on public-access AED deployment, ensuring AEDs are easily accessible, and equipping all OHCA ambulances with defibrillators. EMS organisations are encouraged to establish prehospital critical care teams, including strategies to maintain team members' resuscitation skills. Additionally, systems are advised to implement structured decision-making processes, including termination of resuscitation (TOR) protocols, to improve patient outcomes and optimise care during cardiac arrest responses.
Early warning scores, rapid response systems, and medical emergency teams The focus was mainly on recommending the introduction of rapid response systems (RRS) to reduce in-hospital cardiac arrests and related mortality. The guidelines highlighted the importance of early recognition and intervention but provided limited detail on additional strategies.	**In-hospital cardiac arrest management** The recommendations have expanded significantly. While rapid response systems remain central, the updated guidelines place a greater emphasis on broader strategies for improving system-wide performance.
Cardiac arrest centres The recommendation was that adult patients with non-traumatic out-of-hospital cardiac arrest (OHCA) should be considered for transport to a cardiac arrest centre, based on existing local protocols. The emphasis was on following established procedures to determine whether	**Cardiac arrest centres** The guidance has evolved to strongly advocate that adult patients with non-traumatic OHCA should be cared for at a dedicated cardiac arrest centre whenever possible, reinforcing the importance of specialised post-arrest care. Additionally, there is an

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patients would benefit from being taken to specialised centres; however, there was limited guidance on broader system organisation or the development of networks to support these decisions.	emphasis on healthcare systems establishing and maintaining formal cardiac arrest networks with clear local protocols. This is a shift from only recommending transport decisions to encouraging the development of structured regional systems aimed at improving outcomes through coordinated care.
Measuring the performance of resuscitation systems The focus was on encouraging organisations and communities that manage cardiac arrest to evaluate their system performance and identify key areas for improvement. The emphasis was on assessment and measurement, aiming to understand how effectively resuscitation systems were functioning and to use that information to guide improvements in performance.	**System performance improvement** The guidelines now emphasise the proactive implementation of system improvement strategies designed to optimize patient outcomes in cardiac arrest care. The language has shifted from simply evaluating performance to implementing structured, proactive approaches. This reflected a broader, more outcome-driven focus on ensuring resuscitation systems not only measure their effectiveness but also systematically apply strategies to optimise care and survival rates.
	Survivorship and co-survivorship New recommendations emphasise the importance of survivorship and co-survivorship in cardiac arrest care, promoting a shift towards holistic, patient- and family-centred care beyond the initial resuscitation phase. Healthcare systems should develop multidisciplinary policies to support survivors and their co-survivors from pre-discharge through long-term follow-up. Training healthcare professionals to address these needs, fostering collaboration with survivor organisations, and involving survivors, co-survivors, and the public in policy development and research are also highlighted.
	New technologies and artificial intelligence

	This new recommendation highlights the emerging role of artificial intelligence (AI) and digital health technologies in improving outcomes after cardiac arrest. While these innovations show significant potential to enhance early recognition, optimise resuscitation efforts, and support post-resuscitation care, they are not yet ready for widespread, routine clinical implementation. Their current use should be restricted to research projects or controlled environments, where safety, effectiveness, and ethical considerations can be carefully evaluated. Ongoing studies and pilot programmes are encouraged to further assess their impact and guide future integration into clinical practice.

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[h1] Concise guidelines for clinical practice

[h2] The Chain of Survival

- The Chain of Survival is a concept that summarises the complex Systems Saving Lives approach. It is intended for everyone involved in resuscitation care, including laypersons, healthcare professionals, educators, and stakeholders. The concept can be used for a variety of purposes, ranging from raising awareness to inclusion in educational materials.
- For simplicity and consistency, the four-link format is used by the ERC.
- For specific situations or target audiences, a multifaceted chain system (i.e., the basic Chain of Survival plus additional elements) may be applied.

[h2] The Formula of Survival

- The Formula of Survival depicts the overarching system behind a successful Chain of Survival and its underlying factors. It can be used to highlight the complex interaction of science, education and implementation to achieve optimal outcomes.
- The three interactive factors are: Science (referring to the continuous evaluation of evidence by ILCOR and the development of evidence-informed guidelines by the ERC); Education (referring to resuscitation training for those who may potentially, or actually take care of cardiac arrest patients—training that must be effective and up to date); and Implementation (referring to a well-functioning Chain of Survival at both regional and local levels, potentially adapted to various resource settings).

[h2] Advocacy

- Multi-national collaborative bodies, national governments, local authorities, and national resuscitation councils (NRC) should advocate for policies that increase survival rates and improve the quality of life for cardiac arrest patients through the following actions:
  a. Promotion of comprehensive policies / legislation: advocate for policies that increase survival rates and enhance the quality of life for cardiac arrest patients.
  b. Public awareness campaigns: increase public awareness through initiatives such as World Restart a Heart and Get Trained, Save Lives.
  c. Mandatory CPR training: implement mandatory CPR training for children, students (e.g., Kids Save Lives), and drivers (e.g., Learn to Drive, Learn CPR).
  d. Enhanced workplace preparedness: strengthen policies for workplace preparedness (e.g., Alliance for Workplace Awareness and Response to Emergencies - AWARE).

e. Stakeholder engagement: collaborate with stakeholders to support cardiovascular health and harmonise CPR policies (e.g., the European Alliance for Cardiovascular Health).

f. CPR training at major sporting and large-scale events: offer free short CPR training sessions at major sporting events and other large-scale gatherings to raise awareness and increase knowledge among attendees.

[h2] Awareness campaigns and initiatives to promote CPR

- Community initiatives to promote the implementation of BLS should be endorsed and supported.
- Multi-national collaborative bodies, national governments, local authorities, and national resuscitation councils should actively participate in World Restart a Heart (WRAH) to raise awareness of bystander CPR and the use of AEDs, train as many citizens as possible, and develop new and innovative systems and policies.

[h2] Kids Save Lives (KSL)

- All schoolchildren should receive BLS training every year, with an emphasis on the Check–Call–Compress approach.
- BLS education should start at an early age (around four years of age), progressing to comprehensive training that includes chest compressions by ages 10–12, ventilation by age 14, and AED usage by ages 13–16.
- Children who have been trained should be encouraged to educate family members and friends, aiming to teach at least ten others within two weeks. Take-home CPR training kits should be distributed to maximise the multiplier effect.
- BLS training should also be extended to higher education, particularly for healthcare and teaching students.
- Technology-enhanced learning (e.g., extended reality (XR), serious games, smartphone apps) should be incorporated to engage schoolchildren effectively and supplement traditional training methods.
- Ministries of education and policymakers should mandate BLS education in schools by law across Europe and beyond, supported by legislation, funding, and public awareness campaigns in every country.

[h2] Resuscitation in low-resource settings

- Experts from all resource settings are encouraged to investigate and report on populations, aetiologies, and outcomes of resuscitation, following established reporting standards such as the Utstein reporting template.
- Experts from all resource settings should be consulted regarding cultural differences and the regional and local acceptability, applicability, and implementation of guidelines and recommendations.
- All reports and research on resuscitation should include a brief section on the respective resource setting, for example the income classification of the country.
- In situations where standard guidelines are not applicable, specific recommendations may be developed for low-resource settings (such as areas with limited funding, ships, alpine regions, or remote areas) concerning essential equipment, education, and procedures for managing cardiac arrest both during and after the event.

[h2] Social media

- Social media (SoMe) platforms could be used as research tools for data collection, analysis, education, awareness campaigns, communication, and information sharing on sudden cardiac arrest.
- SoMe platforms should be leveraged to support public awareness campaigns, disseminate knowledge on BLS for any age group, foster community participation, and further the mission of the ERC.
- SoMe platforms should be incorporated into BLS training programmes. Educational and healthcare institutions are encouraged to use concise, engaging videos and interactive materials to reinforce learning and retention.
- Real-time engagement and feedback should be encouraged. Live question-and-answer sessions, interactive posts, and gamified learning should be used to increase engagement and knowledge retention in BLS training.
- The validation of SoMe content by experts should be promoted. Institutions are encouraged to ensure that educational materials shared on social media align with international BLS guidelines to prevent the spread of misinformation.
- SoMe-driven initiatives should be monitored and evaluated. Further research is needed to determine their impact on BLS training efficacy, bystander CPR rates, and patient survival outcomes.

[h2] First responders

- Every healthcare system should implement a first responder programme.
- Registered first responders who are near a suspected OHCA should be notified by the EMS dispatch centre and dispatched to both public locations and private residences, in order to reduce the time to first chest compression and shock delivery, and to improve survival rates with favourable neurological outcomes.
- Systems that dispatch first responders should be linked to AED registries and should prioritise both the physical safety and psychological support of first responders.
- Cardiac arrest events should be reported in a standardised manner to monitor system performance and support continuous quality improvement.

[h2] EMS organisation in response to cardiac arrest

- EMS should use standardised algorithms or criteria to identify cardiac arrest promptly.
- EMS should teach, monitor, and improve OHCA recognition in dispatch centres.
- EMS should implement and evaluate dispatcher-assisted public-access AED systems, including linkage to AED registries.
- The use of locked or inaccessible AED cabinets is discouraged.
- All ambulances responding to OHCA should be equipped with a defibrillator.
- EMS should organise prehospital critical care teams for adult and paediatric OHCA.
- EMS should monitor and address low resuscitation exposure among personnel to ensure teams include members with recent experience and implement proper training to overcome low exposure.
- EMS systems treating OHCA should implement system improvement strategies to enhance patient outcomes, as well as TOR rules to determine whether to stop resuscitation or continue during transport.

[h2] In-hospital cardiac arrest management

- Hospitals should consider introducing a rapid response system (RRS).
- Hospitals should use system improvement strategies to enhance patient outcomes.
- Hospitals should implement protocols for managing family presence during CPR and provide respective education for healthcare teams

- Hospitals are encouraged to use the "Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes" framework to guide structured, system-wide improvements in resuscitation quality, outcomes, and team well-being.

[h2] Cardiac arrest centres (CAC)

- Adult patients with non-traumatic OHCA should be cared for at a CAC whenever possible.
- Healthcare systems should establish local protocols to develop and maintain a cardiac arrest network.

[h2] System performance improvement

- Organisations or communities that treat cardiac arrest should implement system improvement strategies to enhance patient outcomes.

[h2] Survivorship and co-survivorship

- Healthcare systems should create and implement policies for the care of cardiac arrest survivors and their co-survivors (e.g. families, close friends, and partners also impacted by the event) from pre-discharge to long-term follow-up. These policies should adopt a multidisciplinary approach, responsive to the needs of both survivors and co-survivors. Healthcare professionals should receive adequate training to support both the identification of needs and the provision of appropriate care.
- National resuscitation councils (NRCs) should connect with and support cardiac arrest survivor organisations within their countries, strengthening ties with healthcare systems, survivors, and co-survivors.
- Engaging in partnerships among NRCs, and with organisations that have broader missions—such as cardiovascular healthcare organisations—can help address the diverse needs of survivors and co-survivors and optimise resource utilisation.
- Healthcare systems should actively engage cardiac arrest survivors, co-survivors, and the public as partners in policy development and research to enhance the quality, relevance, and integrity of outcomes.

[h2] New technologies and artificial intelligence

- Artificial intelligence (AI) and digital health technologies show potential to improve cardiac arrest outcomes but are not yet ready for routine clinical use, and their application should be limited to research or controlled settings.

[h1] The evidence informing the Systems Saving Lives guidelines

[h2] Chain of Survival

The chain of survival for victims of cardiac arrest dates back to concepts proposed by Friedrich Wilhelm Ahnefeld and Peter Safar, and emphasises the time-sensitive interventions, represented as links, that maximise the chance of survival.[3,4] This foundational concept has been expanded in subsequent years, with contributions from various organisations and academics, involving significant modifications in 1991.[5] Over time, designs depicting the chain of survival have evolved; however, the core messages behind each link have largely remained unchanged.

The ERC first published the chain of survival in its four-link format in the 2005 ERC guidelines, summarising the vital links needed for successful resuscitation, including early recognition and call for help, early bystander CPR, early defibrillation, and early ALS and standardised post-resuscitation care. Each of these links highlights the interconnection and urgency of effective actions, emphasising the importance of a prompt response to optimise the chances of survival.[6] The term ‘chain of survival’ is now used internationally in resuscitation awareness building, education, and science. A large and heterogenous body of literature on the chain of survival has emerged. An ILCOR scoping review found several novel versions and adaptations, partly expanding into other medical fields beyond resuscitation.[7] Adaptations addressed different situations or target audiences, but were inconsistent in design and without an underlying system. Any chain link should be evidence-based and contribute to improved patient, education, or implementation outcomes.[8,9] The ILCOR scoping review proposed a six-link chain comprising: 1) Prevention and recognition, 2) Early call for help, 3) High-quality CPR, 4) Early defibrillation and ALS, 5) Post-cardiac arrest care, and 6) Recovery and rehabilitation.[6,7] In contrast, the ERC Guideline 2025 still recommends a four-link Chain of Survival for clarity and consistency. However, the original messages and links of the chain have been expanded and rearranged (Fig.1 - Chain of Survival). This basic chain should be used for all cardiac arrest aetiologies and locations, and all patient age groups.

Only a few studies have so far formally assessed the impact of the Chain of Survival on clinical and educational outcomes. Findings suggest increased survival rates and better neurological outcomes following the introduction of new components to the chain, underscoring its potential effectiveness as a framework for improving practice.[7,8]

Apart from the basic Chain of Survival, individuals or organisations may require adaptations for specific situations or target audiences. The ERC follows ILCOR with an adaptive approach: an adapted ‘one-size-fits-all’ concept as a multifaceted system can be used when the basic Chain of

Survival is not sufficient.[7,8] The basic Chain of Survival serves as the foundation; the Chainmail of Survival can be used with a multitude of additional links, depicting different situations and factors and highlighting the complexity of the system. Specific versions of the Chain of Survival can also be used for specific situations and audiences (e.g., trauma, drowning).[7,8] This adaptive concept is particularly important in the context of low-resource settings, where high-resource links in the basic chain may not be applicable or may need to be replaced.[10]

[h2] The Formula of Survival

The Formula of Survival combines scientific treatment, effective education, and local implementation to improve cardiac arrest survival rates.[11,12] These elements are multiplicands and are essential for a strong Chain of Survival.[12] Resuscitation guidelines are updated through the ILCOR evidence evaluation process and annual CoSTR publications. The ERC courses provide effective education. Local champions play a key role in putting resuscitation practices into action, overcoming challenges, using facilitators, and incorporating feedback systems.[8,13,14]

[h2] Advocacy

Advocacy is a civil endeavour in which individuals or groups support policies across various social, economic, or legislative domains to influence the allocation of both human and financial resources.[15] Advocacy is essential in addressing the multifaceted needs of cardiac arrest patients and their relatives.[16] This subchapter explores the definitions, actions, and impacts of such efforts, emphasising the ERC role in promoting comprehensive policies, public awareness, and support systems to improve outcomes and quality of life for cardiac arrest survivors and their co-survivors.

[h3] Advocacy role of scientific societies in the field of resuscitation

Advocacy is crucial for strengthening emergency care systems. Some initiatives advocate for new regulations, while others focus on training hospital staff and frontline physicians locally. These programs improve emergency care for various traumas and life-threatening conditions, including cardiac arrest. Advocacy aims to bridge gaps, enhance outcomes, and make life-saving treatments more effective and accessible.[17]

The ERC plays a leading role at the European level in advocating for increased survival following cardiac arrest and improved quality of life through comprehensive policies and public awareness campaigns. One outcome of this advocacy was the establishment of European Cardiac Arrest

Awareness Week by the European Parliament. This initiative encouraged member states to implement AED programmes, adapt legislation to enable CPR by non-medical individuals, collect data for quality management, support national CPR strategies, and provide legal immunity for non-medical first responders.[18]

The ERC has launched several key initiatives, including European Restart a Heart in 2013, Kids Save Lives in 2015, and broader campaigns to promote CPR training and AED accessibility across Europe.[18–20] Current ERC advocacy priorities include mandating CPR training for new drivers, strengthening CPR education among young people, harmonising CPR-related legislation, improving workplace emergency preparedness, and increasing public awareness and engagement. The Learn to Drive, Learn CPR initiative, developed jointly by the ERC and the European Driving Schools Association (EFA), aims to integrate BLS training into driver education programmes across Europe.[19,21] Currently, fewer than half of European countries require such training (Fig. 2 – Map EFA ERC). This project aims to equip new drivers with life-saving skills, significantly increasing the number of potential responders [REF under review]

The Alliance for Workplace Awareness and Response to Emergencies (AWARE) seeks to enhance preparedness for sudden cardiac arrest in the workplace. The coalition advocates for widespread CPR and first aid training, as well as broad availability of AEDs in European workplaces—areas not currently addressed by unified EU policy. AWARE calls on the EU to reopen the Health and Safety at Work Framework Directive (89/391/EEC) to strengthen these regulations.[22]

The ERC also collaborates with the European Alliance for Cardiovascular Health to promote cardiovascular disease prevention and rehabilitation.[23] This collaboration includes developing a Cardiovascular Health Knowledge Centre and Observatory, co-creating national action plans, and supporting digital health policies.

Finally, the ERC hosted the EU Resuscitate Workshop: CPR Harmony for a Healthier Europe at the European Parliament. The event brought together Members of the European Parliament for hands-on CPR training. Its goals were to equip participants with life-saving skills, raise awareness of cardiac arrest statistics, and underscore the urgency of harmonising CPR training policies across member states to improve survival outcomes.[24]

[h3] Get Trained Save Lives

The Get Trained Save Lives (GTSL) campaign is a public health initiative collaboratively developed between the Union of European Football Associations (UEFA) and the ERC (Fig. 3 – UEFA ERC). This initiative aims to increase public awareness and engagement in CPR and AED training across Europe by leveraging the widespread influence of football and the expertise of resuscitation professionals. This campaign seeks to empower laypersons with essential life-saving skills to improve bystander intervention rates in OHCA. Through accessible, standardised training programmes and high-visibility events, the GTSL campaign aspires to foster a culture of preparedness, ultimately contributing to enhanced survival outcomes and strengthening the Chain of Survival in the community.[25]

[h2] Awareness campaign and initiatives to promote CPR

[h3] Community initiatives to promote CPR implementation

A scoping review by ILCOR in 2024, identified 21 new studies[26–46] that focused on adult OHCA, with community interventions implemented in workplaces, schools, government offices, public events, and shared community spaces,[47] and were grouped into three categories:

1. Community CPR training programmes (n = 11).[26–28,37–44]
2. Mass-media campaigns (n = 1),[36] focusing on public awareness through media outlets.
3. Bundle interventions (n = 9):[29–35,45,46] efforts to combine CPR training with other community-based strategies (e.g., public awareness campaigns, guideline implementation, legislative changes, and mandatory training for driver’s licence applicants).

The bystander CPR rate was the outcome consistently evaluated across nearly all included studies. Most reported improvements following community initiatives,[47] and six studies reported an increase in the number of people trained.[31,32,45,46,48,49] These results suggest that community initiatives are effective in improving the response to OHCA; however, the effect on survival and neurological outcome was neutral. Based on expert consensus, community initiatives should be endorsed and supported that promote BLS implementation.

[h3] European Restart A Heart and World Restart A Heart

Following an ERC campaign, the European Parliament adopted a Written Declaration calling for improved CPR and AED training across all EU member states. The Declaration also urged legislative changes to ensure equal access to high-quality CPR and defibrillation for all Europeans, and proposed the establishment of a European Cardiac Arrest Awareness Week,[18] recognising that national resuscitation policies can increase citizens’ willingness to perform bystander CPR. To promote these policies, the ERC established European Restart a Heart Day on 16 October to raise awareness.[18,50,51] This initiative later evolved into World Restart a Heart (WRAH), endorsed by ILCOR with the motto: 'All people of the world can save a life—all that is needed is two hands (Check, Call, Compress)' (Fig. 4 – Poster WRAH).

As a result, between 2018 and 2023, more than 12.6 million people have been trained, and 570.7 million individuals have been reached through WRAH messaging.[20] The initiative has showcased a wide variety of campaigns tailored to each country's specific context and culture. Its success lies in annual collaboration among nations, organisations, and communities, reinforcing its global significance and reach. The adaptability of WRAH makes it an accessible and effective response to one of the world's most critical health challenges—saving lives through bystander CPR.

Based on expert consensus, national resuscitation councils, governments, and local authorities engaging in WRAH should aim to train as many people as possible, raise public awareness of the importance of bystander CPR and AEDs, establish protective legislation for lay rescuers, and develop innovative systems and policies to further improve survival outcomes.

[h2] Kids Save Lives (KSL)

The Kids Save Lives initiative aims to introduce BLS education early and reinforce it throughout the school years. Implementing mandatory, nationwide BLS training for schoolchildren has been shown to have the greatest long-term impact on bystander CPR rates. Scandinavian countries, where CPR training has been compulsory for decades, report some of the highest bystander CPR rates globally.

The World Health Organization (WHO) endorses the ERC's Kids Save Lives initiative and recommends that children receive at least two hours of CPR training annually, starting at the age of 12—an age considered optimal for learning and retaining these skills.[20]

An ILCOR scientific statement titled Basic Life Support Education for Schoolchildren outlines best practices for teaching these essential life-saving skills, advocating for the integration of BLS training into school curricula worldwide.[52] This comprehensive review of the literature identifies the most effective strategies for educating children and adolescents in BLS. For details on educational approaches, consult the section on Tailored Resuscitation Education in ERC Guidelines 2025 – Education for Resuscitation (Fig. 5 – Infographics KSL ILCOR).[52]

[h3] Multiplication effect and social impact

Teaching BLS to children creates a multiplier effect, as they often pass on their skills to others. Studies show that each trained child educates between 1.8 and 4.9 people, helping to improve bystander CPR rates, especially in underserved areas. In one study, students from a predominantly Black, low-income community trained an average of 4.9 others after learning BLS, highlighting its potential to spread CPR knowledge where formal training is limited.[52,53]

[h3] Legislative support and public campaigns

Legislative support is crucial for large-scale BLS education. ILCOR advocates making BLS training mandatory in schools, with government funding for materials and teacher training. The 2023 ILCOR statement outlines a global framework for integrating BLS into school curricula.

[h3] European Kids Save Lives survey

A survey assessed the implementation of the Kids Save Lives initiative to evaluate the status of CPR education across Europe, examining whether it is mandated, recommended, or absent in school curricula.[54] The findings revealed significant disparities: six countries—Belgium, Denmark, France, Italy, Portugal, and the UK—have national laws mandating CPR training in schools, reflecting strong political and educational commitment. Others, such as Germany, Poland, and Sweden, recommend CPR training without mandating it, resulting in inconsistent implementation. Countries like Albania, Azerbaijan, and Moldova lack formal policies and rely on sporadic local or international efforts. Even in countries with mandates, implementation is challenged by limited funding, inadequate teacher training, and regional disparities. Public awareness campaigns also vary widely, underscoring the need for a more unified approach to CPR education across Europe (Fig. 6 – Map KSL 2025).

[h2] Resuscitation in low-resource settings

A 2020 ILCOR scoping review on clinical outcomes of resuscitation in low-resource settings highlighted the scarcity and heterogeneity of available literature.[55] This prompted discussions about the applicability of global resuscitation guidelines—often developed from a high-resource perspective by experts in high-income countries—as a one-size-fits-all model.[55–57]

Initially, low-resource settings were equated with low-income countries, as defined by the World Bank.[58] While this holds true in many cases, and outcomes remain poor in such contexts, resource availability can vary significantly across locations and over time.[59] For example, a major city in a low-income country might offer high-level cardiac arrest care, whereas an offshore facility or alpine region in a high-income country might lack essential resources. Moreover, resource conditions can shift due to infrastructural changes, environmental factors, or events such as natural disasters, pandemics, or armed conflicts.

In a 2023 ILCOR task force statement, the limitations of prior, exclusionary guideline approaches were acknowledged, and a more inclusive perspective was adopted.[9] Drawing from existing emergency care networks—such as the WHO emergency care system framework, first aid guidelines from the International Federation and regional Red Cross and Red Crescent Societies, and the Helping Babies Breathe initiative—the task force identified enablers and barriers to implementing an effective Chain (or 'Chainmail') of Survival.[60–63]

Most links in the chain require further research in low-resource contexts, ideally in collaboration with organisations experienced in such environments—e.g., resuscitation societies in low-income countries or groups focused on mountain, expedition, wilderness, or military medicine. A uniform approach will never fully address the diversity of these settings. Instead, existing guidelines can serve as a flexible foundation. ILCOR is currently working on evidence-informed expert opinions addressing specific subtopics relevant to low-resource environments.[10,61,64,65]

Alongside proposed action points—including the examination of ethical questions (e.g., is it appropriate to initiate advanced life support when no ICU or hospital is available?), the involvement of experts in the field, and support for research and registries—a list of essential basic and advanced resuscitation resources has been suggested. However, this list still requires validation before it can be universally recommended.[10,66] Cost-effectiveness must also be considered in all related initiatives (Fig. 7 – Low-resource scheme).[67]

[h2] Social media

The growing use of social media (SoMe) in healthcare education has created new opportunities to promote adult BLS training. A recent scoping review examined SoMe applications in BLS, highlighting its effectiveness as a tool for data analysis, collection, education, awareness campaigns, communication, and information sharing on sudden cardiac arrest (SCA).[68]

With around five billion users worldwide as of 2024, SoMe is a powerful platform for public health interventions. In adult BLS research, YouTube and X (formerly Twitter) were the most commonly used platforms for content dissemination, followed by WhatsApp and Instagram.[69] The main applications of SoMe in BLS include:

- Data analysis (41%) – used to evaluate public sentiment, trends in CPR training, emotional responses to SCA events, and knowledge gaps.
- Data collection (36%) – enabling large-scale surveys and real-time engagement studies on CPR knowledge and bystander behaviour.
- Teaching (10%) – leveraging videos, infographics, and interactive content to improve knowledge retention among laypersons and healthcare students.
- Campaign promotion (7%) – supporting initiatives like *World Restart a Heart*[20] that significantly increased engagement, though long-term behavioural impact remains unclear.
- Communication (4%) – facilitating direct interaction between trainers and the public.
- Content sharing (2%) – encouraging peer-to-peer learning and spreading awareness through viral posts.[68]

As another example, the widely used 'emojis' in social media, and especially in text messaging, could be used for spreading awareness about BLS. Since there are barriers in introducing official CPR emojis, 'stickers' have been proposed instead. [70]

Despite its benefits, SoMe-based BLS education faces several challenges. A significant portion of BLS-related content does not align with guidelines from accredited bodies, raising concerns about quality and misinformation, and highlighting the need for expert validation.[69,71–74] Selection bias is another limitation, as users are more likely to engage with content aligned with their existing interests, which can affect generalisability. Socioeconomic disparities and inconsistent internet access may create inequality and limit the reach of SoMe-based BLS training.[75,76] Furthermore, while SoMe enables rapid dissemination of information, its effect on long-term knowledge retention remains uncertain. To maximise SoMe's benefits in BLS education, standardised frameworks are needed to assess impact and ensure consistent training outcomes. Public health organisations and policymakers are encouraged to integrate SoMe strategies into national resuscitation programs to extend their reach.[77]

Future research should explore the role of emerging platforms—such as TikTok and Bilibili for education and awareness, LinkedIn, Bluesky, and Mastodon for professional communication and advocacy, and Instagram and Snapchat for public engagement—while considering demographic diversity and income disparities across countries. Implementing AI-driven content moderation and fact-checking tools is also recommended to reduce misinformation and improve content quality.

Integrating SoMe into BLS education has significant potential to boost public knowledge, increase bystander CPR rates, and improve survival outcomes in OHCA. By leveraging digital platforms, healthcare professionals can create more effective, scalable, and engaging training programs tailored to diverse populations. Future work should focus on optimising SoMe content, standardising evaluation metrics, and addressing barriers to digital education access.

[h2] First responders

[h3] CPR, defibrillation and survival

First responders (FRs) may be either community FRs or on-duty FRs.[78,79] Community FRs are volunteers who receive alerts about nearby emergencies and may choose whether to respond. On-duty FRs are professionals such as firefighters or police officers who are dispatched while on duty but are typically unable to transport patients. A recent survey found that 19 countries, including 15 in Europe, currently operate community FR systems.[80]

The current recommendation is based on a 2019 ILCOR systematic review.[81] Only one randomised controlled trial (RCT) has directly assessed the impact of community FR systems (dispatched vs. not dispatched) on bystander-initiated CPR.[82] In this trial, 5,989 lay volunteers were randomly allocated via a text-message system. Bystander-initiated CPR was significantly higher in the intervention group than the control group (62% vs 48%, p<0.001).

A separate non-randomised stepped-wedge cluster intervention study enrolled 5,735 text-alerted volunteer responders directed to retrieve AEDs.[83] The study found survival after OHCA increased from 26% to 39% [adjusted relative risk (RR) 1.5, 95% confidence interval (CI): 1.03–2.0]. The RR for neurologically favourable survival was 1.4 (95% CI: 0.99–2.0). Several observational studies have reported that FR system implementation is associated with higher rates of bystander CPR and defibrillation, shorter time to defibrillation, and improved survival with good neurological outcomes.[83–86] Although RCT data on the effect of FR programmes on defibrillation and survival are limited, several trials are currently underway to address this gap.[35,87–90] The existing evidence is drawn from heterogeneous studies across various systems—differing in FR type (community vs professional), activation methods, activation radius, number of responders, and study designs (population, outcomes, etc.)—which limits generalisability.[91–97]

In line with ILCOR, the ERC recommends that individuals located near a suspected OHCA and willing to be engaged by a healthcare system should be alerted.[1]

[h3] Activation systems

First responder systems can operate via text messages, but most now use app-based platforms. App-based systems appear to reduce the time to FR arrival.[98] Using true-line distances rather than radial estimates may improve the accuracy of distance calculations, although further evidence is needed to determine whether this leads to better outcomes. FR systems should be integrated with AED registries and provide directions to nearby devices.[99,100] To ensure FR safety and appropriate support from emergency medical services (EMS), activations should be managed through EMS dispatch centres.[101,102] Protocols for FR activation must prioritise both physical and psychological safety (Fig. 8 –First Responder scheme).[83,102,103]

[h3] Follow up after missions

Current evidence indicates a low risk of psychological distress and physical harm among dispatched first responders (FRs). Studies from the Netherlands, Denmark, Sweden, Australia, and New Zealand have reported low levels of post-traumatic stress symptoms at 3–6 weeks following deployment, and one study found minimal psychological distress just days after a mission.[104–107] However, one study noted that in rural OHCAs, FRs are more likely to know the patient or their relatives, which may present emotional challenges.[108] In a survey of FRs in Australia and New Zealand, most participants found debriefing to be beneficial.[106]

Based on available evidence and expert consensus, FR systems are encouraged to implement systematic follow-up procedures to identify those who may have experienced physical harm or require defusing or psychological support.[109–112] Feedback and psychological support are considered essential for sustaining volunteer well-being and ongoing engagement.[107,113] Various follow-up models have been described, but further research is needed to determine the most effective approach.[103,107]

[h3] Customisation

The optimal activation radius or number of FRs dispatched per mission remains unclear and varies widely between systems.[99] First responder systems are encouraged to tailor activation protocols based on regional and EMS characteristics, such as population density and the number of available responders.[113,114]

Dispatching FRs to private residences appears reasonable because: (i) most OHCAs occur at home; (ii) survival rates for home OHCAs are lower; and (iii) AEDs are less accessible in residential areas.[85,106,115–117] Studies from Sweden and Denmark have reported a higher likelihood of bystander defibrillation when FRs are dispatched to home OHCAs.[85] A retrospective study from the Netherlands found improved survival in patients with ventricular fibrillation following implementation of a residential FR system.[83] Similarly, a US study showed increased CPR rates, defibrillation, and survival to hospital discharge for patients who received professional FR assistance at home.[37] The impact of FR systems may be even greater in rural areas, where observational studies show a higher proportion of FRs arrive before EMS and initiate resuscitation.[37,101,118–120] Systems are encouraged to prioritise FR recruitment in less densely populated regions.[121]

Qualification requirements for community FRs vary across systems (Fig. 9 –Map 2025 of First Responder activities in Europe). A recent survey found that 69% of FR systems require at least some level of BLS training.[80] A retrospective analysis reported higher survival to hospital discharge when CPR was performed by medically trained bystanders, compared to lay responders.[122] In a study assessing anaesthesiologists' perceptions of dispatched FRs, 84% 'strongly agreed' that FRs had adequate CPR skills, despite no mandatory BLS training within the programme.[123]

Restrictive qualification criteria may reduce the pool of available FRs. However, a higher number of FRs arriving before EMS has been associated with increased rates of bystander CPR and defibrillation.[117,124] A survey also showed that FRs who had completed CPR training within the past 12 months were more likely to respond to a mission.[106] First responders with prior CPR training or a professional background reported lower self-perceived psychological impact.[125]

Currently, there is a lack of studies evaluating system efficiency and patient outcomes based on FR proficiency levels. FR systems should routinely assess mission data, including patient outcomes and FR safety, ideally using a standardised reporting template to enable comparisons across systems.[110]

[h2] EMS organization in response to cardiac arrest

[h3] Optimisation of dispatcher assisted recognition of OHCA

A 2020 ILCOR diagnostic systematic review included 47 observational studies and reported wide variability in dispatchers' ability to recognise OHCA (sensitivities and specificities varied from 0.46 to 0.98 and 0.32 to 1.00, respectively). There were no differences between dispatching criteria/algorithms or level of education of dispatchers although comparisons were hampered by heterogeneity across studies.[126,127]

A recent ILCOR scoping review identified 62 studies on dispatcher-assisted (DA) recognition of OHCA, using qualitative, mixed-methods, observational, and randomised clinical trial approaches. Research focused on four key areas: caller-dispatcher communication, new technologies, patient characteristics, and quality improvement initiatives. Most studies were retrospective, assessing OHCA recognition rates and influencing factors. A major challenge was distinguishing normal from abnormal breathing. Various strategies were tested, but none outperformed the standard two-question method: (1) “Is the person awake and alert?” and (2) “Is (s)he breathing normally?”. Only one RCT examined AI-assisted recognition and found no significant improvement because of a high rate of false positives. Overall, no new evidence supports changes to current OHCA recognition protocols.[1,128]

Consistent with ILCOR, the ERC recommends that dispatch centres implement standardised algorithms or criteria to quickly identify OHCA during emergency calls. Additionally, dispatch centres should monitor their diagnostic accuracy to ensure effective recognition but also seek ways to optimise sensitivity and minimise false negatives.

[h3] Optimisation of dispatcher-assisted CPR

A 2020 ILCOR systematic review and meta-analysis evaluated the impact of dispatcher-assisted CPR (DA-CPR) programmes, including 33 observational studies. It found that the provision of DA-CPR was consistently associated with improved outcomes across all analyses, although the certainty of evidence was low or very low. A more recent ILCOR scoping review sought to identify new evidence to optimise DA-CPR. It included 31 studies examining innovations such as updated protocols, pre-recorded instructions, centralised dispatch systems, advanced dispatcher training, metronomes, and undressing guidance.[1,8,129] However, there was insufficient evidence to draw conclusions about the effectiveness of these interventions. Among interventions with at least five supporting studies, some strategies showed promise for improving CPR quality—for example, simplifying instructions (e.g. “Push as hard as you can”) and incorporating video into emergency calls. However, language barriers may limit generalisability, and nearly half of the video-based studies were conducted in simulated settings.

In line with ILCOR, the ERC recommends that emergency medical dispatch centres implement systems allowing call handlers to deliver CPR instructions for adult cardiac arrest patients.

Dispatchers should provide guidance when deemed necessary. However, current evidence is insufficient to support specific interventions aimed at improving the quality of dispatcher-assisted CPR.

[h3] Optimisation of dispatcher-assisted public-access AED retrieval and use

A recent ILCOR scoping review assessed DA instructions for public access AED retrieval and use among adult and paediatric OHCAs and identified 16 studies: five observational and 11 simulation studies (six RCTs, one observational, and non-randomised comparisons). The review did not include AED use within volunteer first-responder systems. No studies assessed survival outcomes, ROSC, or quality of life. One observational study linked dispatcher-assisted AED retrieval instructions to improved bystander defibrillation, though its direct impact was unclear. Observational studies showed low AED retrieval and application rates, with some reports of confusion and delays. Simulation studies found dispatcher assistance improved AED use competence but delayed the first shock. Video guidance had mixed results, and pre-recorded instructions were less effective than real-time dispatcher support.

ILCOR noted limited research and lack of data to support a systematic review. Given that most OHCAs occur in the home, public-access AEDs are likely to be in close proximity in only a minority of cases. A potential risk of delays in CPR and decreased CPR efficacy was identified, especially when a lone rescuer is present. Future studies should focus on optimising dispatcher instructions, AED retrieval integration, phrasing, video use, and technology-supported AED location assistance.[129] In line with ILCOR, the ERC encourages EMS agencies implementing DA public-access AED systems to monitor and evaluate their effectiveness. Once OHCA is recognised and CPR has begun, dispatchers are encouraged to ask if an AED is available. If no AED is accessible and multiple rescuers are present, dispatchers should provide instructions to locate and retrieve one, using up-to-date registries where available. Once an AED is retrieved, dispatchers should guide the caller in its use.[8]

[h3] Ambulance equipment

According to the European Standard EN 1789:2020 every road ambulance (type A1, A2, B and C) must be equipped with defibrillators that can record rhythm and patient data.[130] The ERC supports this recommendation as timely defibrillation with restoration of circulation is one of the strongest determinants of survival with favourable neurological outcome.[131] The chances of survival decrease rapidly with time, even when bystander CPR is provided, and defibrillation after 15 min is associated with dismal chances of survival with favourable neurological outcome. This is in line with the World Health Organization's Emergency Medical Teams 2030 Strategy which calls on countries and organisations to take a proactive approach, and to build and strengthen their EMT and rapid response capacities by implementing standardisation and quality assurance.[132]

[h3] AED accessibility

A recent ILCOR scoping review evaluated the benefits and harms of locking AEDs in cabinets, identifying 10 studies (eight observational, two simulation) involving between 39 and 31,938 devices.[133] None reported patient outcomes. Most studies found low rates of theft and vandalism (<2.0%), even when AEDs were accessible 24 hours a day. A comparison between locked and unlocked cabinets showed similarly low theft rates (0.3% vs 0.1%). However, simulation studies demonstrated that locked cabinets delayed AED retrieval, and one study reported rescuer injuries caused by breaking glass to access cabinet keys.[133] In line with ILCOR, the ERC advises against locking AED cabinets or making them inaccessible in any other way. Novel anti-theft systems like geolocation tracking modules on the AEDs can be explored instead. However, if locks are unavoidable and still used, clear unlocking instructions must be provided to avoid delays. Systems deploying public-access AEDs should also establish procedures for retrieving and redeploying used devices.

[h3] Prehospital critical care for out-of-hospital cardiac arrest

A recent ILCOR systematic review included 15 non-randomised studies assessing the impact of prehospital critical care teams on OHCA outcomes, involving 1,188,287 patients. Most teams included physicians, while some involved critical care paramedics, primarily in the UK and Australia.[133] Attendance of these teams at OHCAs was associated with increased rates of survival to hospital discharge and favourable neurological outcome. In line with ILCOR, the ERC recommends that prehospital critical care teams attend OHCAs if the EMS system has sufficient resource infrastructure.

[h3] EMS experience and exposure to OHCA

An ILCOR systematic review including seven non-randomised studies evaluated the impact of resuscitation exposure and career experience on out-of-hospital cardiac arrest (OHCA) outcomes.[134] The certainty of evidence was very low. Only one study assessed EMS physician exposure but provided insufficient data to determine any effect on survival with favourable neurological outcome.[135] Three studies[135–137] reported mixed findings on survival to hospital discharge: the largest study showed that higher team exposure over the previous three years was associated with increased survival, while two others found no association. However, both of these also reported lower survival among patients treated by teams with no resuscitation exposure in the preceding six months.[136] Two studies[135,138] found that higher paramedic exposure (defined as ≥15 cases over five years or ≥10 cases in one year) was associated with increased rate of ROSC, although no studies specifically assessed event survival. Four studies[136,139–141] found no consistent association between years of clinical experience and survival, except one, which reported higher survival rates among patients treated by more experienced EMS providers. Overall, the evidence suggests that greater exposure to resuscitation may improve survival and ROSC, but the findings are inconsistent and subject to bias.[1]

In line with ILCOR, the ERC suggests that EMS systems: (i) monitor clinical personnel's exposure to resuscitation; and (ii) implement strategies, where possible, to mitigate low exposure or ensure that teams include members with recent resuscitation experience.

[h3] EMS system performance improvements

An ILCOR systematic review evaluated system performance improvement initiatives for cardiac arrest management in both prehospital and in-hospital settings.[142] The review included one randomised controlled trial (RCT) and 41 non-randomised studies, focusing on interventions aimed at improving system structure, care pathways, clinical processes, and overall quality of care. One example is the use of real-time CPR feedback and post-event debriefing, which offer immediate guidance on compression quality and promote continuous team learning. The RCT reported that system-level interventions improved resuscitation skills, including a lower compression rate (103 vs 108 per minute, $p<0.001$), higher chest compression fraction (66% vs 64%, $p=0.016$), deeper compressions (40 mm vs 38 mm, $p=0.005$), and fewer incomplete releases (10% vs 15%, $p<0.001$).[143] However, there was no significant difference in survival. Among the 41 non-RCT studies 17 showed significant improvements in neurologically favourable survival, 20 reported increased survival to hospital discharge, and 16 demonstrated enhanced skill performance. Additional studies reported improvements in system-level metrics such as response time and CPR quality. The overall certainty of evidence ranged from moderate to very low, with considerable heterogeneity across interventions. While system performance initiatives appear promising, their resource requirements and cost-effectiveness remain unclear and warrant further investigation. In line with ILCOR, the ERC recommends that EMS systems implement performance improvement strategies to enhance outcomes following in-hospital cardiac arrest (IHCA).

[h3] Out-of-hospital cardiac arrest termination of resuscitation rules

A recent ILCOR systematic review identified 10 new observational studies evaluating termination of resuscitation (TOR) rules for OHCA, focusing on prediction of no ROSC, in-hospital death, and survival with unfavourable neurological outcomes.[144] Because of high bias and heterogeneity, no meta-analysis was conducted.

Studies assessing ROSC prediction found variable sensitivity and high specificity, particularly in paediatric cases. For in-hospital death, adult TOR rules such as KoCARC and uTOR had moderate sensitivity (0.31–0.79) but high specificity (0.80–1.00), meaning they effectively identified non-survivors but had limited predictive accuracy. Studies evaluating death or unfavourable neurological outcomes reported low sensitivity but high specificity, limiting their clinical utility. Two cost-effectiveness studies found Korean and European TOR rules to be cost-effective, with potential savings in cases terminated in the field.[145,146]

One paediatric study developed a new TOR rule, achieving 99.1% specificity, though with low sensitivity (30.4%).[147] Overall, TOR rules accurately identify non-survivors but lack reliability in predicting individual survival, particularly in children.[1]

Consistent with ILCOR, the ERC conditionally recommends that EMS systems may implement TOR rules to assist clinicians in deciding whether to discontinue resuscitation efforts at the scene or to transport to hospital with ongoing CPR for adults. We suggest that TOR rules may only be implemented following local validation of the TOR rule with acceptable specificity considering local culture, values, and setting. For paediatric OHCA because of insufficient evidence we suggest against the use of TOR rules to decide whether to terminate resuscitation efforts (Fig. 10 Infographics EMS].

[h2] In-hospital cardiac arrest management

[h3] Rapid response systems

An ILCOR systematic review identified 62 relevant papers.[148] There was high heterogeneity among studies, with overall evidence rated as very low to low due to serious risk of bias and imprecision. No studies reported on hospital discharge with favourable neurological outcomes. For survival to hospital discharge, low-certainty evidence from eight non-RCTs showed no significant improvement after implementation of a rapid response system (RRS). One study found that implementation of an RRS was associated with no difference in 30-day survival after cardiac arrest, while another reported increased long-term survival in hip fracture patients (p = 0.008). Three RCTs found no significant reduction in the incidence of IHCA, while 56 non-RCTs provided mixed results: 39 showed significant improvement, and 17 did not. Adjusted analyses indicated that higher-intensity RRS implementations (e.g., frequent activation, senior medical staff) were more effective. Despite study heterogeneity, findings suggest a reduction in cardiac arrest incidence in hospitals implementing an RRS, with a dose-response effect favouring higher-intensity systems.[1] Consistent with ILCOR, the ERC suggests hospitals should introduce an RRS to reduce the incidence of IHCA.

[h3] In-hospital system performance improvements

To increase quality of IHCA detection and treatment on a system level, ILCOR proposes ten steps which include advice on plans, preparations and prevention of IHCA, as well as how to perform resuscitation and how to improve a culture of person-centered care.[149] A recent ILCOR systematic review assessed system performance improvement initiatives for cardiac arrest management in in-hospital settings. The review included one RCT and 41 non-RCTs, examining interventions designed to enhance structure, care pathways, processes, and quality of care.[142] Among these 41 non-RCT studies, 17 showed a significant improvement in neurologically favourable survival, 20 reported increased survival to hospital discharge, and 16 found enhanced skill performance. Other studies demonstrated improvements in system-level variables such as response time and CPR quality. The overall certainty of evidence ranged from moderate to very low, with significant heterogeneity across interventions. While system performance improvements showed promise, the resource requirements and cost-effectiveness remain uncertain, requiring further research.[1] Consistent with ILCOR, the ERC thus recommends that hospitals use system improvement strategies to improve patient outcomes after in-hospital cardiac arrest.

[h3] Family presence

An ILCOR systematic review examined the impact of family presence during adult resuscitation from cardiac arrest including 18 quantitative studies (including two RCTs), 12 qualitative studies, and one mixed methods study.[150] Providers' experience was variable, and family members had mixed psychological outcome (e.g. depression, post-traumatic stress disorder). The evidence remains of low or very low certainty.

A recent ILCOR systematic review focused on family presence during resuscitation in paediatric and neonatal cardiac arrest, which included 36 studies.[151] Papers addressing the experiences and opinions of parents and family found broad agreement on the wish to be present during resuscitation. In contrast, the articles focusing on the healthcare providers´ experience and opinion showed mixed results. Healthcare providers who had experience in family presence during resuscitation had a higher agreement. There were seven studies on family presence during neonatal resuscitation, with different topics and approaches. As this is a highly emotional situation, there is a need for staff training for support and debriefing.

Consistent with ILCOR, the ERC suggests that family members be provided with the option to be present during in-hospital adult resuscitation from cardiac arrest. Hospitals should develop policies to guide family presence during resuscitation and provide healthcare providers with training to manage these situations effectively.[1]

[h3] Pre-arrest prediction of survival following in-hospital cardiac arrest

An ILCOR systematic review identified 23 studies evaluating 13 pre-arrest prediction rules for survival following IHCA.[152] The pre-arrest morbidity (PAM) score and prognosis after resuscitation (PAR) score were the most frequently studied, though clinical heterogeneity prevented meta-analysis.

For predicting survival to hospital discharge, seven historical cohort studies examined the PAM score, and four also assessed the PAR score. Sensitivity was generally high (close to 100%), but specificity was low, meaning these scores often overestimated mortality risk. No single cut-off reliably predicted non-survival. Similarly, studies on the modified pre-arrest morbidity index (MPI) score, National Early Warning Score (NEWS), and Clinical Frailty Scale (CFS) showed inconsistent predictive value, with low certainty evidence due to bias, imprecision, and inconsistency. For predicting survival with favourable neurological outcomes, seven studies examined the Good Outcome Following Attempted Resuscitation (GO-FAR) score, which had high sensitivity but low specificity, meaning it identified most survivors but poorly distinguished non-survivors. Other models, including GO-FAR 2, prediction of outcome following in-hospital cardiac arrest (PIHCA), and classification and regression tree (CART), showed similar limitations.

Overall, no pre-arrest prediction rule reliably predicted survival or death following IHCA. The certainty of evidence was very low, limiting confidence in these models for clinical decision-making.[1]

In line with ILCOR, the ERC recommends against using any currently available pre-arrest prediction rule as a sole reason not to resuscitate an adult with in-hospital cardiac arrest.

[h2] Cardiac arrest centres

Cardiac arrest centres are specialised hospitals that provide comprehensive post-resuscitation care through integrated, multidisciplinary teams, advanced technologies, and adherence to evidence-based guidelines.[153–155] Until recently, the definition of a cardiac arrest centre varied across healthcare systems, contributing to heterogeneity and limiting generalisability of findings.[156] In 2020, a European multi-society consensus document provided a standardised definition and outlined core characteristics of cardiac arrest centres.[154] The minimum requirements for cardiac arrest centres include:

- 24/7 on-site coronary angiography lab,
- Emergency department,
- ICU with temperature control capability,
- Echocardiography, CT and MRI imaging,
- Multimodal neuroprognostication,
- Rehabilitation services,
- Education and training facilities,
- Data collection and quality assurance, and
- Clear protocols for transferring selected patients to OHCA hub hospitals with additional services.

These hub hospitals offer expanded diagnostics and treatments during or after the acute phase, including extracorporeal CPR (ECPR), arrhythmia management and electrophysiological studies, device therapy (e.g. implantable cardioverter defibrillator ICD implantation), survivor screening, genetic testing and counselling for families, research infrastructure, and fundraising capacity (Fig. 11 – Cardiac arrest scheme).

Local accreditation programmes have been successfully implemented in some countries, such as Germany and Spain.[157,158] Accreditation should be based on defined interdisciplinary criteria, including:

- Structural quality: 24/7 percutaneous coronary intervention (PCI) availability and intensive care unit (ICU) capacity with temperature control (TC).
- Process quality: standard operating procedures (SOPs) for communication between EMS and emergency department staff, protocols for inter-hospital transfer following OHCA, and neuroprognostication guidelines.
- Quality assessment: systematic recording of interventions, time intervals, and outcomes.
- Defined treatment pathways with clearly documented protocols.
- Transparent communication of outcomes.

Another important aim of designating cardiac arrest centres is to improve both survival and neurological outcomes in OHCA patients, while also fostering education and research in resuscitation care.

ILCOR conducted a systematic review in 2020 to assess the impact of cardiac arrest centres on OHCA survival. The review concluded that such centres might be beneficial, but all included studies were observational, limiting the strength of the evidence.[159,160] In response to emerging data, ILCOR performed a new systematic review in 2024, incorporating over 145,000 patients across 15 observational studies[161–174] and, for the first time, an RCT.[175] The observational studies consistently found that transporting OHCA patients to cardiac arrest centres was associated with improved survival and better neurological outcomes.[154] However, the RCT found no significant differences in outcomes between cardiac arrest centres and non-designated hospitals. This discrepancy highlights the limitations of observational studies, including potential confounding factors such as patient selection bias and variation in hospital resources.

Despite these limitations, the overall body of evidence suggests that cardiac arrest centres may provide superior care, especially when advanced interventions such as PCI and ECPR are available. Supporting this, a recent multi-centre European survey of 247 hospitals showed that cardiac arrest centres admit more patients annually, are better equipped, and more consistently follow guideline-based care.[176,177]

There is currently insufficient data to support subgroup-specific recommendations, such as for different ages, presenting rhythms, or primary versus secondary transfers. Additionally, cardiac arrest centres are likely to be feasible only in high-resource settings, and healthcare systems should ensure that resources are optimally distributed across the entire chain of survival.

In line with ILCOR, the ERC suggests that adult patients with non-traumatic OHCA should be treated in cardiac arrest centres whenever possible. Ongoing research and refinement of the criteria for such centres are essential to support further improvements.

[h2] System performance improvement

To improve survival outcomes, systems must continuously strive to enhance their performance. This principle is captured in the local implementation element of the Utstein Formula for Survival. System performance improvement refers to coordinated efforts aimed at strengthening the structure, care pathways, processes, and overall quality of care, either at the organisational or population level. These efforts may involve single or bundled interventions and can include one or multiple departments or organisations. This ERC recommendation is informed by the 2024 ILCOR CoSTR on system performance improvement.[178,179] The 2024 update included 15 additional studies, adding to the 27 identified in the 2020 review.[160–175,177–181] Reported interventions included:

- Implementation programmes,
- Technology (e.g. dispatcher video connections, smartphone apps),
- Event-specific feedback (real-time coaching or post-event debriefing),
- Logistical and educational initiatives,
- Public awareness campaigns (e.g. *Kids Save Lives*), and
- System evaluations and audits.

The updated ILCOR CoSTR found that four non-randomised studies reported improved survival with favourable neurological outcomes at discharge and six non-randomised studies reported increased survival to hospital discharge. These studies encompassed both OHCA and IHCA cases.[34,182–195] Based on the consistent positive impact across provider-, organisational-, and system-level outcomes, ILCOR issued a strong recommendation in support of performance improvement initiatives. However, implementing such strategies requires financial resources, personnel, and stakeholder support, which may vary across systems. Examples of impactful initiatives include the Resuscitation Academy programmes developed by the Global Resuscitation Alliance for OHCA, and the ILCOR consensus statement on Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes.[196,197] Based on this evidence, the ERC recommends that all organisations and communities involved in the treatment of cardiac arrest adopt system improvement strategies to enhance patient outcomes.

[h2] Survivorship and co-survivorship

[h3] Multidisciplinary care and long-term follow-up

Cardiac arrest survivors are individuals who have been successfully resuscitated from a cardiac arrest. Most will be discharged home with varying levels of neurological, psychological, and/or physical impairment. [198] Depending on local policies regarding the withdrawal of life-sustaining treatments, a smaller but varying proportion of patients may experience prolonged consciousness disorders, necessitating extended rehabilitation and institutionalisation. [198]

Key supporters have been defined as individuals with a significant relationship with cardiac arrest survivors.[199] This group includes family members, spouses, partners, close friends, or others who share a close bond with the survivor. Key supporters play a crucial role in the survivor's recovery and well-being. Some within this group may identify as 'co-survivors,' recognising their shared experience and impact from the event'. The concept of survivorship and co-survivorship acknowledges the complex and often enduring emotional, physical, social, and economic challenges associated with life during and after critical illness such as cardiac arrest. It has been identified as one of the key challenges for the resuscitation community.[200]

Cardiac arrest survivors may exhibit an array of symptoms and challenges related to both the cause of the cardiac arrest and its aftermath. [198] Various physical, emotional, and cognitive limitations which can impact an individual's health-related quality of life and ability to re-engage with society can be present even in those discharged with 'good' neurological outcome; these limitations can persist for years.[201–205] Family members and close friends, especially those who witnessed the arrest, may have substantial emotional problems and experience high levels of care-giver strain.[206] These issues require a comprehensive, multi-disciplinary approach involving medical, psychological, physical, occupational, and social support.[204,205] However, current follow-up programs may not fully address these needs.[207–209] Care pathways for survivors and co-survivors should be tailored to an individual's often fluctuating needs across the recovery journey, from both the early stages post-event to the longer-term follow-up. The focus should be on optimising psychological recovery, independence, societal reintegration, and improved health-related quality of life.[198]

[h3] Cardiac arrest survivor organisations

Recent evidence indicates that cardiac arrest survivors have a wide range of needs beyond just healthcare.[210] These needs encompass spirituality, social networks, practical assistance, legal issues, and economic support, highlighting the importance of community-based support systems. Cardiac arrest survivor organisations are community-based organisations supporting survivors and co-survivors. An international survey conducted by the ERC in 2024 aimed to identify active organisations and to examine their structure and activities.[211] The survey found seven active organisations worldwide, six based in Europe. These organisations offer resources and support during the recovery process, provide information, and raise awareness about sudden cardiac arrest and its consequences. They also promote research in this field and create communities where individuals can share their experiences, benefitting from peer support. Although evidence of the impact of peer-support following cardiac arrest is limited, wide ranging benefits, including reduced anxiety and enhanced health-related quality of life, have been described in other conditions such as stroke and cancer.[212–215]

Cardiac arrest survivor organisations describe numerous barriers to the support that they can offer to survivors, including a lack of connection with healthcare systems and the local national resuscitation councils. It is also acknowledged that organisations focused on related diseases, such as cardiovascular diseases, could provide additional support for cardiac arrest survivors whose arrest is linked to their disease of interest. This underscores the importance of enhanced connectivity between national resuscitation councils, healthcare systems and survivor organisations with other major organisations to better address survivors' needs and the optimisation of resources (Fig. 12 – Survivors Map).

[h3] Patient and public involvement and engagement

Although variously defined, Patient and Public Involvement and Engagement refers to the active involvement of people as partners in the planning and conduct of research, in developing the evidence-base for healthcare guidelines, and in contributing to policy decisions. This engagement is quite different to patients participating as passive research subjects; rather, activities are conducted ‘with’ or ‘by’ the public, rather than ‘to’ or ‘for’ them.[216,217] Increasingly seen as a mainstay of healthcare research, Patient and Public Involvement and Engagement is underpinned by ethical principles and an ambition to enhance both the quality of outcomes and the relevance, quality and integrity of decisions.[218] Whilst engagement with Patient and Public Involvement and Engagement in resuscitation research is relatively new,[210,219–221] a growing body of research highlights its added value.[222]

Numerous funding bodies and organisations, such as the National Institute for Health Research in the UK, the Patient-Centered Outcomes Research Institute in the US, and the Canadian Health Institute, champion the importance of Patient and Public Involvement and Engagement across all stages of the research cycle. Similarly, opportunities for Patient and Public Involvement and Engagement exist throughout the chain of survival, but its potential in resuscitation research and healthcare policy remains largely untapped and unexplored.[223] Recognising the importance of Patient and Public Involvement and Engagement to the future of resuscitation research, the ERC is committed to Patient and Public Involvement and Engagement. As a starting point, initial steps have been taken to work collaboratively with community advisors (cardiac arrest survivors, co-survivors, etc.) in the development of this ERC Guidelines 2025. International standards for high-quality, evidence-based clinical guideline development include Patient and Public Involvement and Engagement as a core principle,[224] with the proposition that meaningful engagement enhances community relevance.[225] No standardised methodologies for active Patient and Public Involvement and Engagement in the co-production of guidelines are available.[226]

[h2] New technologies and artificial intelligence

In recent years, digital health tools, artificial intelligence (AI), and advanced sensor-based monitoring systems have reshaped how cardiac arrest might be we identified and managed. While traditional resuscitation has typically relied on bystanders and EMS acting quickly, a significant change is underway.[227–234] AI-driven technologies, wearable devices, and automated systems are changing the response to these life-threatening emergencies.[235] Currently no ILCOR-graded evidence is available on this topic. The ERC System Saving Lives writing group explored new technologies in general narratively, while AI-related advancements are addressed through a scoping review.

[h3] The role of new technology in resuscitation

Wearable health devices including smartwatches and biometric patches are opening new doors for continuous, real-time cardiac monitoring.[236–240] According to recent studies, technologies like photoplethysmography and electrocardiogram sensors are highly effective in detecting arrhythmias, including atrial fibrillation, with both high sensitivity and specificity.[241–245] Projects such as Home Emergency Alerting and Response Technology – Survive A Fatal Event (HEART-SAFE) and BEating Cardiac Arrest (BECA) are developing AI-integrated smartwatches capable of detecting OHCA and the ability of autonomously alerting EMS, shaving off precious minutes from response times, especially in cases that would otherwise go unnoticed.[246,247]

Beyond wearables, contactless monitoring solutions use infrared and radar-based sensors broadening the ability to detect cardiac events from a distance.[247–253] Some smart speakers and home AI assistants are already being equipped with software capable of recognising agonal breathing, a tell-tale sign of cardiac arrest. These devices can automatically notify EMS, offering a possible lifeline in situations where no one is around to witness the collapse.[254,255]
Mobile apps and digital platforms are also playing a critical role in connecting bystanders with emergency resources. For example, smartphone apps that pinpoint the location of nearby AEDs, crowdsource first responder networks, and provide on-the-spot CPR guidance are helping bridge the gap between the moment a cardiac arrest occurs and when professional care arrives. AI-powered platforms capable of analysing real-time sensor data potentially allow life-saving interventions to be activated before a cardiac event fully develops.[256,257]

Training in CPR is also evolving. Smart technologies improve technique and performance. Wearable devices now offer live feedback on the depth and rate of chest compressions, and haptic feedback via smartwatches and similar tools is helping both trainees and professionals perform higher-quality resuscitations, which in turn is known to improve patient outcomes.[258–260] Despite these advances, there are still tough challenges. The concerns about the accuracy of AI algorithms, hurdles in getting regulatory approval, and persistent questions about data privacy.[261,262] Not everyone has access to these technologies, particularly in lower-resource settings, raising important questions about health equity.[263–265]

Looking ahead, research should focus on fine-tuning AI detection systems, improving the ways different technologies work together, and testing these tools in clinical settings to show improved patient outcomes. As AI becomes more common in resuscitation protocols, building public trust and promoting awareness will be key. The intersection of AI, wearable technologies, and automated emergency responses represents a huge shift in resuscitation science. If implemented thoughtfully, these innovations could drastically reduce delays in cardiac arrest recognition and intervention, possibly leading to better survival rates and neurological outcomes. As the science moves forward, technology-driven solutions are likely to play a central role in reshaping how both healthcare professionals and the public respond to cardiac emergencies.

[h3] Artificial intelligence

Artificial intelligence (AI) is emerging as a powerful tool in cardiac arrest management, complementing traditional practices and advancing areas like early detection, risk assessment, treatment decision-making, and outcome forecasting.[265] But while AI holds promise, it is not without complications. There are still big questions about data quality, algorithm bias, transparency, and patient privacy that need careful consideration.[266,267] We conducted a scoping review that mapped out the current state of AI applications in cardiac arrest management. [268] The review covered 197 studies, highlighting how AI is being used to improve risk assessment, CPR performance, and outcome prediction. AI-based models are consistently outperforming traditional methods in predicting ROSC and survival rates. Deep learning and machine learning systems are also helping identify shockable rhythms, guide CPR in real time, and optimise emergency dispatch protocols. Yet, most studies so far have been retrospective, with limited real-world validation. Prospective trials are badly needed to confirm AI's impact on clinical outcomes.[267,268]

AI systems are showing impressive abilities when it comes to predicting cardiac arrests and life-threatening arrhythmias.[264] By continuously analysing ECG data, these models can identify subtle warning signs that may indicate an impending cardiac event. Studies even suggest AI can outperform conventional risk assessment tools, particularly in predicting in-hospital cardiac arrest—something traditional methods often struggle to do reliably.[231–266,268] This means clinicians could intervene earlier and potentially save lives. For example, by mining electronic health records, AI tools have identified patients at increased risk of sudden cardiac death, often within a specified timeframe.[257] This insight enables healthcare providers to craft personalised prevention strategies. The ability of AI to detect subtle ECG changes that may be overlooked by human eyes is another advantage, offering early warnings and supporting timely clinical decisions.[269]
AI is also playing a growing role in diagnosing cardiac arrest. Systems powered by AI can quickly analyse patient data to identify shockable rhythms, allowing for prompt defibrillation.[270] And when it comes to CPR, AI-based systems can provide real-time feedback to healthcare providers, improving the quality of chest compressions and overall resuscitation efforts.[271–273] Beyond detection and diagnosis, AI is being explored for its ability to identify early risk factors and help refine CPR techniques.[274]

Another area where AI performs well is in interpreting ECGs. These algorithms can identify subtle irregularities that may indicate cardiac problems before they become apparent to even experienced cardiologists. This enables earlier diagnosis and intervention.[275] AI is also being used to predict neurological outcomes following cardiac arrest. By analysing clinical factors and biomarkers, AI models offer guidance that can help clinicians make informed treatment decisions and provide families with more accurate prognostic information.[276] Artificial neural networks, in particular, have shown the potential for greater accuracy and personalisation than traditional forecasting methods.[277,278] A recent review of 41 studies looking at 97 machine learning models and 16 deep learning models found strong predictive capabilities for key outcomes, including ROSC, survival, and neurological recovery. The pooled area under the curve for predicting favourable neurological outcomes (CPC 1-2) at hospital discharge was 0.871 (95% CI: 0.813–0.928) for machine learning and 0.877 (95% CI: 0.831–0.924) for deep learning models. Still, despite these encouraging numbers, challenges remain. Many studies have limitations because of missing data, inconsistent external validation, and varying methodologies, all of which can affect reliability and raise concerns about bias.[279]

The use of AI in healthcare is not without ethical implications. Patient privacy and data protection are major concerns, requiring strict data handling and security measures. Algorithmic bias is another serious issue. If AI models are trained on skewed datasets—say, overrepresenting one demographic group—they might perform poorly for patients outside that group.[280] That could mean misdiagnosis, delayed treatment, or even inappropriate care. To address these risks, it is important to train AI systems on diverse datasets, evaluate their performance across different populations, and build fairness into their development from the ground up. There is also the question of whether AI might depersonalise healthcare, reducing human interaction and making patients feel like they are being treated by machines rather than people. While AI can boost efficiency and accuracy, it is essential to keep empathy and patient engagement at the core of care.

AI's potential is enormous, but it has limits. These systems require massive, diverse datasets to train on, and managing unstructured data—like imaging or free text in electronic records—is still a hurdle. Oversight by human experts remains essential to ensure AI's recommendations are reliable. Despite the expanding body of research in AI-driven cardiac arrest prediction, much of it still depends on traditional machine learning methods. Exploring advanced deep learning techniques could lead to even better results. However, concrete evidence that AI improves real-world outcomes in cardiac arrest remains limited for now. That is why future studies should focus on developing more robust, explainable AI models, testing them in varied clinical environments, and addressing the ethical challenges head-on. AI could also have a key role in global strategies for preventing sudden cardiac death, which deserves more investigation.

AI offers exciting possibilities for improving how we manage cardiac arrest—helping clinicians detect problems earlier, make better treatment decisions, and predict outcomes more accurately. But to make the most of these technologies, we need to be mindful of their limitations and ethical issues. Healthcare providers should follow strict ethical guidelines, prioritise patient privacy, and work to minimise bias in AI tools. Continued research and collaboration are crucial for refining these systems and ensuring they are used responsibly in practice. Done correctly, AI could transform cardiac arrest care and significantly improve patient outcomes.[281–285]

AI integration in resuscitation medicine faces several key challenges. These include concerns about data privacy, algorithmic bias, the need for transparency, and earning the trust of clinicians and patients alike. Standardising evaluation metrics and conducting more collaborative research will be essential for promoting safe, equitable AI adoption in cardiac arrest care. By addressing these concerns thoughtfully and ethically, the medical community can unlock AI's full potential helping to optimise emergency response strategies, improve outcomes, and drive further innovations in resuscitation science.

[h1] Collaborators

The following individuals contributed as collaborators to the 2025 version of this guideline: Mazarine Thyssens Mazarine contributed to writing the advocacy paragraph as an expert in European affairs. Kirstie Haywood contributed to the revision of the survivors and co-survivors paragraph thanks to her deep knowledge of the survivors' world.

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[h1] Figure legends

Figure 1. Chain of survival 2025

Figure 2. CPR Training included in driving license courses.

Figure 3. UEFA and ERC Get Trained Save Lives campaign

Figure 4. International World Restart a Heart poster

Figure 5. Summary of the Kids Save Lives ILCOR statement suggestions

Figure 6. Map 2025 of schoolchildren CPR training in Europe

Figure 7. Low resource setting scheme

Figure 8. First Responder scheme

Figure 9. Map 2025 of First Responder activities in Europe

Figure 10. Optimising emergency dispatch for cardiac arrest response

Figure 11. Cardiac arrest organisation

Figure 12. Survivor communities map

[H1] References

1. 2025 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces. Preprint at (2025).
2. ERC authors; European Resuscitation Council Guideline Collaborators. European Resuscitation Council Guidelines 2025: Executive summary. Resuscitation. Preprint at (2025).
3. Dick, W. F. Friedrich Wilhelm Ahnefeld. *Resuscitation* **53**, 247–249 (2002).
4. Safar, P. *Cardiopulmonary Cerebral Resuscitation*. vol. 1988 (New York: Grune & Stratton).
5. Cummins, R. O., Ornato, J. P., Thies, W. H. & Pepe, P. E. Improving survival from sudden cardiac arrest: the 'chain of survival' concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation* **83**, 1832–1847 (1991).
6. Nolan, J., Soar, J. & Eikeland, H. The chain of survival. *Resuscitation* **71**, 270–271 (2006).
7. Schnaubelt, S. *et al.* International facets of the 'chain of survival' for out-of-hospital and in-hospital cardiac arrest – A scoping review. *Resuscitation Plus* **19**, 100689 (2024).
8. Greif, R. *et al.* 2024 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces. *Resuscitation* 110414 (2024) doi:10.1016/j.resuscitation.2024.110414.
9. Berg, K. M. *et al.* Part 7: Systems of Care: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation* **142**, S580–S604 (2020).
10. Schnaubelt, S. *et al.* Cardiopulmonary resuscitation in low-resource settings: a statement by the International Liaison Committee on Resuscitation, supported by the AFEM, EUSEM, IFEM, and IFRC. *Lancet Glob Health* **11**, e1444–e1453 (2023).
11. Chamberlain, D. A. & Hazinski, M. F. Education in Resuscitation. *Resuscitation* **59**, 11–43 (2003).
12. Søreide, E. *et al.* The formula for survival in resuscitation. *Resuscitation* **84**, 1487–1493 (2013).
13. Berwick, D. M. Disseminating Innovations in Health Care. *JAMA* **289**, 1969 (2003).
14. Grol, R. & Grimshaw, J. From best evidence to best practice: effective implementation of change in patients' care. *The Lancet* **362**, 1225–1230 (2003).
15. Nikolaou, N., Semeraro, F., Van Dooren, J. & Monsieurs, K. Advancing cardiac arrest survival: A decade of advocacy, awareness, and action by the European Resuscitation Council. *Resuscitation* **195**, 110115 (2024).
16. Babu, A. S. *et al.* Advocacy for outpatient cardiac rehabilitation globally. *BMC Health Serv Res* **16**, 471–471 (2016).
17. Advocating for emergency care: a guide for nongovernmental organizations. https://www.who.int/publications/i/item/9789240064317.
18. Declaration of the European Parliament of 14 June 2012 on establishing a European cardiac arrest awareness week. https://www.europarl.europa.eu/doceo/document/TA-7-2012-0266_EN.html.

19. Rott, N., Reinsch, L., Böttiger, B. W., Lockey, A., & WRAH Collaborators. ILCOR World Restart a Heart - Spreading global CPR awareness and empowering communities to save lives since 2018. *Resusc Plus* **21**, 100853–100853 (2024).

20. Horriar, L., Rott, N., Semeraro, F. & Böttiger, B. W. A narrative review of European public awareness initiatives for cardiac arrest. *Resuscitation Plus* **14**, 100390 (2023).

21. Semeraro, F., Picardi, M. & Monsieurs, K. G. "Learn to Drive. Learn CPR.": A lifesaving initiative for the next generation of drivers. *Resuscitation* **188**, (2023).

22. Event Report: Creating Cardiac AWAREness at Work. https://www.erc.edu/event-report-creating-cardiac-awareness-at-work.

23. European Alliance for Cardiovascular Health. *EACH* https://www.cardiovascular-alliance.eu/.

24. EU Resuscitate Workshop: CPR Harmony for a Healthier Europe. https://www.erc.edu/erc-hosts-eu-resuscitate-workshop-cpr-harmony-for-a-healthier-europe.

25. Lott, C. *et al.* Increasing CPR awareness in Europe through EURO 2024: Lessons from "Get Trained Save Lives". *Resuscitation* **208**, 110532 (2025).

26. Eisenberg, M. *et al.* CPR Instruction by Videotape: Results of a Community Project. *Annals of Emergency Medicine* **25**, 198–202 (1995).

27. Malta Hansen, C. *et al.* Association of Bystander and First-Responder Intervention With Survival After Out-of-Hospital Cardiac Arrest in North Carolina, 2010-2013. *JAMA* **314**, 255 (2015).

28. Tay, P. J. M. *et al.* Effectiveness of a community based out-of-hospital cardiac arrest (OHCA) interventional bundle: Results of a pilot study. *Resuscitation* **146**, 220–228 (2020).

29. Wissenberg, M. *et al.* Association of National Initiatives to Improve Cardiac Arrest Management With Rates of Bystander Intervention and Patient Survival After Out-of-Hospital Cardiac Arrest. *JAMA* **310**, 1377 (2013).

30. Ro, Y. S. *et al.* Public awareness and self-efficacy of cardiopulmonary resuscitation in communities and outcomes of out-of-hospital cardiac arrest: A multi-level analysis. *Resuscitation* **102**, 17–24 (2016).

31. Hwang, W. S. *et al.* A system-wide approach from the community to the hospital for improving neurologic outcomes in out-of-hospital cardiac arrest patients. *European Journal of Emergency Medicine* **24**, 87–95 (2017).

32. Ro, Y. S. *et al.* Association between county-level cardiopulmonary resuscitation training and changes in Survival Outcomes after out-of-hospital cardiac arrest over 5 years: A multilevel analysis. *Resuscitation* **139**, 291–298 (2019).

33. Nishiyama, C. *et al.* Community-Wide Dissemination of Bystander Cardiopulmonary Resuscitation and Automated External Defibrillator Use Using a 45-Minute Chest Compression-Only Cardiopulmonary Resuscitation Training. *J Am Heart Assoc* **8**, e009436–e009436 (2019).

34. Kim, J. Y. *et al.* Application of the "Plan-Do-Study-Act" Model to Improve Survival after Cardiac Arrest in Korea: A Case Study. *Prehospital and Disaster Medicine* **35**, 46–54 (2019).

35. Cone, D. C. *et al.* Sudden cardiac arrest survival in HEARTSafe communities. *Resuscitation* **146**, 13–18 (2020).

36. Becker, L., Vath, J., Eisenberg, M. & Meischke, H. The impact of television public service announcements on the rate of bystander cpr. *Prehospital Emergency Care* **3**, 353–356 (1999).

37. Fordyce, C. B. *et al.* Association of Public Health Initiatives With Outcomes for Out-of-Hospital Cardiac Arrest at Home and in Public Locations. *JAMA Cardiol* **2**, 1226–1235 (2017).

38. Bergamo, C. *et al.* TAKE10: A community approach to teaching compression-only CPR to high-risk zip codes. *Resuscitation* **102**, 75–79 (2016).
39. Boland, L. L. *et al.* Minnesota Heart Safe Communities: Are community-based initiatives increasing pre-ambulance CPR and AED use? *Resuscitation* **119**, 33–36 (2017).
40. Del Rios, M. *et al.* Pay It Forward: High School Video-based Instruction Can Disseminate CPR Knowledge in Priority Neighborhoods. *West J Emerg Med* **19**, 423–429 (2018).
41. Uber, A., Sadler, R. C., Chassee, T. & Reynolds, J. C. Does Non-Targeted Community CPR Training Increase Bystander CPR Frequency? *Prehospital Emergency Care* **22**, 753–761 (2018).
42. Møller Nielsen, A., Lou Isbye, D., Knudsen Lippert, F. & Rasmussen, L. S. Engaging a whole community in resuscitation. *Resuscitation* **83**, 1067–1071 (2012).
43. Nielsen, A. M., Isbye, D. L., Lippert, F. K. & Rasmussen, L. S. Persisting effect of community approaches to resuscitation. *Resuscitation* **85**, 1450–1454 (2014).
44. Isbye, D. L., Rasmussen, L. S., Ringsted, C. & Lippert, F. K. Disseminating Cardiopulmonary Resuscitation Training by Distributing 35 000 Personal Manikins Among School Children. *Circulation* **116**, 1380–1385 (2007).
45. Lockey, A. S., Brown, T. P., Carlyon, J. D. & Hawkes, C. A. Impact of community initiatives on non-EMS bystander CPR rates in West Yorkshire between 2014 and 2018. *Resusc Plus* **6**, 100115–100115 (2021).
46. Li, S. *et al.* Survival After Out-of-Hospital Cardiac Arrest Before and After Legislation for Bystander CPR. *JAMA Netw Open* **7**, e247909–e247909 (2024).
47. Community Initiatives to promote BLS implementation: EIT 6306 TF ScR. https://costr.ilcor.org/document/community-initiatives-to-promote-bls-implementation-eit-6306-tf-scr.
48. Wissenberg, M. *et al.* Association of National Initiatives to Improve Cardiac Arrest Management With Rates of Bystander Intervention and Patient Survival After Out-of-Hospital Cardiac Arrest. *JAMA* **310**, 1377–1384 (2013).
49. Ro, Y. S. *et al.* Public awareness and self-efficacy of cardiopulmonary resuscitation in communities and outcomes of out-of-hospital cardiac arrest: A multi-level analysis. *Resuscitation* **102**, 17–24 (2016).
50. Georgiou, M. Restart a Heart Day: A strategy by the European Resuscitation Council to raise cardiac arrest awareness. *Resuscitation* **84**, 1157–1158 (2013).
51. Lockey, A. S. European Restart a Heart Day. *Emerg Med J* **31**, 696–697 (2014).
52. Schroeder, D. C. *et al.* KIDS SAVE LIVES: Basic Life Support Education for Schoolchildren: A Narrative Review and Scientific Statement From the International Liaison Committee on Resuscitation. *Resuscitation* **188**, 109772 (2023).
53. Semeraro, F. *et al.* Empowering the next Generation: An innovative "Kids Save Lives" blended learning programme for schoolchildren training. *Resuscitation* **194**, 110088 (2024).
54. Semeraro, F., Thilakasiri, K., Schnaubelt, S. & Böttiger, B. W. Progress and challenges in implementing "Kids Save Lives" across Europe in 2025. *Resuscitation* **208**, 110541 (2025).
55. Schnaubelt, S. *et al.* Clinical outcomes from out-of-hospital cardiac arrest in low-resource settings — A scoping review. *Resuscitation* **156**, 137–145 (2020).
56. Wallis, L. A. ILCOR's first foray into low resource settings. *Resuscitation* **159**, 178 (2021).
57. Schnaubelt, S. *et al.* Reply to: "ILCOR's first foray into low resource settings". *Resuscitation* **159**, 179 (2021).

58. World Bank Country and Lending Groups – World Bank Data Help Desk. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.
59. Ali Baig, M. N. *et al.* Effectiveness of chain of survival for out-of-hospital-cardiac-arrest (OHCA) in resource limited countries: A systematic review. *Resusc Plus* **22**, 100874–100874 (2025).
60. WHO Emergency care system framework. https://www.who.int/publications/i/item/who-emergency-care-system-framework.
61. Basic First Aid for Africa. *www.globalfirstaidcentre.org* https://www.globalfirstaidcentre.org/resource/basic-fa-for-africa-manual/.
62. International first aid, resuscitation and education guidelines | IFRC. https://www.ifrc.org/document/international-first-aid-resuscitation-and-education-guidelines.
63. Keenan, W. J. *et al.* Helping Babies Breathe Global Development Alliance and the Power of Partnerships. *Pediatrics* **146**, S145–S154 (2020).
64. Losonczy, L. I. *et al.* White Paper on Early Critical Care Services in Low Resource Settings. *Ann Glob Health* **87**, 105–105 (2021).
65. Schnaubelt, S., Greif, R. & Monsieurs, K. G. The frame of survival for cardiopulmonary resuscitation in lower resource settings – Authors' reply. *The Lancet Global Health* **12**, e380 (2024).
66. van Rensburg, L., Majiet, N., Geldenhuys, A., King, L. L. & Stassen, W. A resuscitation systems analysis for South Africa: A narrative review. *Resusc Plus* **18**, 100655–100655 (2024).
67. Werner, K. *et al.* A systematic review of cost-effectiveness of treating out of hospital cardiac arrest and the implications for resource-limited health systems. *Int J Emerg Med* **17**, 151–151 (2024).
68. Fijačko, N. *et al.* The use of social media platforms in adult basic life support research: a scoping review. *Resusc Plus* **23**, 100953–100953 (2025).
69. Digital 2024: Global Overview Report. *DataReportal – Global Digital Insights* https://datareportal.com/reports/digital-2024-global-overview-report (2024).
70. Veigl, C., Adami, F., Greif, R., Semeraro, F. & Schnaubelt, S. CPR emojis and stickers – Additional pieces of the BLS awareness puzzle. *Resuscitation Plus* **23**, 100964 (2025).
71. Murugiah, K., Vallakati, A., Rajput, K., Sood, A. & Challa, N. R. YouTube as a source of information on cardiopulmonary resuscitation. *Resuscitation* **82**, 332–334 (2011).
72. Tourinho, F. S. V., Medeiros, K. S. D., Salvador, P. T. C. D. O., Castro, G. L. T. & Santos, V. E. P. Análise de vídeos do YouTube sobre suporte básico de vida e reanimação cardiopulmonar. *Rev. Col. Bras. Cir.* **39**, 335–339 (2012).
73. Yilmaz Ferhatoglu, S. & Kudsioglu, T. Evaluation of the reliability, utility, and quality of the information in cardiopulmonary resuscitation videos shared on Open access video sharing platform YouTube. *Australas Emerg Care* **23**, 211–216 (2020).
74. Aksoy, İ. Evaluation of YouTube Videos on Defibrillation Applications in Cardiopulmonary Resuscitation: A Comprehensive Analysis. *Nigerian Journal of Clinical Practice* **27**, 886–890 (2024).
75. Gjoneska, B. *et al.* Problematic use of the Internet in low- and middle-income countries before and during the COVID-19 pandemic: a scoping review. *Current Opinion in Behavioral Sciences* **48**, 101208 (2022).
76. Hjort, J. & Tian, L. The Economic Impact of Internet Connectivity in Developing Countries. *Annual Reviews of Economics* (2025) doi:10.1146/annurev-economics-081224-102352.

77. Bumpus, S. When TikTok Is Not Enough: Engaging Nurses at All Levels in the Advocacy Process. *Nurse Leader* **20**, 277–280 (2022).
78. Grasner, J.-T. *et al.* Cardiac arrest and cardiopulmonary resuscitation outcome reports: 2024 update of the Utstein Out-of-Hospital Cardiac Arrest Registry template. *Resuscitation* **201**, 110288 (2024).
79. Metelmann, C. *et al.* Defining the terminology of first responders alerted for out-of-hospital cardiac arrest by medical dispatch centres: An international consensus study on nomenclature. *Resusc Plus* **22**, 100912–100912 (2025).
80. Marks, T. Smartphone-based alert of community first responders: A multinational survey to characterise contemporary systems. Preprint at (2025).
81. Semeraro, F., Zace, D., Bigham, B. L., Scapigliati, A. & Ristagno, G. First responder engaged by technology Consensus on Science with Treatment Recommendations. Preprint at (2019).
82. Ringh, M. *et al.* Mobile-Phone Dispatch of Laypersons for CPR in Out-of-Hospital Cardiac Arrest. *New England Journal of Medicine* **372**, 2316–2325 (2015).
83. Stieglis, R. *et al.* Alert system-supported lay defibrillation and basic life-support for cardiac arrest at home. *Eur Heart J* **43**, 1465–1474 (2022).
84. Andelius, L. *et al.* Smartphone-activated volunteer responders and bystander defibrillation for out-of-hospital cardiac arrest in private homes and public locations. *Eur Heart J Acute Cardiovasc Care* **12**, 87–95 (2023).
85. Andelius, L. *et al.* Smartphone Activation of Citizen Responders to Facilitate Defibrillation in Out-of-Hospital Cardiac Arrest. *Journal of the American College of Cardiology* **76**, 43–53 (2020).
86. Jonsson, M. *et al.* Dispatch of Volunteer Responders to Out-of-Hospital Cardiac Arrests. *Journal of the American College of Cardiology* **82**, 200–210 (2023).
87. Folke, F. *Public Access Defibrillation by Activated Citizen First-Responders - The HeartRunner Trial*. https://clinicaltrials.gov/study/NCT03835403 (2022).
88. Brooks, D. S. *Evaluating the PulsePoint Mobile Device Application to Increase Bystander Resuscitation for Victims of Sudden Cardiac Arrest*. https://clinicaltrials.gov/study/NCT04806958 (2024).
89. Todd, V. *et al.* A study protocol for a cluster-randomised controlled trial of smartphone-activated first responders with ultraportable defibrillators in out-of-hospital cardiac arrest: The First Responder Shock Trial (FIRST). *Resusc Plus* **16**, 100466–100466 (2023).
90. Krychtiuk, K. A. *et al.* RAndomized Cluster Evaluation of Cardiac ARrest Systems (RACE-CARS) trial: Study rationale and design. *American Heart Journal* **277**, 125–137 (2024).
91. Müller, M. P. *et al.* Out-of-Hospital cardiac arrest & SmartphonE RespOndErS trial (HEROES Trial): Methodology and study protocol of a pre-post-design trial of the effect of implementing a smartphone alerting system on survival in out-of-hospital cardiac arrest. *Resusc Plus* **17**, 100564–100564 (2024).
92. Regensburg Resuscitation App Study. https://drks.de/search/en/trial/DRKS00031349.
93. Metelmann, C. *et al.* Smartphone-based dispatch of community first responders to out-of-hospital cardiac arrest - statements from an international consensus conference. *Scand J Trauma Resusc Emerg Med* **29**, 29–29 (2021).
94. Müller, M. P. *et al.* Reporting standard for describing first responder systems, smartphone alerting systems, and AED networks. *Resuscitation* **195**, 110087 (2024).
95. Folke, F., Andelius, L., Gregers, M. T. & Hansen, C. M. Activation of citizen responders to out-of-hospital cardiac arrest. *Current Opinion in Critical Care* **27**, 209–215

(2021).
96. Valeriano, A., Van Heer, S., de Champlain, F. & C. Brooks, S. Crowdsourcing to save lives: A scoping review of bystander alert technologies for out-of-hospital cardiac arrest. *Resuscitation* **158**, 94–121 (2021).
97. Oving, I. *et al.* European first responder systems and differences in return of spontaneous circulation and survival after out-of-hospital cardiac arrest: A study of registry cohorts. *Lancet Reg Health Eur* **1**, 100004–100004 (2020).
98. Caputo, M. L. *et al.* Lay persons alerted by mobile application system initiate earlier cardio-pulmonary resuscitation: A comparison with SMS-based system notification. *Resuscitation* **114**, 73–78 (2017).
99. Smith, C. M. *et al.* Calculating real-world travel routes instead of straight-line distance in the community response to out-of-hospital cardiac arrest. *Resusc Plus* **8**, 100176–100176 (2021).
100. Berglund, E. *et al.* A smartphone application for dispatch of lay responders to out-of-hospital cardiac arrests. *Resuscitation* **126**, 160–165 (2018).
101. Gamberini, L. *et al.* Factors associated with the arrival of smartphone-activated first responders before the emergency medical services in Out-of-Hospital cardiac arrest dispatch. *Resuscitation* **185**, 109746 (2023).
102. Baldi, E. *et al.* Perceived threats and challenges experienced by first responders during their mission for an out-of-hospital cardiac arrest. *Resusc Plus* **14**, 100403–100403 (2023).
103. Berglund, E. *et al.* Wellbeing, emotional response and stress among lay responders dispatched to suspected out-of-hospital cardiac arrests. *Resuscitation* **170**, 352–360 (2022).
104. Zijlstra, J. A., Beesems, S. G., De Haan, R. J. & Koster, R. W. Psychological impact on dispatched local lay rescuers performing bystander cardiopulmonary resuscitation. *Resuscitation* **92**, 115–121 (2015).
105. Ries, E. S. *et al.* Association of Psychological Distress, Contextual Factors, and Individual Differences Among Citizen Responders. *J Am Heart Assoc* **10**, e020378–e020378 (2021).
106. Haskins, B. *et al.* A binational survey of smartphone activated volunteer responders for out-of-hospital cardiac arrest: Availability, interventions, and post-traumatic stress. *Resuscitation* **169**, 67–75 (2021).
107. Gamberini, L. *et al.* Logistic and cognitive-emotional barriers experienced by first responders when alarmed to get dispatched to out-of-hospital cardiac arrest events: a region-wide survey. *Internal and Emergency Medicine* **19**, 813–822 (2023).
108. Allert, C., Nilsson, B., Svensson, A. & Andersson, E. K. Voluntary first responders' experiences of being dispatched to suspected out-of-hospital cardiac arrest in rural areas: an interview study. *BMC Cardiovasc Disord* **24**, 157 (2024).
109. Schnaubelt, S. *et al.* Out of sight - Out of mind? The need for a professional and standardized peri-mission first responder support model. *Resusc Plus* **15**, 100449–100449 (2023).
110. Rolin Kragh, A. *et al.* Follow-up on volunteer responders dispatched for out-of-hospital cardiac arrests: Addressing the psychological and physical impact. *Resusc Plus* **14**, 100402–100402 (2023).
111. Heffernan, E. *et al.* Community first response and out-of-hospital cardiac arrest: a qualitative study of the views and experiences of international experts. *BMJ Open* **11**, e042307–e042307 (2021).
112. Nabecker, S., Theodorou, M., Huwendiek, S., Kasper, N. & Greif, R. Out-of-hospital cardiac arrest: comparing organised groups to individual first responders: A qualitative focus

group study. *Eur J Anaesthesiol* **38**, 1096–1104 (2021).

113. Luu, J. M. *et al.* Clinical Practice Variations in the Management of Ischemia With No Obstructive Coronary Artery Disease. *J Am Heart Assoc* **11**, e022573–e022573 (2022).

114. Møller, S. G. *et al.* Pre-hospital factors and survival after out-of-hospital cardiac arrest according to population density, a nationwide study. *Resusc Plus* **4**, 100036–100036 (2020).

115. Gräsner, J. T. *et al.* Survival after out-of-hospital cardiac arrest in Europe - Results of the EuReCa TWO study. *Resuscitation* **148**, 218–226 (2020).

116. Juul Grabmayr, A. *et al.* Public Out-of-Hospital Cardiac Arrest in Residential Neighborhoods. *Journal of the American College of Cardiology* **82**, 1777–1788 (2023).

117. Gregers, M. C. T. *et al.* Association Between Number of Volunteer Responders and Interventions Before Ambulance Arrival for Cardiac Arrest. *Journal of the American College of Cardiology* **81**, 668–680 (2023).

118. Nordberg, P. *et al.* The survival benefit of dual dispatch of EMS and fire-fighters in out-of-hospital cardiac arrest may differ depending on population density – A prospective cohort study. *Resuscitation* **90**, 143–149 (2015).

119. Mathiesen, W. T., Bjørshol, C. A., Kvaløy, J. T. & Søreide, E. Effects of modifiable prehospital factors on survival after out-of-hospital cardiac arrest in rural versus urban areas. *Crit Care* **22**, 99–99 (2018).

120. Lapidus, O. *et al.* Effects of a volunteer responder system for out-of-hospital cardiac arrest in areas of different population density – A retrospective cohort study. *Resuscitation* **191**, 109921 (2023).

121. Svensson, A. *et al.* Response times in rural areas for emergency medical services, fire and rescue services and voluntary first responders during out-of-hospital cardiac arrests. *Resusc Plus* **17**, 100548–100548 (2024).

122. Haskins, B. *et al.* The impact of bystander relation and medical training on out-of-hospital cardiac arrest outcomes. *Resuscitation* **150**, 72–79 (2020).

123. Jellestad, A.-S. L. *et al.* Collaboration between emergency physicians and citizen responders in out-of-hospital cardiac arrest resuscitation. *Scand J Trauma Resusc Emerg Med* **29**, 110–110 (2021).

124. Bo, N. *et al.* Volunteer Responder Recruitment, Voluntary Deployment of Automated External Defibrillators, and Coverage of Out-of-Hospital Cardiac Arrest in Denmark. *Journal of the American Heart Association* (2025) doi:10.1161/jaha.124.036363.

125. Kragh, A. R. *et al.* Immediate psychological impact on citizen responders dispatched through a mobile application to out-of-hospital cardiac arrests. *Resusc Plus* **7**, 100155–100155 (2021).

126. Dispatch Diagnosis of Cardiac Arrest (BLS): Systematic Review. https://costr.ilcor.org/document/dispatch-diagnosis-of-cardiac-arrest-systematic-review.

127. Drennan, I. R. *et al.* Diagnosis of out-of-hospital cardiac arrest by emergency medical dispatch: A diagnostic systematic review. *Resuscitation* **159**, 85–96 (2021).

128. Juul Grabmayr, A. *et al.* Optimising telecommunicator recognition of out-of-hospital cardiac arrest: A scoping review. *Resusc Plus* **20**, 100754–100754 (2024).

129. Dainty, K. N. *et al.* Interventions to optimize dispatcher-assisted CPR instructions: A scoping review. *Resuscitation Plus* **19**, 100715 (2024).

130. Medical vehicles and their equipment - Road ambulances. https://standards.cencenelec.eu/dyn/www/f?p=205:110:0::::FSP_PROJECT:78733&cs=10A98AE1423D4B868386098F90918CD70.

131. Stieglis, R. *et al.* Association Between Delay to First Shock and Successful First-Shock Ventricular Fibrillation Termination in Patients With Witnessed Out-of-Hospital

Cardiac Arrest. *Circulation* **151**, 235–244 (2025).

132. World Health Organization. *Emergency Medical Teams 2030 Strategy*. (World Health Organization, 2023).

133. Oonyu, L. *et al.* The impact of locked cabinets for automated external defibrillators (AEDs) on cardiac arrest and AED outcomes: A scoping review. *Resusc Plus* **20**, 100791–100791 (2024).

134. Bray, J. *et al.* A systematic review of the impact of emergency medical service practitioner experience and exposure to out of hospital cardiac arrest on patient outcomes. *Resuscitation* **155**, 134–142 (2020).

135. Weiss, N. *et al.* Does Experience Matter? Paramedic Cardiac Resuscitation Experience Effect on Out-of-Hospital Cardiac Arrest Outcomes. *Prehospital Emergency Care* **22**, 332–337 (2017).

136. Dyson, K. *et al.* Paramedic Exposure to Out-of-Hospital Cardiac Arrest Resuscitation Is Associated With Patient Survival. *Circulation: Cardiovascular Quality and Outcomes* **9**, 154–160 (2016).

137. Bjornsson, H. M., Marelsson, S., Magnusson, V., Sigurdsson, G. & Thorgeirsson, G. Physician experience in addition to ACLS training does not significantly affect the outcome of prehospital cardiac arrest. *Eur J Emerg Med* **18**, 64–67 (2011).

138. Tuttle, J. E. & Hubble, M. W. Paramedic Out-of-hospital Cardiac Arrest Case Volume Is a Predictor of Return of Spontaneous Circulation. *West J Emerg Med* **19**, 654–659 (2018).

139. Soo, L. H., Gray, D., Young, T., Skene, A. & Hampton, J. R. Influence of ambulance crew's length of experience on the outcome of out-of-hospital cardiac arrest. *Eur Heart J* **20**, 535–540 (1999).

140. Gold, L. S. & Eisenberg, M. S. The effect of paramedic experience on survival from cardiac arrest. *Prehosp Emerg Care* **13**, 341–344 (2009).

141. Lukić, A. *et al.* Analysis of out-of-hospital cardiac arrest in Croatia – survival, bystander cardiopulmonary resuscitation, and impact of physician's experience on cardiac arrest management: a single center observational study. *Croat Med J* **57**, 591–600 (2016).

142. Ko, Y.-C. *et al.* The effect of system performance improvement on patients with cardiac arrest: A systematic review. *Resuscitation* **157**, 156–165 (2020).

143. Hostler, D. *et al.* Effect of real-time feedback during cardiopulmonary resuscitation outside hospital: prospective, cluster-randomised trial. *BMJ* **342**, d512 (2011).

144. Lauridsen, K., Allan, K. & Greif, R. Prehospital termination of resuscitation (TOR) rules Draft Consensus on Science with Treatment Recommendations. International Liaison Committee on Resuscitation (ILCOR) Education, Implementation and Teams Task Force. (2024).

145. Khan, K. A. *et al.* Comparative cost-effectiveness of termination of resuscitation rules for patients transported in cardiac arrest. *Resuscitation* **201**, 110274 (2024).

146. Nazeha, N. *et al.* Cost-effectiveness analysis of a 'Termination of Resuscitation' protocol for the management of out-of-hospital cardiac arrest. *Resuscitation* **202**, 110323 (2024).

147. Shetty, P. *et al.* Derivation of a clinical decision rule for termination of resuscitation in non-traumatic pediatric out-of-hospital cardiac arrest. *Resuscitation* **204**, 110400 (2024).

148. Allan, K. Medical Emergency Systems/ Rapid Response Teams for adult in-hospital patients. (2024).

149. Nallamothu, B. K. *et al.* Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes. *Circ Cardiovasc Qual Outcomes* **16**, e010491 (2023).

150. Considine, J. *et al.* Family presence during adult resuscitation from cardiac arrest: A

systematic review. *Resuscitation* **180**, 11–23 (2022).

151. Dainty, K. N. *et al.* Family presence during resuscitation in paediatric and neonatal cardiac arrest: A systematic review. *Resuscitation* **162**, 20–34 (2021).

152. Lauridsen, K. G. *et al.* Pre-arrest prediction of survival following in-hospital cardiac arrest: A systematic review of diagnostic test accuracy studies. *Resuscitation* **179**, 141–151 (2022).

153. Nolan, J. P. *et al.* European Resuscitation Council and European Society of Intensive Care Medicine Guidelines 2021: Post-resuscitation care. *Resuscitation* **161**, 220–269 (2021).

154. Sinning, C. *et al.* The cardiac arrest centre for the treatment of sudden cardiac arrest due to presumed cardiac cause – aims, function and structure: Position paper of the Association for Acute CardioVascular Care of the European Society of Cardiology (AVCV), European Association of Percutaneous Coronary Interventions (EAPCI), European Heart Rhythm Association (EHRA), European Resuscitation Council (ERC), European Society for Emergency Medicine (EUSEM) and European Society of Intensive Care Medicine (ESICM). *European Heart Journal. Acute Cardiovascular Care* **9**, S193–S202 (2020).

155. Boulton, A. J. *et al.* Cardiac arrest centres for patients with non-traumatic cardiac arrest: A systematic review. *Resuscitation* **203**, 110387 (2024).

156. Rott, N. & Böttiger, B. W. Five years of Cardiac Arrest Center (CAC) certification in Germany – a success story. *Resuscitation* 110130 (2024) doi:10.1016/j.resuscitation.2024.110130.

157. May, T. L. *et al.* Variability in functional outcome and treatment practices by treatment center after out-of-hospital cardiac arrest: analysis of International Cardiac Arrest Registry. *Intensive Care Med* **45**, 637–646 (2019).

158. Rott, N. *et al.* Cardiac Arrest Center Certification for out-of-hospital cardiac arrest patients successfully established in Germany. *Resuscitation* **156**, 1–3 (2020).

159. Jorge-Perez, P. *et al.* Management of comatose survivors of out-of-hospital cardiac arrest in Europe: current treatment practice and adherence to guidelines. A joint survey by the Association for Acute CardioVascular Care (ACVC) of the ESC, the European Resuscitation Council (ERC), the European Society for Emergency Medicine (EUSEM), and the European Society of Intensive Care Medicine (ESICM). *Eur Heart J Acute Cardiovasc Care* **12**, 96–105 (2023).

160. Soar, J. *et al.* Adult Advanced Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation* **156**, A80–A119 (2020).

161. Greif, R. *et al.* Education, Implementation, and Teams. *Resuscitation* **156**, A188–A239 (2020).

162. Chien, C.-Y. *et al.* Impact of Transport Time and Cardiac Arrest Centers on the Neurological Outcome After Out-of-Hospital Cardiac Arrest: A Retrospective Cohort Study. *J Am Heart Assoc* **9**, e015544–e015544 (2020).

163. Chocron, R. *et al.* Are characteristics of hospitals associated with outcome after cardiac arrest? Insights from the Great Paris registry. *Resuscitation* **118**, 63–69 (2017).

164. Cournoyer, A. *et al.* Impact of the direct transfer to percutaneous coronary intervention-capable hospitals on survival to hospital discharge for patients with out-of-hospital cardiac arrest. *Resuscitation* **125**, 28–33 (2018).

165. Kragholm, K. *et al.* Direct Transport to a Percutaneous Cardiac Intervention Center and Outcomes in Patients With Out-of-Hospital Cardiac Arrest. *Circulation: Cardiovascular Quality and Outcomes* **10**, (2017).

166. KIM, J. Y. *et al.* Effect of transported hospital resources on neurologic outcome after out-of-hospital cardiac arrest. https://www.signavitae.com/articles/10.22514/SV151.042019.7

(2019) doi:10.22514/SV151.042019.7.

167. Matsuyama, T. *et al.* Hospital characteristics and favourable neurological outcome among patients with out-of-hospital cardiac arrest in Osaka, Japan. *Resuscitation* **110**, 146–153 (2017).

168. McKenzie, N. *et al.* Direct transport to a PCI-capable hospital is associated with improved survival after adult out-of-hospital cardiac arrest of medical aetiology. *Resuscitation* **128**, 76–82 (2018).

169. Mumma, B. E., Diercks, D. B., Wilson, M. D. & Holmes, J. F. Association between treatment at an ST-segment elevation myocardial infarction center and neurologic recovery after out-of-hospital cardiac arrest. *Am Heart J* **170**, 516–523 (2015).

170. Søholm, H. *et al.* Prognostic Implications of Level-of-Care at Tertiary Heart Centers Compared With Other Hospitals After Resuscitation From Out-of-Hospital Cardiac Arrest. *Circulation: Cardiovascular Quality and Outcomes* **8**, 268–276 (2015).

171. Spaite, D. W. *et al.* Statewide Regionalization of Postarrest Care for Out-of-Hospital Cardiac Arrest: Association With Survival and Neurologic Outcome. *Annals of Emergency Medicine* **64**, 496-506.e1 (2014).

172. Stub, D. *et al.* Hospital characteristics are associated with patient outcomes following out-of-hospital cardiac arrest. *Heart* **97**, 1489–1494 (2011).

173. Sunde, K. *et al.* Implementation of a standardised treatment protocol for post resuscitation care after out-of-hospital cardiac arrest. *Resuscitation* **73**, 29–39 (2007).

174. Tagami, T. *et al.* Implementation of the Fifth Link of the Chain of Survival Concept for Out-of-Hospital Cardiac Arrest. *Circulation* **126**, 589–597 (2012).

175. Yeh, C.-C. *et al.* Survival analysis in out-of-hospital cardiac arrest patients with shockable rhythm directly transport to Heart Centers. https://www.signavitae.com/articles/10.22514/sv.2021.084 (2021) doi:10.22514/sv.2021.084.

176. Wilcox, J., Redwood, S. & Patterson, T. Cardiac arrest centres: What do they add? *Resuscitation* **189**, 109865 (2023).

177. Patterson, T. *et al.* Expedited transfer to a cardiac arrest centre for non-ST-elevation out-of-hospital cardiac arrest (ARREST): a UK prospective, multicentre, parallel, randomised clinical trial. *The Lancet* **402**, 1329–1337 (2023).

178. Cardiac Arrest Centers: EIT 6301 TF SR. https://costr.ilcor.org/document/cardiac-arrest-centers-eit-6301-tf-sr.

179. System performance improvement. Preprint at (2025).

180. Jung, E., Ro, Y. S., Park, J. H., Ryu, H. H. & Shin, S. D. Direct Transport to Cardiac Arrest Center and Survival Outcomes after Out-of-Hospital Cardiac Arrest by Urbanization Level. *J Clin Med* **11**, 1033 (2022).

181. EIT 6310 System Performance Improvement: EIT 6310 TF SR. https://costr.ilcor.org/document/eit-6310-system-performance-improvement-eit-6310-tf-sr.

182. Semeraro, F. *et al.* European Resuscitation Council Guidelines 2021: Systems saving lives. *Resuscitation* **161**, 80–97 (2021).

183. Blewer, A. L. *et al.* Impact of bystander-focused public health interventions on cardiopulmonary resuscitation and survival: a cohort study. *The Lancet Public Health* **5**, e428–e436 (2020).

184. Lee, D. E., Ryoo, H. W., Moon, S., Park, J. H. & Shin, S. D. Effect of citywide enhancement of the chain of survival on good neurologic outcomes after out-of-hospital cardiac arrest from 2008 to 2017. *PLoS One* **15**, e0241804–e0241804 (2020).

185. Kim, G. W. *et al.* A multidisciplinary approach for improving the outcome of out-of-hospital cardiac arrest in South Korea. *Eur J Emerg Med* **27**, 46–53 (2020).

186. Auricchio, A. *et al.* Gender-specific differences in return-to-spontaneous circulation

and outcome after out-of-hospital cardiac arrest: Results of sixteen-year-state-wide initiatives. *Resusc Plus* **4**, 100038–100038 (2020).

187. Nehme, Z. *et al.* Effect of a resuscitation quality improvement programme on outcomes from out-of-hospital cardiac arrest. *Resuscitation* **162**, 236–244 (2021).

188. Dong, X. *et al.* Effect of a Targeted Ambulance Treatment Quality Improvement Programme on Outcomes from Out-of-Hospital Cardiac Arrest: A Metropolitan Citywide Intervention Study. *J Clin Med* **12**, 163 (2022).

189. Kim, G. W. *et al.* Effects of Smart Advanced Life Support protocol implementation including CPR coaching during out-of-hospital cardiac arrest. *The American Journal of Emergency Medicine* **56**, 211–217 (2022).

190. Lin, H.-Y. *et al.* Outcomes of out-of-hospital cardiac arrests after a decade of system-wide initiatives optimising community chain of survival in Taipei city. *Resuscitation* **172**, 149–158 (2022).

191. McCoy, C. *et al.* Empowering telemetry technicians and enhancing communication to improve in-hospital cardiac arrest survival. *BMJ Open Qual* **12**, e002220 (2023).

192. Freedman, A. J., Madsen, E. C. & Lowrie, L. Establishing a Quality Improvement Program for Pediatric In-hospital Cardiac Arrest. *Pediatr Qual Saf* **8**, e706–e706 (2023).

193. Li, T. *et al.* Resuscitation Quality Improvement® (RQI®) HeartCode Complete® program improves chest compression rate in real world out-of hospital cardiac arrest patients. *Resuscitation* **188**, 109833 (2023).

194. Lyngby, R. M. *et al.* Association of Real-Time Feedback and Cardiopulmonary-Resuscitation Quality Delivered by Ambulance Personnel for Out-of-Hospital Cardiac Arrest. *J Am Heart Assoc* **12**, e029457–e029457 (2023).

195. Riyapan, S. *et al.* Enhancing survival outcomes in developing emergency medical service system: Continuous quality improvement for out-of-hospital cardiac arrest. *Resusc Plus* **19**, 100683–100683 (2024).

196. Vaillancourt, C. *et al.* Multi-phase implementation of automated external defibrillator use by nurses during in-hospital cardiac arrest and its impact on survival. *Resuscitation* **197**, 110148 (2024).

197. Global Resuscitation Alliance. https://www.globalresuscitationalliance.org/.

198. Nolan, J. Post-Resus Chapter 2025 guidelines (add detailed reference as agreed up in Steering Committee please). *ERC*.

199. Chan, P. S. *et al.* Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes. *Resuscitation* **193**, 109996–109996 (2023).

200. Quality Standards: Survivors | Resuscitation Council UK. https://www.resus.org.uk/library/quality-standards-cpr/quality-standards-survivors.

201. Sawyer, K. N. *et al.* Sudden Cardiac Arrest Survivorship: A Scientific Statement From the American Heart Association. *Circulation* **141**, (2020).

202. Zook, N. *et al.* Neurocognitive function following out-of-hospital cardiac arrest: A systematic review. *Resuscitation* **170**, 238–246 (2022).

203. Chin, Y. H. *et al.* Long-term outcomes after out-of-hospital cardiac arrest: A systematic review and meta-analysis. *Resuscitation* **171**, 15–29 (2022).

204. Yaow, C. Y. L. *et al.* Prevalence of anxiety, depression, and post-traumatic stress disorder after cardiac arrest: A systematic review and meta-analysis. *Resuscitation* **170**, 82–91 (2022).

205. Perkins, G. D. *et al.* Brain injury after cardiac arrest. *The Lancet* **398**, 1269–1278 (2021).

206. Cronberg, T. *et al.* Brain injury after cardiac arrest: from prognostication of comatose patients to rehabilitation. *The Lancet Neurology* **19**, 611–622 (2020).

207. Rojas, D. A. *et al.* Family experiences and health outcomes following a loved ones' hospital discharge or death after cardiac arrest: A scoping review. *Resusc Plus* **14**, 100370–100370 (2023).

208. Mion, M. *et al.* Follow-up care after out-of-hospital cardiac arrest: A pilot study of survivors and families' experiences and recommendations. *Resusc Plus* **7**, 100154–100154 (2021).

209. Israelsson, J., Lilja, G., Bremer, A., Stevenson-Ågren, J. & Årestedt, K. Post cardiac arrest care and follow-up in Sweden - a national web-survey. *BMC Nurs* **15**, 1–1 (2016).

210. Tang, L. H., Joshi, V., Egholm, C. L. & Zwisler, A.-D. Are survivors of cardiac arrest provided with standard cardiac rehabilitation? – Results from a national survey of hospitals and municipalities in Denmark. *European Journal of Cardiovascular Nursing* **20**, 115–123 (2020).

211. Douma, M. J. *et al.* What Are the Care Needs of Families Experiencing Sudden Cardiac Arrest? A Survivor- and Family-Performed Systematic Review, Qualitative Meta-Synthesis, and Clinical Practice Recommendations. *Journal of Emergency Nursing* **49**, 912–950 (2023).

212. Wan, X., Chau, J. P. C., Mou, H. & Liu, X. Corrigendum to "Effects of peer support interventions on physical and psychosocial outcomes among stroke survivors: A systematic review and meta-analysis" [Int. J. Nurs. Stud., 121 (2021) 104001]. *International Journal of Nursing Studies* **157**, 104827 (2024).

213. Wan, X., Chau, J. P. C., Mou, H. & Liu, X. Effects of peer support interventions on physical and psychosocial outcomes among stroke survivors: A systematic review and meta-analysis. *Int J Nurs Stud* **121**, 104001 (2021).

214. Gamberini, L. Survivor survey. Preprint at (2025).

215. Wallace, S. J. *et al.* Do caregivers who connect online have better outcomes? A systematic review of online peer-support interventions for caregivers of people with stroke, dementia, traumatic brain injury, Parkinson's disease and multiple sclerosis. *Brain Impairment* **22**, 233–259 (2021).

216. Jablotschkin, M., Binkowski, L., Markovits Hoopii, R. & Weis, J. Benefits and challenges of cancer peer support groups: A systematic review of qualitative studies. *European Journal of Cancer Care* **31**, (2022).

217. Going the extra mile: Improving the nation's health and wellbeing through public involvement in research | NIHR. https://www.nihr.ac.uk/going-the-extra-mile.

218. Briefing notes for researchers - public involvement in NHS, health and social care research | NIHR. https://www.nihr.ac.uk/briefing-notes-researchers-public-involvement-nhs-health-and-social-care-research.

219. Boivin, A. *et al.* Evaluating patient and public involvement in research. *BMJ* k5147 (2018) doi:10.1136/bmj.k5147.

220. Haywood, K. *et al.* COSCA (Core Outcome Set for Cardiac Arrest) in Adults: An Advisory Statement From the International Liaison Committee on Resuscitation. *Resuscitation* **127**, 147–163 (2018).

221. Dainty, K. N. *et al.* Partnering with survivors & families to determine research priorities for adult out-of-hospital cardiac arrest: A James Lind Alliance Priority Setting Partnership. *Resusc Plus* **7**, 100148–100148 (2021).

222. Haywood, K. L. *et al.* An international collaborative study to co-produce a patient-reported outcome measure of cardiac arrest survivorship and health-related quality of life (CASHQoL): A protocol for developing the long-form measure. *Resusc Plus* **11**, 100288–100288 (2022).

223. Palm, M. E. *et al.* Public involvement in UK health and care research 1995-2020:

reflections from a witness seminar. *Res Involv Engagem* **10**, 65–65 (2024).

224. Haywood. Preprint at (2025).

225. Armstrong, M. J., Rueda, J.-D., Gronseth, G. S. & Mullins, C. D. Framework for enhancing clinical practice guidelines through continuous patient engagement. *Health Expect* **20**, 3–10 (2017).

226. Standards | NHMRC. https://www.nhmrc.gov.au/guidelinesforguidelines/standards.

227. Bryant, E. A., Scott, A. M., Greenwood, H. & Thomas, R. Patient and public involvement in the development of clinical practice guidelines: a scoping review. *BMJ Open* **12**, e055428–e055428 (2022).

228. Lampreia, F., Madeira, C. & Dores, H. Digital health technologies and artificial intelligence in cardiovascular clinical trials: A landscape of the European space. *Digit Health* **10**, 20552076241277703–20552076241277703 (2024).

229. Whitelaw, S., Pellegrini, D. M., Mamas, M. A., Cowie, M. & Van Spall, H. G. C. Barriers and facilitators of the uptake of digital health technology in cardiovascular care: a systematic scoping review. *Eur Heart J Digit Health* **2**, 62–74 (2021).

230. Alrawashdeh, A. *et al.* Applications and Performance of Machine Learning Algorithms in Emergency Medical Services: A Scoping Review. *Prehosp Disaster Med* **39**, 368–378 (2024).

231. Toy, J., Bosson, N., Schlesinger, S., Gausche-Hill, M. & Stratton, S. Artificial intelligence to support out-of-hospital cardiac arrest care: A scoping review. *Resuscitation Plus* **16**, 100491 (2023).

232. Alamgir, A., Mousa, O. & Shah, Z. Artificial Intelligence in Predicting Cardiac Arrest: Scoping Review. *JMIR Med Inform* **9**, e30798–e30798 (2021).

233. Huang, J.-D. *et al.* Applying Artificial Intelligence to Wearable Sensor Data to Diagnose and Predict Cardiovascular Disease: A Review. *Sensors (Basel)* **22**, 8002 (2022).

234. Chambers, K. H. The potential role of wearable technology in monitoring and predicting cardiovascular events in high-risk individuals. *Revista Portuguesa de Cardiologia* **42**, 1029–1030 (2023).

235. Roh, K. M., Awosika, A. & Millis, R. M. Advances in Wearable Stethoscope Technology: Opportunities for the Early Detection and Prevention of Cardiovascular Diseases. *Cureus* **16**, e75446–e75446 (2024).

236. Marijon, E. *et al.* The Lancet Commission to reduce the global burden of sudden cardiac death: a call for multidisciplinary action. *Lancet* **402**, 883–936 (2023).

237. Majumder, S., Mondal, T. & Deen, M. J. Wearable Sensors for Remote Health Monitoring. *Sensors (Basel)* **17**, 130 (2017).

238. Prieto-Avalos, G. *et al.* Wearable Devices for Physical Monitoring of Heart: A Review. *Biosensors (Basel)* **12**, 292 (2022).

239. Duncker, D. *et al.* Smart Wearables for Cardiac Monitoring-Real-World Use beyond Atrial Fibrillation. *Sensors (Basel)* **21**, 2539 (2021).

240. Nasarre, M. *et al.* Using a smartwatch electrocardiogram to detect abnormalities associated with sudden cardiac arrest in young adults. *EP Europace* **24**, 406–412 (2021).

241. Bacevicius, J. *et al.* High Specificity Wearable Device With Photoplethysmography and Six-Lead Electrocardiography for Atrial Fibrillation Detection Challenged by Frequent Premature Contractions: DoubleCheck-AF. *Front Cardiovasc Med* **9**, 869730–869730 (2022).

242. Gill, S. *et al.* Smartphone detection of atrial fibrillation using photoplethysmography: a systematic review and meta-analysis. *Heart* **108**, 1600–1607 (2022).

243. Khalili, M. *et al.* Detecting cardiac states with wearable photoplethysmograms and implications for out-of-hospital cardiac arrest detection. *Sci Rep* **14**, 23185–23185 (2024).

244. Shah, K. *et al.* Automated loss of pulse detection on a consumer smartwatch. *Nature* (2025) doi:10.1038/s41586-025-08810-9.

245. Sibomana, O. *et al.* Diagnostic accuracy of ECG smart chest patches versus PPG smartwatches for atrial fibrillation detection: a systematic review and meta-analysis. *BMC Cardiovasc Disord* **25**, 132–132 (2025).

246. Nearing, B. D. & Verrier, R. L. Novel application of convolutional neural networks for artificial intelligence-enabled modified moving average analysis of P-, R-, and T-wave alternans for detection of risk for atrial and ventricular arrhythmias. *Journal of Electrocardiology* **83**, 12–20 (2024).

247. Schober, P. *et al.* Smartwatch based automatic detection of out-of-hospital cardiac arrest: Study rationale and protocol of the HEART-SAFE project. *Resusc Plus* **12**, 100324–100324 (2022).

248. Hup, R. G. *et al.* Rationale and design of the BECA project: Smartwatch-based activation of the chain of survival for out-of-hospital cardiac arrest. *Resusc Plus* **17**, 100576–100576 (2024).

249. Frazao, A., Pinho, P. & Albuquerque, D. Radar-Based Heart Cardiac Activity Measurements: A Review. *Sensors (Basel)* **24**, 7654 (2024).

250. Zhao, Y. & Bergmann, J. H. M. Non-Contact Infrared Thermometers and Thermal Scanners for Human Body Temperature Monitoring: A Systematic Review. *Sensors (Basel)* **23**, 7439 (2023).

251. Choo, Y. J., Lee, G. W., Moon, J. S. & Chang, M. C. Application of non-contact sensors for health monitoring in hospitals: a narrative review. *Front Med (Lausanne)* **11**, 1421901–1421901 (2024).

252. Liebetruth, M., Kehe, K., Steinritz, D. & Sammito, S. Systematic Literature Review Regarding Heart Rate and Respiratory Rate Measurement by Means of Radar Technology. *Sensors (Basel)* **24**, 1003 (2024).

253. He, H. *et al.* What radio waves tell us about sleep! *Sleep* **48**, zsae187 (2025).

254. Liu, Y. *et al.* Monitoring gait at home with radio waves in Parkinson's disease: A marker of severity, progression, and medication response. *Science Translational Medicine* **14**, (2022).

255. Chan, J., Rea, T., Gollakota, S. & Sunshine, J. E. Contactless cardiac arrest detection using smart devices. *NPJ Digit Med* **2**, 52–52 (2019).

256. Semeraro, F. *et al.* Cardiac arrest and cardiopulmonary resuscitation in the next decade: Predicting and shaping the impact of technological innovations. *Resuscitation* **200**, 110250 (2024).

257. Kolk, M. Z. H. *et al.* Prediction of sudden cardiac death using artificial intelligence: Current status and future directions. *Heart Rhythm* **22**, 756–766 (2025).

258. Lee, H. *et al.* Real-time machine learning model to predict in-hospital cardiac arrest using heart rate variability in ICU. *NPJ Digit Med* **6**, 215–215 (2023).

259. Lu, T.-C. *et al.* Using a smartwatch with real-time feedback improves the delivery of high-quality cardiopulmonary resuscitation by healthcare professionals. *Resuscitation* **140**, 16–22 (2019).

260. Semeraro, F. *et al.* iCPR: A new application of high-quality cardiopulmonary resuscitation training. *Resuscitation* **82**, 436–441 (2011).

261. Sun, R. *et al.* Effectiveness of virtual and augmented reality for cardiopulmonary resuscitation training: a systematic review and meta-analysis. *BMC Medical Education* **24**, 730 (2024).

262. Zhou, K. & Gattinger, G. The Evolving Regulatory Paradigm of AI in MedTech: A Review of Perspectives and Where We Are Today. *Ther Innov Regul Sci* **58**, 456–464 (2024).

263. Warraich, H. J., Tazbaz, T. & Califf, R. M. FDA Perspective on the Regulation of Artificial Intelligence in Health Care and Biomedicine. *JAMA* **333**, 241 (2025).

264. Mennella, C., Maniscalco, U., De Pietro, G. & Esposito, M. Ethical and regulatory challenges of AI technologies in healthcare: A narrative review. *Heliyon* **10**, e26297–e26297 (2024).

265. Okada, Y., Mertens, M., Liu, N., Lam, S. S. W. & Ong, M. E. H. AI and machine learning in resuscitation: Ongoing research, new concepts, and key challenges. *Resuscitation Plus* **15**, 100435 (2023).

266. Lin, C.-S. *et al.* AI-enabled electrocardiography alert intervention and all-cause mortality: a pragmatic randomized clinical trial. *Nature Medicine* **30**, 1461–1470 (2024).

267. Semeraro, F., Schnaubelt, S., Montomoli, J., Bignami, E. G. & Monsieurs, K. G. Artificial intelligence in cardiopulmonary resuscitation: Driving awareness and debunking myths. *Resuscitation* **208**, 110539 (2025).

268. Zace, D. *et al.* Artificial Intelligence in Resuscitation: A Scoping Review. *Resuscitation Plus* 100973 (2025) doi:10.1016/j.resplu.2025.100973.

269. Montomoli, J. *et al.* Algor-ethics: charting the ethical path for AI in critical care. *J Clin Monit Comput* **38**, 931–939 (2024).

270. Lee, J. & Shin, M. Using beat score maps with successive segmentation for ECG classification without R-peak detection. *Biomedical Signal Processing and Control* **91**, 105982 (2024).

271. Holmstrom, L. *et al.* An ECG-based artificial intelligence model for assessment of sudden cardiac death risk. *Commun Med (Lond)* **4**, 17–17 (2024).

272. Correction to Lancet Digit Health 2024; published online Sept 17. https://doi.org/10.1016/S2589-7500(24)00143-2. *Lancet Digit Health* **6**, e777–e777 (2024).

273. Sau, A. *et al.* Artificial intelligence-enabled electrocardiogram for mortality and cardiovascular risk estimation: a model development and validation study. *Lancet Digit Health* **6**, e791–e802 (2024).

274. Hajeb-M, S., Cascella, A., Valentine, M. & Chon, K. H. Deep Neural Network Approach for Continuous ECG-Based Automated External Defibrillator Shock Advisory System During Cardiopulmonary Resuscitation. *J Am Heart Assoc* **10**, e019065–e019065 (2021).

275. Brown, G. *et al.* Role of artificial intelligence in defibrillators: a narrative review. *Open Heart* **9**, e001976 (2022).

276. Ni, P., Zhang, S., Hu, W. & Diao, M. Application of multi-feature-based machine learning models to predict neurological outcomes of cardiac arrest. *Resuscitation Plus* **20**, 100829 (2024).

277. Sebastian, P. S. *et al.* Closed-loop machine-controlled CPR system optimises haemodynamics during prolonged CPR. *Resusc Plus* **3**, 100021–100021 (2020).

278. Muzammil, M. A. *et al.* Artificial intelligence-enhanced electrocardiography for accurate diagnosis and management of cardiovascular diseases. *Journal of Electrocardiology* **83**, 30–40 (2024).

279. Zheng, W.-L. *et al.* Predicting neurological outcome in comatose patients after cardiac arrest with multiscale deep neural networks. *Resuscitation* **169**, 86–94 (2021).

280. Zobeiri, A., Rezaee, A., Hajati, F., Argha, A. & Alinejad-Rokny, H. Post-Cardiac arrest outcome prediction using machine learning: A systematic review and meta-analysis. *International Journal of Medical Informatics* **193**, 105659 (2025).

281. Marques, M., Almeida, A. & Pereira, H. The Medicine Revolution Through Artificial Intelligence: Ethical Challenges of Machine Learning Algorithms in Decision-Making. *Cureus* **16**, e69405–e69405 (2024).

282. Semeraro, F., Bignami, E. G., Montomoli, J. & Monsieurs, K. G. Enhancing cardiac arrest response: Evaluating GPT-4o's advanced voice interaction system. *Resuscitation* **205**, 110447 (2024).

283. Bignami, E. G., Semeraro, F., Bellini, V. & Cascella, M. Human Judgment versus ChatGPT: Preserving the Essence of Medical Competence in the Age of Artificial Intelligence. *Anesthesia & Analgesia* (2024) doi:10.1213/ane.0000000000007344.

284. Semeraro, F., Cascella, M., Montomoli, J., Bellini, V. & Bignami, E. G. Comparative analysis of AI tools for disseminating CPR guidelines: Implications for cardiac arrest education. *Resuscitation* **208**, 110528 (2025).

285. Semeraro, F., Fijačko, N., Gamberini, L., Bignami, E. G. & Greif, R. The gap between promise and reality: Evaluating new AI's role in CPR education. *Resuscitation* **208**, 110540 (2025).