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European Resuscitation Council Guidelines 2021: Systems saving lives

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Abstract

The European Resuscitation Council (ERC) has produced these Systems Saving Lives guidelines, which are based on the 2020 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations. The topics covered include chain of survival, measuring performance of resuscitation, social media and smartphones apps for engaging community, European Restart a Heart Day, World Restart a Heart, KIDS SAVE LIVES campaign, lower-resource setting, European Resuscitation Academy and Global Resuscitation Alliance, early warning scores, rapid response systems, and medical emergency team, cardiac arrest centres and role of dispatcher.

Introduction and scope

The Systems Saving Lives chapter describes numerous and important factors that can globally improve the management of cardiac arrest patients not as a single intervention but as a system-level approach. The aim of this chapter is to provide evidence-informed best practice guidance, about interventions which can be implemented by healthcare systems to improve outcomes of out-of-hospital and/or in-hospital cardiac arrest

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(OHCA and IHCA). The intended audience of the chapter are governments, managers of health and education systems, healthcare professionals, teachers, students and laypeople. The concept behind the Systems Saving Lives approach to cardiac arrest is to emphasise the connections between the different individuals involved in the chain of survival. Citizens are involved through cardiac arrest awareness campaigns (e.g. European Restart a Heart Day - ERHD and World Restart a Heart - WRAH) and may be engaged by apps as first responders. The dispatch centre that receives the alert call activates the Emergency Medical System (EMS) vehicle. Whilst the EMS vehicle is en-route the call operator provides pre-arrival instructions to start cardiopulmonary resuscitation (CPR). This chapter also describes the concept of a cardiac arrest centre and emphasises the importance of measuring the performance of resuscitation systems. The key role of track and trigger systems to avoid preventable cardiac arrest and the part played by rapid response teams is described.

In the past, the guidelines of the ERC have been developed from a perspective of an ideal high-resource or high-income environment. Little attention has been paid to the applicability of statements from such areas in the daily practice of lower-income regions. In many parts of the world, a high-resource standard of care is not available due to a lack of financial resources. For example, low-quality performance of EMS can be a barrier

Fig. 1 – System saving lives infographic summary.

to guideline implementation. Internationally valid recommendations should serve as a supportive structure for weaker systems.[1]

The Systems Saving Lives concept emphasises the interconnection between community and EMS (e.g. KIDS SAVE LIVES) and should be implemented in each European community. Systems Saving Lives ranges from the young student who learns CPR at school, to a citizen who receives a cardiac arrest alert through their mobile phone and is willing to start CPR and to use an automated external defibrillator (AED) on the scene, to the EMS team that continues advanced treatment to stabilise and transport the patient for post-resuscitation care in a high-performance hospital. In Systems Saving Lives, everyone and everything is an important link to survival – we are moving from the classical four-link chain of survival to a multitude of links encompassed in the new System Saving Lives concept. Every single step in this complex system is important.

These guidelines were drafted and agreed by the Systems Saving Lives Writing Group members. The methodology used for guideline development is presented in the Executive summary.[1a] The guidelines were posted for public comment in October 2020. The feedback was reviewed by the writing group and the guidelines was updated where relevant. The Guideline was presented to and approved by the ERC General Assembly on 10th December 2020.

Key messages from this section are presented in Fig. 1.

Concise guideline for clinical practice

Chain of survival & the formula of survival

- The actions linking the victim of sudden cardiac arrest with survival are called the chain of survival.
- The goal of saving more lives relies not only on solid and high-quality science but also effective education of lay people and healthcare professionals.
- Systems engaged in the care of cardiac arrest victims should be able to implement resource efficient systems that can improve survival after cardiac arrest.

Measuring the performance of resuscitation systems

- Organisations or communities that treat cardiac arrest should evaluate their system performance and target key areas with the goal to improve performance.

Social media and smartphones apps for engaging the community

- First responders (trained and untrained laypersons, firefighters, police officers, and off-duty healthcare professionals) who are near a suspected OHCA should be notified by the dispatch centre through an alerting system implemented with a smartphone app or a text message.
- Every European country is highly encouraged to implement such technologies in order to:
  - Improve the rate of bystander-initiated cardiopulmonary resuscitation (CPR).
  - Reduce the time to first compression and shock delivery.
  - Improve survival with good neurological recovery.

European Restart a Heart Day (ERHD) & World Restart a Heart (WRAH)

National resuscitation councils, national governments and local authorities should:

- Engage with WRAH.
- Raise awareness of the importance of bystander CPR and AEDs.
- Train as many citizens as possible.
- Develop new and innovative systems and policies that will save more lives.

KIDS SAVE LIVES

- All schoolchildren should routinely receive CPR training each year.
- Teach CHECK - CALL – COMPRESS.
- Trained schoolchildren should be encouraged to train family members and friends. The homework for all children after such training should be: "please train 10 other people within the next two weeks and report back".
- CPR training should also be delivered in higher education institutions, in particular to teaching and healthcare students.
- The responsible people in the Ministries of Education and/or Ministries of Schools and other leading politicians of each country should implement a nationwide program for teaching CPR to schoolchildren. Training schoolchildren in CPR should be mandatory by law all over Europe and elsewhere.

Community initiatives to promote CPR implementation

- Healthcare systems should implement community initiatives for CPR training for large portions of the population (neighbourhood, town, region, a part of or a whole nation).

Low-resource settings

Resuscitation research in low-resource settings

- Research is required to understand different populations, aetiologies and outcome data of cardiac arrest in low-resource settings. Research should follow Utstein guidelines.
- The level of income of countries should be included in reports. A useful system to report level of income is the definition of the World Bank (gross national income per capita).
- When reporting about resuscitation systems and outcome, psychological and sociocultural views on cardiac arrest should be documented.
- Experts from all resource backgrounds should be consulted concerning local acceptability and applicability of international guidelines and recommendations for resuscitation.

Essential resources for resuscitation care systems in low-resource settings

- A list with essential resuscitation care resources that is specially adapted to low resource settings should be developed in collaboration with stakeholders from these low resource settings.

European Resuscitation Academy and Global Resuscitation Alliance

- Programmes such as the European Resuscitation Academy programs should be implemented to increase bystander CPR rates and improve survival in case of OHCA.

Role of dispatcher

Dispatch-assisted recognition of cardiac arrest

- Dispatch centres should implement standardised criteria and algorithms to determine if a patient is in cardiac arrest at the time of the emergency call.
- Dispatch centres should monitor and track their ability to recognize cardiac arrest and continuously look for ways to improve recognition of cardiac arrest.

Dispatch-assisted CPR

- Dispatch centres should have systems in place to make sure call handlers provide CPR instructions for unresponsive persons not breathing normally.

Dispatch-assisted chest compression-only compared with standard CPR

- Dispatchers should provide chest compression–only CPR instructions for callers who identify unresponsive adult persons not breathing normally.

Early warning scores, rapid response systems, and medical emergency teams

- Consider the introduction of rapid response systems to reduce the incidence of in-hospital cardiac arrest and in-hospital mortality.

Cardiac arrest centres

- Adult patients with non-traumatic OHCA should be considered for transport to a cardiac arrest centre according to local protocols.

Evidence informing the guidelines

Chain of survival & the formula of survival

The Chain of Survival for victims of out-of-hospital cardiac arrest (OHCA) was initially described by Friedrich Wilhelm Ahnefeld in 1968 to emphasise all the time-sensitive interventions (represented as links) to maximise the chance of survival.[2] The concept was built upon in 1988 by Mary M Newman of the Sudden Cardiac Arrest Foundation in the United States.[3] It was subsequently modified and adapted by the American Heart Association in 1991.[4]

Designs depicting the chain of survival have been updated frequently, but until recently the message conveyed in each link has remained unchanged. The European Resuscitation Council (ERC) chain of survival in its current format was first published in the 2005 ERC guidelines and summarizes the vital links needed for successful resuscitation: 1. Early recognition and call for help – to prevent cardiac arrest and to activate the EMS; 2. Early bystander CPR - to slow down the rate of deterioration of the brain and heart, and to buy time to enable defibrillation; 3. Early defibrillation - to restore a perfusing rhythm; and 4. Early advanced life support and standardised post-resuscitation care, to restore quality of life. The chain emphasises the interconnection and the need for all links to be fast and effective in order to optimise the chances of intact survival. Most of these links apply to victims of both primary cardiac and asphyxial arrest.[5,6]

Early recognition and call for help

The first link indicates the importance of recognising patients at risk of cardiac arrest and calling for help in the hope of preventing cardiac arrest. Most patients show signs of physiological deterioration in the hours before cardiac arrest or have warning symptoms for a significant duration before cardiac arrest.[7,8] Thus, chest pain should be recognised as a symptom of myocardial ischaemia. Recognising the cardiac origin of chest pain, and calling the emergency services before a victim collapses, enables the emergency medical service to arrive sooner, hopefully before cardiac arrest has occurred, thus leading to better survival.[9,10] Once cardiac arrest has occurred, recognising cardiac arrest can be challenging. Both bystanders and emergency medical dispatchers have to diagnose cardiac arrest promptly to activate the chain of survival. Early recognition is critical to enable rapid activation of the EMS and prompt initiation of bystander CPR. ILCOR and the ERC BLS guidelines highlight the key observations to diagnose cardiac arrest are that the person is unresponsive with absent or abnormal breathing.[11,12]

Early bystander CPR

The immediate initiation of CPR can double or triple survival from cardiac arrest.[13–21] The emergency medical dispatcher is an essential link in the chain of survival to help bystanders initiate CPR. Emergency medical dispatchers are increasingly being trained to recognise cardiac arrest, to instruct and assist bystanders in initiating resuscitation, and to support bystanders in optimising resuscitation efforts, while awaiting the arrival of professional help.[22–31]

Early defibrillation

The benefits of early defibrillation on survival and functional outcome, though public-access defibrillation programs and greater accessibility and availability of AEDs in the community, are unquestionable.[32,33] These benefits have been attributed to the decreased time to defibrillation by bystanders versus EMS because survival in shockable OHCA decreases significantly with each minute of delay in defibrillation. Defibrillation within 3–5 min of collapse can produce survival rates as high as 50–70%. This can be achieved only by public access programs and onsite AEDs.[34–37] Each minute of delay to defibrillation reduces the probability of survival to discharge by 10–12%. The links in the chain work better together: when bystander CPR is provided, the decline in survival is more gradual and averages 3–5% per minute delay to defibrillation.[9,13,38,39]

Early advanced life support and standardised post-resuscitation care

Advanced life support with airway management, drugs and correction of causal factors may be needed if initial attempts at resuscitation are unsuccessful. Prior studies suggested no additional benefit from ALS in previously optimised EMS systems of rapid defibrillation.[40] A recent prospective study comparing the association of ALS care with OHCA outcomes in more than 35,000 patients, showed that early ALS was associated with improved survival to hospital discharge.[41] Better quality of treatment during the post-resuscitation phase with urgent coronary angiography, optimisation of both circulation and ventilation, targeted temperature management, multimodal neuroprognostication, and subsequent rehabilitation, improves outcome.[42,43]

The chain of survival in its current format focuses on specific interventions rather than on the potential for the effectiveness of each link. The contribution of each of the four links diminishes rapidly at each stage as the number of patients decrease with progression along the chain. Thus, a different view of the chain of survival has been proposed to emphasise the relative contribution made by each link to survival.[44] Thus, to improve survival, greater focus should be placed on early recognition and early CPR, and less to post-resuscitation care. This new view of the chain of survival will help to inform clinicians, scientists and researchers of where there is the greatest potential to improve outcome and may provide renewed focus on research, education and implementation, as depicted in the formula for survival.[45]

The chain of survival was extended to the formula for survival because it was realised that the goal of saving more lives relies not only on high-quality science but also on effective education of lay people and healthcare professionals.[45,46] Ultimately, those who are engaged in the care of cardiac arrest victims should be able to implement resource-efficient systems that can improve survival after cardiac arrest.

In the formula for survival, three interactive factors, guideline quality (science), efficient education of patient caregivers (education) and a well-functioning chain of survival at a local level (local implementation), form multiplicands in determining survival from resuscitation.

Science is recognised as an integral part of the other two factors: education and implementation. Given the nature of resuscitation, high-quality scientific evidence from randomised controlled trials is often difficult to obtain and in many cases extrapolations from observational studies are needed. There is also difficulty in applying the same standards of evidence to educational recommendations as to treatment recommendations. Resuscitation education providers and designers of teaching programs should create learning experiences highly likely to result in acquisition and retention of skills, knowledge and attitudes required for good performance. The formula for survival concludes with local implementation. The combination of medical science and educational efficiency is not sufficient to improve survival if implementation is poor or absent. Frequently, this implementation will also require some form of change management to embed new visions into a local culture. Quite often, the easy fix will not be the sustainable solution and prolonged negotiation and diplomacy may be needed. A prime example of this is the implementation of CPR training in the school curriculum. In many cases, countries that eventually achieved this goal spent years campaigning and persuading governments to adopt this strategy.[47,48]

Measuring the performance of resuscitation systems

These ERC recommendations are informed by the ILCOR systematic review, consensus on science and treatment recommendations on system performance.[49] System performance improvement is defined as hospital-level, community-level or country-level improvement related to structure, care pathways, process and quality of care. According to ILCOR, two types of outcomes indicators should be considered for measuring system performance improvement: critical (survival with favourable neurological outcome at discharge and survival to hospital discharge) and important (skill performance in actual resuscitations, survival to admission and system level variables).

ILCOR recommends that organisations or communities that treat cardiac arrest should evaluate their performance and target key areas with the goal of improving performance. (Strong recommendation, very low certainty of evidence). The systematic review published by ILCOR recognises that the evidence in support of this recommendation comes from studies of mostly moderate to very-low-certainty certainty, mainly non-randomised controlled trials.[49]

The majority of these studies associated with system performance improvement found that interventions to improve system performance improved system level variables and skill performance of basic life support (BLS) and advanced life support (ALS) in actual resuscitations,[50–61] leading to improved clinical outcomes following out-of-hospital or in-hospital cardiac arrest. Several studies showed improved survival to hospital discharge[52,54,56,57,61–70] and survival with favourable neurological outcome at discharge.[52,54,61–65,68–71] Some studies have shown an association between system performance improvement and survival to admission[64,67,69] but others have not.[53,71,72]

We also recognise that interventions to improve system performance need money, personnel and stakeholders, and in this context some systems may not have adequate resources to implement system performance improvement.

Further work needs to be done to:

- Identify the most appropriate strategy to improve system performance.
- Better understand the influence of local community and organisational characteristics to improve system performance.
- Evaluate the cost-effectiveness of each intervention for improving system performance.

Social media and smartphones apps for engaging the community

Mobile phone technology is being increasingly used to engage bystanders in out-of-hospital cardiac arrest (OHCA) events. The use of mobile technology, including social media, cellular networks and smartphone applications, could soon be of great impact. The rationale for their use is that notifying citizens as first responders to an OHCA event by a smartphone app with a Mobile Positioning System (MPS) or Text Message (TM)-alert system could increase early CPR and early defibrillation, thereby improving survival.

The ERC guidelines are informed by the ILCOR systematic review, consensus on science and treatment recommendations, led by the Education Implementation and Teams (EIT) Task Force. The review investigated whether in the case of OHCA (P) alerting citizen first responders through mobile-phone technology (I) compared with no notification and standard EMS response (C) affects survival to hospital discharge with good neurological outcome, survival to hospital discharge, hospital admission, return of spontaneous circulation (ROSC), bystander CPR rates, time to first compression/shock (O).[49] The general direction of effect across most studies favours the use of mobile phone technology to alert citizens as first responders in case of OHCA. The rate of bystander-CPR was higher in the intervention group than the comparison group in all studies.[36,73] The rate of survival to hospital discharge, was higher in the intervention group,[73–76] but survival to hospital discharge with favourable neurological outcome was no different between the intervention and the comparison groups.[73,76] Time to first compression/shock was shorter in the intervention group in all the studies.[74,76–78] After that ILCOR

Treatment Recommendation was published, another six articles and a systematic review were published, reinforcing the general direction of effect in favour of the intervention.[76,79–83] One study demonstrated that increasing the density of AEDs and first responders alerted with a text message, decreased time to defibrillation in residential areas compared with the time to defibrillation by EMS personnel. The recommended density of AEDs and first responders for the earliest defibrillation is two AEDs/km^2 and at least 10 first responders/km^2.[81] A systematic review analysed 12 different mobile-phone systems to alert citizens as first responders and found that first responders accepted to intervene in a median 28.7% (interquartile range (IQR) 27–29%) of alerts and reached the scene after a median of 4.6 (IQR 4.4–5.5) minutes for performing CPR and after 7.5 (IQR 6.7–8.4) minutes if an AED was first collected. First responders arrived before EMS, started CPR and attached an AED in a median of 47% (IQR 34–58%), 24% (IQR 23–27%) and 9% (IQR 6–14%) of cases, respectively. Among those victims who had an AED attached by the first responder, the first rhythm registered was shockable in a median of 35% (IQR 25–47%) of cases. Pooled analysis confirmed the general direction of effect in favour of the intervention as reported above.[82]

A recent European survey performed under the umbrella of the ESCAPE-NET project collected data about first responder treatment after OHCA in Europe.[84,85] Forty-seven (92%) OHCA experts from 29 countries responded to the survey. More than half of the European countries have at least one region with a first responder system. First responders in Europe are mainly firefighters (professional/voluntary), police officers, citizens and off-duty healthcare professionals (nurses, medical doctors, paramedics) as well as taxi drivers. The survey reported that the use of an app with a mobile positioning system (MPS) or Text Message (TM)-alert system was implemented in some European countries (e.g. Austria, Czech Republic, Denmark, United Kingdom, Germany, Hungary, Italy, Netherland, Romania, Sweden, and Switzerland). Another survey was conducted from February 6th, 2020 to February 16th, 2020 to obtain a picture of available systems to alert citizen first responders and locate the nearest AEDs across Europe.[86] The results covered 32 European countries. More than half of the countries (62%) had at least one system in one region to alert citizens as first responders for a total of 34 different systems. Almost all systems (94%) required citizens to be trained in BLS to become part of the first responder network. Systems to map and locate the nearest AED were available in 25 European countries (78%). Given the considerable variability across Europe, it would be appropriate to pursue a uniform standard of development of these systems. Moreover, a standardised approach like the Utstein Style is highly encouraged to obtain a uniform reporting of these systems. Smartphone-based activation of first responders to OHCA saves lives. The statements generated by a recent consensus conference involving five European countries may assist the public, healthcare services and governments to use these systems to their full potential and direct the research community towards fields that still need to be addressed.[87]

In line with ILCOR, the ERC recommends that citizens who are near a suspected OHCA event and willing to be engaged/notified by a smartphone app with a mobile positioning system (MPS) or Text Message (TM)-alert system should be notified (strong recommendation, very-low-certainty evidence). As these technologies become ubiquitous, they will play a greater role in the chain of survival. A causal relationship between application-initiated citizen responses and survival has not been proven. Therefore, systems using such technologies should promote research and improve the quality of data collection to further demonstrate the benefit of their integration into the EMS. Privacy legislation, which has been cited as a barrier to the implementation of such technologies, may have to be changed.

European Restart a Heart Day (ERHD) & World Restart a Heart (WRAH)

Survival rates from OHCA around the world remain relatively low, despite the development of guidelines and the influence of technology.[88] The exact magnitude of the burden of cardiac arrest in Europe and worldwide is well documented.[89] The ERC recognises that an important strategy to increase survival rates from OHCA is to increase the rate of bystander CPR. If more people were trained and more AEDs were placed strategically, more lives could be saved from cardiac arrest.[37]

Following a lobbying campaign by the ERC, the European Parliament passed a Written Declaration in June 2012 with a majority vote of 396 signatures calling for comprehensive training programmes in CPR and AED use across all its member states. The Written Declaration called for an adjustment of legislation in EU member states to ensure national strategies for equal access to high-quality CPR and defibrillation. The declaration also called for the establishment of a European cardiac arrest awareness week. As a result of this, and as part of its strategy to increase bystander CPR rates, the ERC announced the establishment of an annual Cardiac Arrest Awareness day on 16 October every year, to be named 'Restart a Heart Day'. The motto for the first European Restart a Heart Day (ERHD) in 2013 was 'Children Saving Lives'. A survey conducted on behalf of the ERC generated responses from 23 of 30 national resuscitation councils. It identified that training in first aid incorporating CPR in the school curricula existed in only 4 of the 23 responding countries.[90] National policies about resuscitation have the power to increase the willingness of citizens to perform bystander CPR. The Restart a Heart initiative actively encourages the development of national policies in all member states throughout Europe.[91]

In 2018, the European Restart a Heart initiative was endorsed by the International Liaison Committee on Resuscitation (ILCOR) and has since taken a global dimension under the name of World Restart a Heart (WRAH).[92–94] The motto of WRAH is 'All citizens of the world can save a life – all that is needed is two hands (CHECK – CALL – COMPRESS)'. Each person trained is a potential lifesaver and the number of additional people they inspire to also receive training is unmeasurable. The results for WRAH 2018 exceeded expectations as over 675,000 people were trained in CPR worldwide.[95]

For WRAH 2019, promotional videos were produced worldwide in iconic places. Moreover, 191 National Red Cross Societies of the five geographical zones of the world were invited to engage in the campaign. The most impressive European results for 2019 were reported from the United Kingdom, where 291,000 people were trained in CPR. This was achieved by the participation of every EMS organisation, as well as teaching delivered by medical students. The subject has subsequently become mandatory in the English school curriculum, as it is in five other European countries. This demonstrates the power of the WRAH in helping to promote change in national policy. In Poland, 150,562 people were trained, in Germany 30,000, and in Italy 17,000. Overall, 493,000 people were trained in CPR in Europe with over 5 million trained and up to 206 million reached by social media worldwide during WRAH 2019.[94]

In conclusion, the ERC has made a significant impact with ERHD and WRAH. In its first two years alone, WRAH has become so influential that it has reached countries not yet represented by ILCOR and it has already become so dynamic and viral that over six million people have been trained in CPR. The purpose of WRAH is that national councils use this initiative to promote uniformity in practice and reporting systems, create benchmarks and, by learning from each other, define weak links in the chain of survival in order to improve healthcare practice. The low rate of bystander CPR may signify the lack of public awareness as part of the problem, thus justifying it as a high priority for the ERC. Education of the public is an essential component of the strategy to fight the burden of OHCA.

On the basis of expert consensus, it is recommended that national resuscitation councils, national governments and local authorities, engage with WRAH to raise awareness of the importance of bystander CPR and AEDs, to train as many citizens as possible, and to develop new and innovative systems and policies that will save more lives.

KIDS SAVE LIVES

Mandatory nationwide training of schoolchildren has the highest and most important long-term impact for improving bystander CPR rate.[96,97] In the long run, this appears to be the most successful way to reach the entire population.[98] The highest bystander CPR rates have been reported in some Scandinavian countries, where education of schoolchildren in CPR has been mandatory for decades, and this concept is starting to spread all over Europe and the world.[16]

Following several activities by the ERC, in 2015 the World Health Organization (WHO) endorsed the ERC 'KIDS SAVE LIVES' a joint statement from the International Liaison Committee on Resuscitation (ILCOR), the European Resuscitation Council (ERC), the European Patient Safety Foundation (EPSF), and the World Federation of Societies of Anaesthesiologists (WFSA).[99,100] This statement recommends two hours of CPR training annually from the age of 12 years in all schools worldwide. At this age, children are more receptive to instructions and they learn more easily to help others. It is accepted that younger children, whilst physically unable to perform CPR, can also learn the principles behind CPR as it provides a foundation for their learning and they may still be able to instruct others to do so instead.[101] As a result, we recommend teaching all schoolchildren the concept of CHECK-CALL-COMPRESS. Additional training can be provided for ventilation and AED particularly for, but not limited to, older children or teenagers.[102] The legal requirement for CPR education in schools across Europe is summarised in Fig. 2.

Starting at a young age also means that performing CPR becomes like swimming or riding a bike: the skills are retained for a lifetime and are easily refreshed even after a prolonged absence.[103] It has been clearly demonstrated in different studies that healthcare professionals, teachers trained to teach CPR, students, peers and others can successfully teach schoolchildren, and all can serve as multipliers.[104]

CPR knowledge and skills can be spread further by asking children to teach their family and friends.[102] Evolving experience indicates that even children in the kindergarten and from the age of four years are able to successfully recognise a cardiac arrest and call the EMS.[105] Teachers can and should be qualified to teach schoolchildren in CPR.[102] Educating schoolchildren in resuscitation is performed in several countries around the world.[92,98,106–108] To date, education of schoolchildren in resuscitation is mandatory by law in six countries in Europe, and it is a recommendation in another 24 countries. However, implementation has not yet been achieved nationwide in all these countries, all over Europe and the world. [48,94] CPR education for schoolchildren may hugely improve public health, since lay resuscitation is the most important factor for high-quality survival following sudden cardiac arrest.[102]

The principles of KIDS SAVE LIVES can be extended to higher education institutions as well. Teacher training courses should include tuition of CPR competencies to enable teachers to deliver CPR education to schoolchildren.[109] All healthcare students should get high quality resuscitation education to enable them to teach CPR and act as first CPR responders.[97]

Community initiatives to promote CPR implementation

The role of the community in providing the first response to OHCA through bystander CPR is critically important but in most systems is still far from optimal. Many interventions have been implemented to improve the community response to OHCA and have been described in other sections of these guidelines. Several initiatives have been implemented with the aim to increase the engagement of the community, which is the general population of a studied area (i.e. a group of neighbourhoods, one or more cities/towns or regions, a part of or a whole Nation), consisting of individuals with no specific duty to respond.

ILCOR led a scoping review to identify relevant studies. Nineteen studies were identified which described community initiatives amongst the adult population only.

The main community initiatives identified were grouped in three categories:

- Community CPR instructor-led training interventions.[20,110–114]
- Mass-media interventions.[115,116]
- Bundled interventions.[16,56,117–125] The impact of the three groups of community initiatives on specific outcomes can be summarised as follows:

Instructor-led training

All the studies that implemented instructor-led training reported bystander CPR rate as an outcome, with 67% of the studies showing a benefit of the intervention.[20,110,112,114] Survival to discharge was reported in 83% of cases and improved in 40% of these studies.[20,114] Survival with good neurological outcome was reported in 67% of these studies and showed benefit of the intervention in only 25% of cases.[112] ROSC was assessed in 33% of these studies and in half of the cases showed improvement with the intervention.[114]

Mass-media

The two studies assessing the impact of this type of intervention reported only the outcome bystander CPR rate, with one study showing benefit and the other showing no benefit.[115,116]

Bundled intervention

None of these studies reported survival with good neurological outcome or ROSC. Survival to discharge was reported in 25% of these studies and showed no benefit of the intervention.[120,124] Bystander CPR rate was reported in 89% of these studies, showing benefit in all cases,[56,117–119] except one.[122]

In conclusion, the only outcome that was assessed in almost all the included studies was bystander CPR rate and almost all the studies showed a benefit with the implementation of

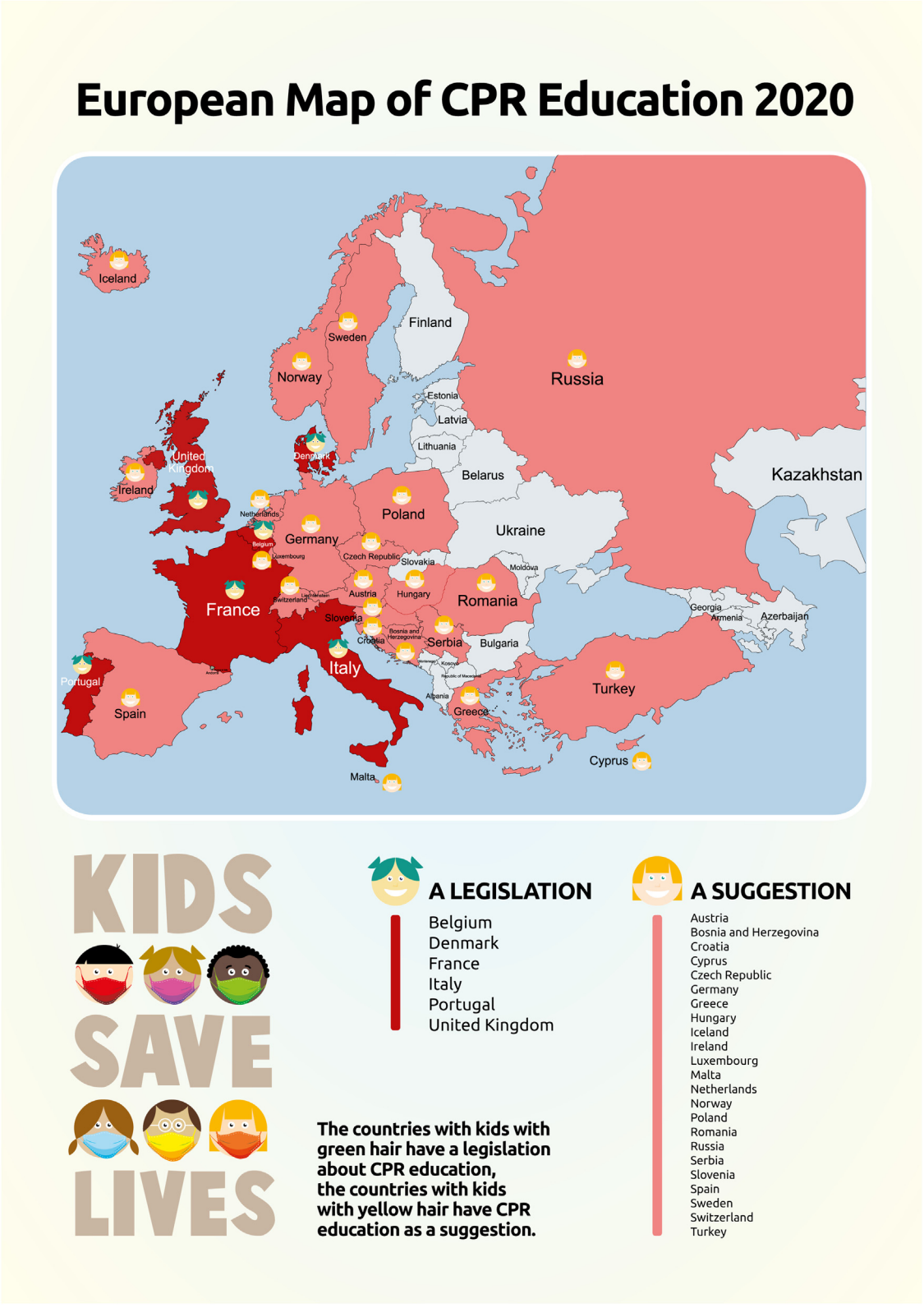

Fig. 2 – Kids save lives: legal requirement for CPR education in schools across Europe.

community initiatives. This benefit was more frequent when the type of intervention was a bundle compared with instructor-led training or mass-media. Furthermore, there was a slight benefit (only 40% of studies that reported it) in survival at hospital discharge. Therefore, despite low certainty of evidence and some conflicting results, we consider it worthwhile to implement community initiatives such as CPR training involving a large proportion of the population or bundled interventions in order to

improve the bystander CPR rate among laypersons in case of OHCA.

Low-resource settings

In 2015, ILCOR published a systematic review on resuscitation training in developing countries.[126] This review showed that resuscitation training in low-resource settings is well-received and has significantly reduced the mortality of cardiac arrest However, limited information is available about the outcome of resuscitation in low-resource settings. A recent ILCOR scoping review of OHCA in low-resource settings showed wide variability in outcomes.[1] The scoping review recommended future studies to be undertaken in specific (sub-) populations and aetiologies of cardiac arrest including paediatric cardiac arrest, traumatic cardiac arrest, cardiac arrest in disaster or conflict zones, or even cardiac arrest in single neighbourhoods or areas within an otherwise high-resource setting.[1]

The definition of low resource settings varies. Therefore, a comprehensive approach such as classifying countries according to their gross domestic product (GDP) per capita based on the World Bank definitions (https://data.worldbank.org) was applied.[49]

Considering the scarcity of resources in low-income countries, the feasibility of full ALS and post-resuscitation care is controversial. There is debate whether it is ethically acceptable that ALS for OHCA patients is not available in certain countries or areas.[127] Moreover, longer-term outcomes such as 30-day survival or neurological performance after cardiac arrest in low-resource countries tend to be worse than those reported in patients from high-resource countries.[1,128] A list of essential resuscitation equipment and resources like the 2009 World Health Organization statement on the quality of trauma care may help improving the chain of survival to improve outcome after OHCA.[129]

European Resuscitation Academy (ERA) and Global Resuscitation Alliance (GRA)

The European Resuscitation Academy aims to improve survival from cardiac arrest through a focus on healthcare system improvements that bring the individual links in the chain of survival and the formula for survival together. Entire EMS staff (managers, administrative and medical directors, physicians, EMTs and dispatchers) from different healthcare systems and countries are invited to learn from the ERA Program (derived from the Seattle (US) based Resuscitation Academy ten steps for improving cardiac arrest survival) together with the local host health institutions.[130] The ERA puts emphasis on defining the local cardiac arrest survival rate by understanding the importance of reporting data in a standardised Utstein template. Participating EMS systems are encouraged to develop concrete measures to improve cardiac arrest survival followed by appropriate measurements of these action plans. 'It takes a system to save a life' summarises the essentials (the core) of every Resuscitation Academy program globally - to acknowledge that all medical science and educational efficiency won't result in positive outcomes from OHCA and IHCA itself without a clear strategic plan to foster the local implementation in our systems. This is reflected in the formula for survival in resuscitation. The Global Resuscitation Alliances (GRA) mission is "to advance resuscitation through the Resuscitation Academy model by accelerating community implementation of effective programs through a quality improvement strategy to measure and improve."

Role of dispatcher

ILCOR recommends that dispatch centres implement a standardised algorithm and/or standardised criteria to determine immediately if a patient is in cardiac arrest at the time of the emergency call and to monitor and track their diagnostic capability. ILCOR also recommends that dispatch centres look for ways to optimise their sensitivity to recognise cardiac arrest (minimise false negatives).[11] This strong recommendation was based on very-low certainty evidence drawn from 46 observational studies which included 789,004 adult OHCAs reporting recognition of arrest varying between 46% and 98% and a specificity varying between 32% and 100%.[27,28,79,131–172] The review concluded that the studies were too heterogeneous for head-to-head comparisons of different criteria, algorithms, dispatcher background or training, and the diagnostic capabilities varied greatly within all the various categories with no clear patterns emerging.

The strong recommendation for dispatch centres to implement a standardised algorithm and/or standardised criteria to immediately determine if a patient is in cardiac arrest despite very-low-certainty evidence is outweighed by the benefits related to early recognition and early bystander CPR. Further, ILCOR found the large variation in the reported diagnostic capabilities across all systems to underline the need for systems to monitor and track their diagnostic capabilities and continuously look for ways to improve.

Consistent with ILCOR, the ERC recommends dispatch centres to implement a standardised algorithm and/or standardised criteria to immediately determine if a patient is in cardiac arrest at the time of emergency call. The ERC supports the need for high-quality research that examines gaps in this area.

Dispatch-assisted CPR

ILCOR recommends that emergency medical dispatch centres have systems in place to enable call handlers to provide CPR instructions for adult patients in cardiac arrest.[22] This strong recommendation was based on very-low certainty evidence drawn from 30 observational studies; 16 studies comparing outcomes from patients when dispatch-assisted CPR instruction was offered with outcomes from patients when dispatch-assisted CPR instruction was not offered[23,31,135,140,148,151,153,173–181] and 14 studies comparing outcomes from patients when dispatch-assisted CPR instruction was received with outcomes from patients when dispatch-assisted CPR instruction was not received.[135,140,148,173–176,179,180]

Six studies reported survival with good neurological outcome when dispatch-assisted CPR instructions were offered compared with when dispatch-assisted CPR instructions were not offered. Survival with good neurological outcome at hospital discharge (5533 patients) was higher among those offered CPR instructions (relative risk (RR) 1.67 (95% CI 1.21, 2.31); $p = 0.002$).[151,174] Survival with good neurological outcome at 1 month (44,698 patients) was higher among those offered CPR instructions (RR 1.09 (95% CI 1.03–1.15;$p = 0.004$).[175,179,181] Survival with good neurological outcome at 6 months (164 patients) was not significantly higher among those offered CPR instructions (RR 1.27 (95% CI 0.72, 2.27); $p = 0.14$).[180]

Five studies reported adjusted analysis for survival with good neurological outcome when dispatch-assisted CPR instruction was received compared with when dispatch-assisted CPR instruction was not received.[24–26,178,179] Survival with good neurological outcome at hospital discharge (35,921 patients) was higher among those receiving dispatch-assisted CPR compared with no bystander CPR

(adjusted odds ratio (OR_{adj}) 1.54 (95% CI 1.35, 1.76)).[24–26] Survival with good neurological outcome at 1 month (4306 patients) was higher among those receiving dispatch-assisted CPR compared with no bystander CPR (OR_{adj} 1.81 (95% CI 1.23, 1.76)).[179]

Survival with good neurological outcome at hospital discharge (17,209 patients) was similar among those receiving dispatch-assisted CPR compared with unassisted bystander CPR (OR_{adj} 1.12 (95% CI 0.94, 1.34)).[25] Survival with good neurological outcome at 1 month (78,112 patients) was similar among those receiving dispatch-assisted CPR compared to unassisted bystander CPR (OR_{adj} 1.00 (95% CI 0.91, 1.08)).[178]

The science evaluating the effect of dispatcher-assisted CPR is complex as it compares outcomes for patients who have been offered or received dispatch-assisted CPR with outcomes for both patients who received no bystander CPR and patients who received unassisted bystander CPR. Taken together, ILCOR found that these studies supported dispatch-assisted CPR as outcomes are generally better for patients who receive dispatch-assisted CPR compared with no bystander CPR, and for some outcomes as good as unassisted bystander CPR. ILCOR placed a greater value on studies providing adjusted analysis, as cohorts of patients who received unassisted CPR generally had more favourable prognostic characteristics, and cohorts of patients who did not receive any bystander CPR generally has less favourable prognostic characteristics.

Consistent with ILCOR, the ERC recommends emergency medical dispatch centres have systems in place to enable call handlers to provide CPR instructions for adult patients in cardiac arrest, and that emergency call takers provide CPR instructions (when required) for adult patients in cardiac arrest. The ERC supports research into the role of new technologies such as locating and distributing AEDs and their interphase with bystanders and first responders.

Dispatch-assisted chest compression-only CPR compared with standard CPR

ILCOR recommends dispatchers provide instructions to perform compression-only CPR to callers for adults with suspected OHCA.[182] This strong recommendation was based on low-certainty evidence from three randomised controlled trials which included 3728 adult OHCAs.[183–185] Only one study reported the outcome survival with favourable neurological outcome, and did not demonstrate any benefit of chest compression-only CPR over standard CPR (RR 1.25 (95% CI 0.94, 1.66); p = 0.13).[184] [Rea 2010 423] Survival to hospital discharge was similarly not significantly different (RR 1.20 (95% CI 1.00, 1.45); p = 0.05).[183–185]

In making these recommendations, ILCOR recognised that the evidence in support of these recommendations was of low certainty and performed at a time when the ratio of ventilations to chest compressions was 15:2, which leads to greater interruptions of chest compressions than the currently recommended ratio of 30:2. However, the signal from every trial is consistently in favour of dispatch-assisted CPR protocols that use a compression-only CPR instruction set. Reviewing the totality of available evidence and considering current common practice, training and quality assurance experiences, the ILCOR BLS task force has kept the strong recommendation for compression-only for dispatcher-assisted CPR despite low-certainty evidence. In making these recommendations, ILCOR placed a higher value on the initiation of bystander compressions, and a lower value on possible harms of delayed ventilation.

Consistent with ILCOR, the ERC recommends that dispatchers provide instructions to perform compression-only CPR to callers for adults with suspected OHCA. The ERC supports high-quality research to address unresolved issues relating to optimal instruction sequence, identifying key words, and the impact of dispatch-assisted CPR instructions on non-cardiac aetiology arrests such as drowning, trauma, and asphyxia in adults and children.

Rapid response systems including early warning scores and medical emergency teams

Unwell patients admitted to hospital are at risk of deterioration and may progress to cardiorespiratory arrest. Patients commonly show signs and symptoms of deterioration for hours or days before cardiorespiratory arrest.[7] Rapid response systems (RRSs) are programs that are designed to improve the safety of hospitalised patients whose condition is deteriorating quickly.[186] A successful RRS may be defined as a hospital-wide system that ensures observation, detection of deterioration, and tailored response to ward patients that may include rapid response teams (RRTs), also called medical emergency teams (METs).[187]

The ILCOR treatment recommendation suggests that hospitals consider the introduction of rapid response systems (rapid response team/medical emergency team) to reduce the incidence of in-hospital cardiac arrest and in-hospital mortality based on a systematic review (weak recommendation, low-quality evidence).[49] A total of 57 observational studies[63,188–242] and 2 randomised trials[243,244] were included in the systematic review. There are low-certainty data to suggest improved hospital survival and reduced incidence of cardiac arrests in those hospitals that introduce a RRS, and a suggestion of a dose-response effect, with higher-intensity systems (e.g. higher RRS activation rates, senior medical staff on RRS teams) being more effective.

Consistent with ILCOR, the ERC suggests that hospitals consider the introduction of a rapid response system (rapid response team/medical emergency team) to reduce the incidence of IHCA and in-hospital mortality.

Cardiac arrest centres

There is wide variation among hospitals in the availability and type of post resuscitation care, as well as clinical outcomes.[245,246] Cardiac arrest centres are hospitals providing evidence-based resuscitation treatments including emergency interventional cardiology, and bundled critical care with targeted temperature management, and protocolised cardiorespiratory support and prognostication.[247,248] ILCOR suggests that wherever possible, adult patients with non-traumatic OHCA cardiac arrest should be treated in cardiac arrest centres.[49,249] This weak recommendation is based on very low certainty evidence from a systematic review that included 21 observational studies [250–270] and 1 pilot randomized trial.[271] Of these, 17 observational studies were ultimately included in a meta-analysis.[250–256,261–270] This meta-analysis found that patients cared for in cardiac arrest centres had improved survival to hospital discharge with favourable neurological outcomes and survival to hospital discharge. This survival benefit from care at cardiac arrest centres did not extend to long term survival (survival to 30 days with favourable neurological outcome and survival to 30 days).

The resulting ILCOR treatment recommendations included:[22]

- We suggest adult non-traumatic OHCA cardiac arrest patients be cared for in cardiac arrest centres rather than in non-cardiac arrest centres.
- We cannot make a recommendation for or against regional triage of OHCA patients to a cardiac arrest centre by primary EMS transport (bypass protocols) or secondary interfacility transfer.

Consistent with ILCOR, the ERC suggests that adult patients with non-traumatic OHCA cardiac arrest be cared for in cardiac arrest centres rather than in non-cardiac arrest centres. In 2020 the main European organisations involved in OHCA reached a consensus that patients with OHCA of presumed cardiac aetiology should be transported directly to a hospital with 24/7 coronary angiography.[272]

Conflicts of interest

TMO declares research funding from Laerdal Foundation and Zoll Foundation

BB declared speakers honorarium from Baxalta, BayerVital, BoehringerIngelheim, ZOLL, FomF, Bard, Stemple, NovartisPharma

RG declares his role as Editor of the journal Trends in Anaesthesia and Critical Care, associate editor European Journal of Anaesthesiology. He reports institutional research funding.

GR declares his role of consultant for Zoll; he reports research grant from Zoll for the AMSA trial and other Institutional grants: EU Horizon 2020 support for ESCAPE-NET, Fondazione Sestini support for the project "CPArtrial", EU Horizon 2020 and also Coordination and support for the action "iProcureSecurity"

AL reports his role of Medical advisor First on Scene training company

AS declares research funding from EU Horizon 2020 for "I procure security project"

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