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ILCOR Scientific Statement

KIDS SAVE LIVES: Basic Life Support Education for Schoolchildren: A Narrative Review and Scientific Statement From the International Liaison Committee on Resuscitation ☆

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Abstract

BACKGROUND: Basic life support education for schoolchildren has become a key initiative to increase bystander cardiopulmonary resuscitation rates. Our objective was to review the existing literature on teaching schoolchildren basic life support to identify the best practices to provide basic life support training in schoolchildren.

METHODS: After topics and subgroups were defined, a comprehensive literature search was conducted. Systematic reviews and controlled and uncontrolled prospective and retrospective studies containing data on students <20 years of age were included.

RESULTS: Schoolchildren are highly motivated to learn basic life support. The CHECK-CALL-COMPRESS algorithm is recommended for all schoolchildren. Regular training in basic life support regardless of age consolidates long-term skills. Young children from 4 years of age are able to assess the first links in the chain of survival. By 10 to 12 years of age, effective chest compression depths and ventilation volumes can be achieved on training manikins. A combination of theoretical and practical training is recommended. Schoolteachers serve as effective basic life support instructors. Schoolchildren also serve as multipliers by passing on basic life support skills to others. The use of age-appropriate social media tools for teaching is a promising approach for schoolchildren of all ages.

CONCLUSIONS: Schoolchildren basic life support training has the potential to educate whole generations to respond to cardiac arrest and to increase survival after out-of-hospital cardiac arrest. Comprehensive legislation, curricula, and scientific assessment are crucial to further develop the education of schoolchildren in basic life support.

Keywords: cardiopulmonary resuscitation, ILCOR Scientific Statements, out-of-hospital cardiac arrest, retrospective studies, students, sudden cardiac death

With an incidence of 67 to 170 per 100 000 inhabitants, out-of-hospital cardiac arrest (OHCA) is a leading cause of death worldwide.[1–3] Survival rates range between 2% and 20% and are particularly low without an immediate bystander response.[4]

Cardiac arrest causes systemic ischemia, resulting in immediate damage to critical tissue. Being most vulnerable, brain tissue will be damaged within 5 minutes.[5–8] The most effective prevention of cell death is the early restoration of *circulation* and oxygen supply through providing basic life support (BLS) in the form of cardiopulmonary resuscitation (CPR) and defibrillation.[9–11] Consequently, quick initiation of BLS is a significant determining factor for good neurological outcome and survival.[11] Given that most OHCAs occur at home,[3] bystanders are required to provide BLS until the arrival of emergency medical services.

Although bystander CPR rates vary widely between countries, they are typically low, averaging 20% worldwide.[2,3,12] To increase

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the population's willingness to provide BLS, comprehensive public initiatives have been initiated.[13] Training schoolchildren in BLS has become a key element in these initiatives.

Accompanied by the establishment of schoolchildren BLS training in some countries, evaluations and research in the field have also increased.[14–16] However, evidence-based data and standardized recommendations are still limited. Reasons for this include the young scientific field, a wide variety of local requirements and legislation, and different activities undertaken by umbrella associations, organizations, countries, communities, schools, and dedicated individuals. However, considering the next generation as lifesavers requires a rigorous academic foundation. Thus, the purpose of this scientific statement is to bring together global resuscitation scientists to review the existing literature on teaching schoolchildren BLS and to develop best practices being considered to further promote schoolchildren BLS training.

Methods

Elaboration

This narrative review and International Liaison Committee on Resuscitation scientific statement was developed in a multistep process: (1) A writing group was established; (2) the scope of the scientific statement was defined; (3) topics were defined by the lead author (D.C.S.) and discussed by the group in an online meeting (June 9, 2021); (4) writing group members with expertise in a key topic were identified; (5) a subgroup related to each topic including a responsible author and a coauthor was established; (6) the literature was searched; (7) an evidence review for each topic was formulated and sent to the responsible authors (B.W.B. and D.C.S.); and (8) a single document was compiled (B.W.B.; D.C.S.) and sent to the entire writing group for review.

All writing group members had expertise in the field of schoolchildren BLS. The key topics were developed on the basis of existing scientific reviews.[15–17] The following topics were compiled: Motivational Aspects of Schoolchildren Toward CPR, Appropriate Starting Age, Gender Aspects, Detection of Cardiac Arrest, Transmission of an Emergency Call, Chest Compression Depth, Chest Compression Rate, Mouth-to-Mouth Ventilation, Automated External Defibrillation, Physical Conditions to Initiate Adequate CPR, Retrieval of Theoretical Knowledge, Integration of KIDS SAVE LIVES in School Curricula, Practical Versus Theoretical, Multiplier Effect, Innovative Technology and Young Media for CPR Education, Who Should Teach?, Uniform Curricula for Training of Schoolchildren in CPR, and Role of Public Campaigns.

The writing group met several times through online meetings (June 9, 2021; August 4, 2021; September 15, 2021; November 10, 2021; January 18, 2022; February 15, 2022; and March 31, 2022). An intermediate status was presented at the general International Liaison Committee on Resuscitation assembly by the leader of the writing group (B.W.B.) on November 2, 2021. The development process was facilitated by a coordinator from the American Heart Association. Figures and infographics were developed in several independent meetings by a subgroup of the writing group (B.W.B, D.C.S., F.S., R.G., T.S.).

Multiple professions, including anesthesiology, cardiology, emergency medicine, intensive care medicine, pediatrics, epidemiology, and physiotherapy, were represented in the writing group by individuals with acknowledged expertise. Ethics approval was not required. Summaries of each topic were individually discussed between the writing group members and the responsible authors (B.W.B., D.C.S.). Participants of the entire writing group were able to discuss and complement each paragraph during the online meetings and the review process. Modifications were subsequently incorporated into the manuscript. After 3 circulations of the draft, consensus was reached, and the manuscript was sent for external review.

Literature Research

First, search terms were determined by the entire writing group (see Supplement). Second, searching was conducted in the PubMed database by each subgroup between September 1, 2021, and March 10, 2022. Each study containing relevant content in any language identified by the subgroup was allowed to be included. Systematic reviews, controlled and uncontrolled prospective, and retrospective evaluations could be incorporated into the manuscript.

The review process is described in detail in Figure 1. In total, 20 709 reports were found. All articles included were written in English except 2 articles that were written in Spanish. Duplicates were excluded. Titles and abstracts were discussed by each subgroup and determined to be relevant. Articles were excluded by consensus of the subgroup. Subsequently, full texts were reviewed. There was no minimal age set to be included. The upper age of schoolchildren

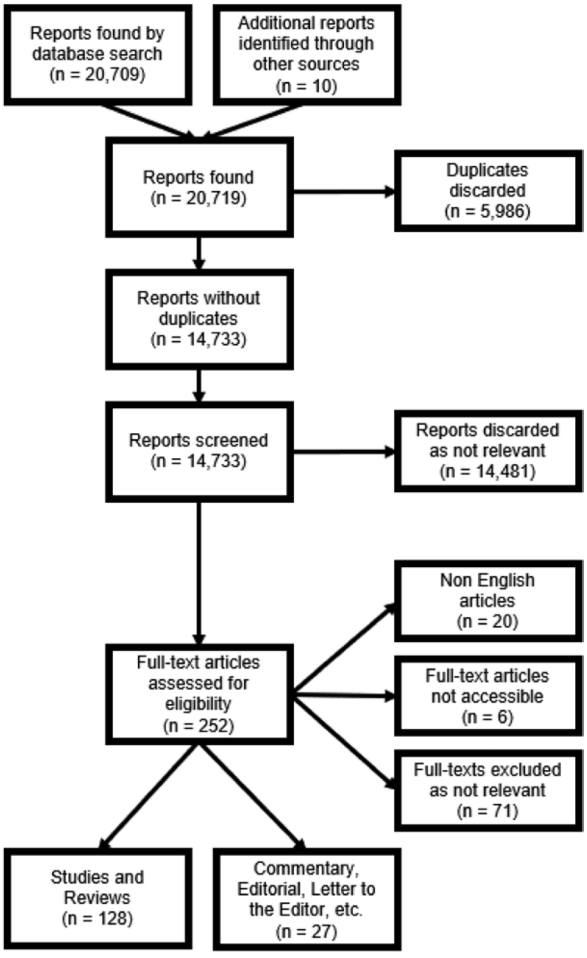

Figure 1 – Search strategy. After definition of topics and subgroups, a comprehensive literature search was conducted.

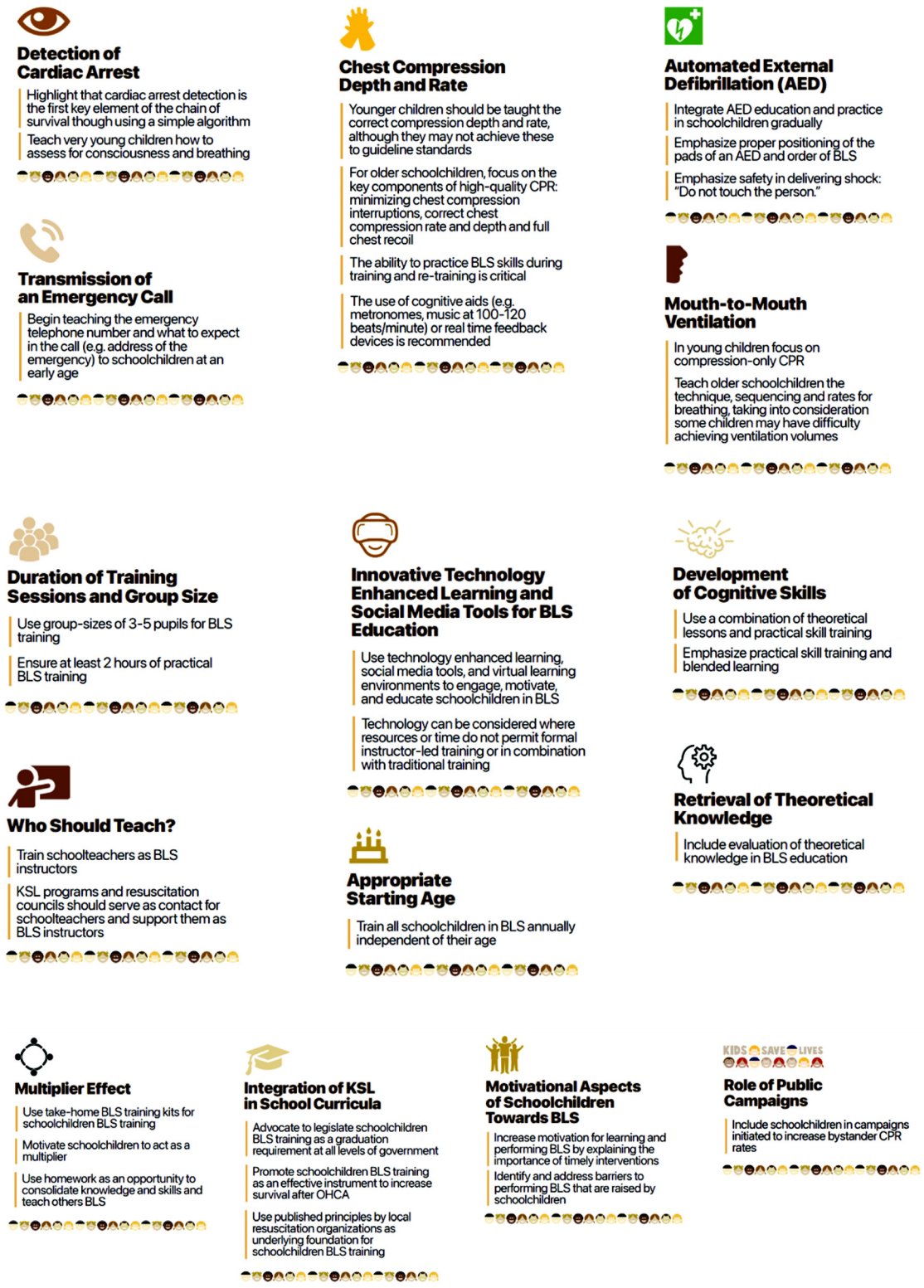

Figure 2 – Overview of suggestions for schoolchildren BLS training. The literature research revealed several suggestions that improve schoolchildren basic life support (BLS) training. CPR indicates cardiopulmonary resuscitation; KSL, KIDS SAVE LIVES; and OHCA, out-of-hospital cardiac arrest.

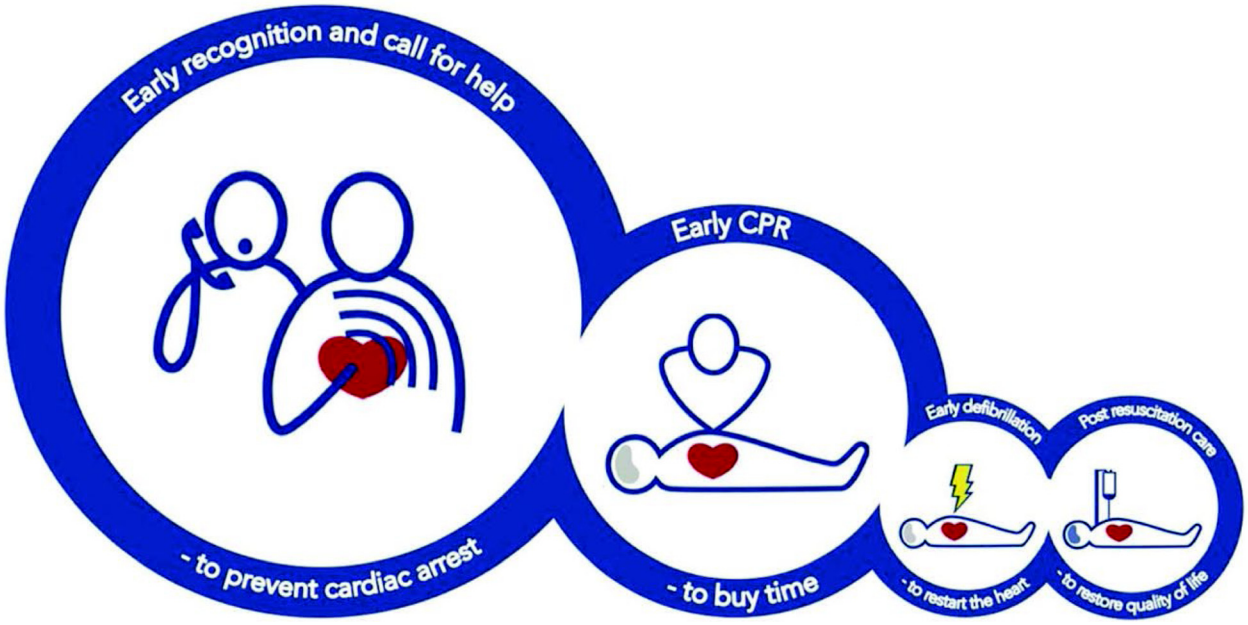

Figure 3 – Links of the chain of survival influenced by schoolchildren BLS training. BLS indicates basic life support; and CPR, cardiopulmonary resuscitation. Reprinted from Deakin et al.[49] with permission from Elsevier.

and adolescents investigated in the studies was 20 years. For consistency, the term schoolchildren was used for children ≥6 years of age. The term young children was used for children <6 years of age.

Results

Motivational Aspects of Schoolchildren Toward BLS

Schoolchildren are able to comprehend that a rapid bystander response increases OHCA survival and can grasp the need for BLS education in schools.[18,19] Several studies demonstrate a high motivation in schoolchildren to learn and perform BLS,[18–25] to share knowledge, and to serve as a multiplier.[22,26] Schoolchildren are particularly motivated to learn and conduct CPR if cardiac arrest occurs in children.[20,21,23,27] Because the majority of cardiac arrests are witnessed by family members,[28] it was suggested that schoolchildren are more motivated to perform BLS if the person in cardiac arrest is a relative.[19–21,23–25,27] Further motivational factors include preventing deaths and increasing survival.[19] Access to BLS training in schools increases schoolchildren's willingness to perform CPR and to attend BLS training.[19–21,29–32] The inability to perform adequate BLS does not seem to influence the motivation to learn BLS either at the time of teaching or in the future.[33]

Barriers to performing BLS identified by schoolchildren are similar to those seen in adults and include fear of making mistakes and other determinants, including bleeding, vomiting, drug abuse, dangerous situations, and the infectious status of the patient.[19,23,25,30,34] Reasons for the refusal of BLS need to be addressed in training to increase schoolchildren's willingness to perform bystander CPR (Figure 2).[19,21,27,31,35,36]

Suggestions for Schoolchildren Training

- Increase motivation for learning and performing BLS by explaining the importance of timely interventions.
- Identify and address barriers to performing BLS that are raised by schoolchildren.

Detection of Cardiac Arrest

Correct detection of cardiac arrest can be challenging and is a skill that may be forgotten over time.[37,38] The current international guidelines recommend conducting BLS in a person who is unresponsive with absent or abnormal breathing.[39] In training schoolchildren, the

Table – Scientific Evidence Demonstrates That Links in the Chain of Survival Can Be Improved by Schoolchildren After BLS Training

Schoolchildren are able to improve the first links in the chain of survival.
The chain of survival should be considered a key element in schoolchildren BLS training, and the steps should be taught to all age groups.
Teaching children as young as 4 y of age can lead to improved knowledge about how to call for help.
Schoolchildren as young as 6 y of age can demonstrate how to give the correct information over the phone after training.
Primary schoolchildren (7–8 y) should be taught the emergency number, and secondary schoolchildren (9–10 y) should be taught how to alert emergency services.
The emergency telephone number and what to expect in the call should be taught at an early age.
All schoolchildren should be trained in BLS annually regardless of their age.
Understanding of early defibrillation after OHCA has increased among schoolchildren.

BLS indicates basic life support; and OHCA, out-of-hospital cardiac arrest.

approach recommended by International Liaison Committee on Resuscitation is the use of a simple algorithm such as CHECK-CALL-COMPRESS.[40,41] The simplified CHECK assessment includes speaking to the patient; trying to wake them up; and then looking, listening, and feeling for normal breathing.[42] There is evidence that both young children and schoolchildren 4 to 15 years of age can correctly reproduce assessments for consciousness and breathing after demonstration and hands-on practice (Figures 2 and 3 and the Table).[37,43,44]

Suggestions for Schoolchildren Training

- Highlight that cardiac arrest detection is the first key element of the chain of survival by using a simple algorithm.
- Teach young children how to assess for consciousness and normal breathing.

Transmission of an Emergency Call

An important component of the chain of survival is knowing how to call emergency medical services and knowing what information to provide in the call. Evidence from the published literature shows that teaching children as young as 4 years of age can lead to improved knowledge about how to call for help.[43,45,46] This effect becomes more pronounced as the age increases.[37,47] Schoolchildren as young as 6 years of age are able to demonstrate how to dial the emergency number and give the correct information in the emergency call after training.[20,37,48]

It is evident that teaching knowledge related to emergency calls should be started early and can be used as a foundation to subsequent tuition covering the skills of how to make an emergency call. On the basis of the available evidence and expert consensus, it has been proposed that young children beginning at 4 years of age should be taught the emergency number. Schoolchildren should be taught how to alert the emergency services correctly (eg, address of the emergency; Figures 2 and 3 and the Table).[20,48]

Suggestion for schoolchildren training:

- Begin teaching the emergency telephone number to young children beginning at 4 years of age.
- Teach how to alert the emergency service correctly (eg, address of the emergency) to schoolchildren beginning at 6 years of age.

Chest Compression Depth and Rate

Chest compression demonstrations and practice should include the correct hand positioning and techniques to achieve the correct compression rate, depth, and chest recoil and should aim to minimize pauses.

Performing BLS is a physically demanding psychomotor skill that requires training and practice. Age itself may not be the most important variable; a child's weight or body mass index may be just as important.[16,50,51] Mean compression depths achieved by schoolchildren on manikins after BLS training vary widely and depend on their body size, which in turn can vary by age and sex.[15,52–56] A minimum body weight of 40 to 50 kg appears to be required to achieve sufficient force for adequate depth of compressions.[57] A linear correlation between weight, height, and body mass index and deeper chest compressions has been demonstrated.[51] Thus, boys and older schoolchildren with greater body mass typically are able to deliver adequate chest compression depths.[16,44,51,56,57] The addition of real-time feedback during practice may produce deeper chest compressions at the time of training and over the course of the following year.[58]

Regardless of the method or duration of training, a large body of evidence suggests that correct hand positioning and compression rates can be delivered by schoolchildren beginning at 10 years of age.[44,52,58–60] The addition of real-time feedback devices to ensure correct compression rates may be required.[61] Although the evidence is less clear in young children, studies have reported guideline-recommended chest compression rates by schoolchildren as young as 6 to 9 years of age.[54,55] When compression rates are taught to schoolchildren <14 years of age, verbal CPR instruction without practice is less effective than hands-on practice.[62,63]

Evidence suggests that BLS skills deteriorate over months.[64–69] After annual trainings over 3 consecutive years, retention can be observed up to 6 years later.[16,65,66] Brief refresher courses with a duration of 5 minutes in 4-month intervals seem to have beneficial effects on practical CPR performance.[51] Tempo-reinforcing tools, which provide a beat to guideline standard (ie, music with the correct beats per minute), are effective adjuncts to verbal CPR instructions for schoolchildren (Figures 2 and 3 and the Table).[62]

Suggestions for Schoolchildren Training

- Teach young children the correct compression depth and rate, although they may not achieve them to guideline standards.
- For schoolchildren, focus on the key components of high-quality CPR: minimizing chest compression interruptions, correct chest compression rate and depth, and full chest recoil.
- Provide an opportunity to practice BLS skills during training and retraining.
- Use cognitive aids (eg, metronomes, music at 100–120 bpm) or real-time feedback devices.

Mouth-to-Mouth Ventilation

Mouth-to-mouth ventilation involves a sequence of events and techniques to open the airway, create a seal to prevent air escaping, and blow air into a person's mouth.

Although several studies have focused mainly on teaching compression-only CPR,[55,70] evidence suggests that schoolchildren $\geq$10 years of age can reproduce the correct rate and sequencing of mouth-to-mouth ventilations.[59,71,72] However, young children are unlikely to be able to achieve large volumes of air because of their smaller lung capacity.[72] By 10 to 12 years of age, some schoolchildren are able to achieve acceptable ventilation volumes on BLS training manikins.[52,53,58,64,65] By 14 years of age, most schoolchildren can produce volumes to guideline standards (Figures 2 and 3 and the Table).[65,71,72]

Suggestions for Schoolchildren Training

- In young children, focus on compression-only CPR.
- Teach schoolchildren the technique, sequencing, and rates for breathing, taking into consideration the fact that some schoolchildren may have difficulty achieving ventilation volumes.

Automated External Defibrillation

Schoolchildren are able to understand the importance of early defibrillation after OHCA.[73] However, without training, only 20% of schoolchildren can correctly use an automated external defibrillator (AED) in simulations.[74] The most common errors committed by schoolchildren in AED use are the incorrect order of execution (≈76%) and incorrect positioning of the pads (≈14%).[74] Research suggests that AED education in schoolchildren should be progressive[75] and include discussion of the purpose of an AED and hands-on training.[74–78] Some studies have proposed that both young

Table – Writing Group Disclosures.

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
Bernd W. Böttiger	Faculty of Medicine and University Hospital of Cologne (Germany)	European Resuscitation Council (immediate past director science and research)*	None	None	None	None	None	European Resuscitation Council (treasurer)*; European Resuscitation Council Research NET (founder)*; German Resuscitation Council (chairman)*; German Interdisciplinary Association for Intensive and Emergency Medicine (treasurer)*; Notfall+Rettungsmedizin (coeditor)* European Journal of Anaesthesiology (coeditor)* Brazilian Journal of Anesthesiology (coeditor)*; Resuscitation (coeditor)*; Medical advisor/federal state doctor of the German Red Cross*
Federico Semeraro	Department of Anesthesia, Intensive Care and Prehospital Emergency, Maggiore Hospital Carlo Alberto Pizzardi, Bologna (Italy)	None	None	None	None	None	None	European Resuscitation Council (Chair-Elect) (unpaid); Italian Resuscitation Council Foundation (member) (unpaid)
Farhan Bhanji	McGill University (Canada)	None	None	None	None	None	None	None
Janet Bray	Monash University (Australia)	Heart Foundation of Australia†	None	None	None	None	None	None
Marina Del Rios	University of Iowa	NIH (coinvestigator Reducing Ethnic-Racial Disparities in Cardiac Arrest Survival Outcomes (REDCASO))*	None	None	None	None	None	Illinois Heart Rescue (director of community engagement, dissemination, and implementation)†
Simon-Richard Finke	University of Cologne (Germany)	None	None	None	None	None	None	None
Robert Greif	Bern University Hospital and University of Bern (Switzerland)	None	None	None	None	None	None	None
Taku Iwami	Kyoto University (Japan)	Zoll Foundation†; Zoll Medical Corp†; Hamamatsu Photonics†; Laerdal Foundation†	None	None	None	None	None	None
Andrew Lockey	Calderdale and Huddersfield NHS Trust (UK)	None	None	None	None	None	None	Resuscitation Council UK (President)*
Carolina Malta Hansen	Copenhagen EMS Clinical Research (Denmark)	TrygFonden†; Helsefonden†; Laerdal Foundation†; Capital Region of Denmark, Research Foundation†	None	None	None	None	Consultant fee from Duke Clinical Research Institute for the RACE-CARS Trial (unpaid)	None

Table (continued)

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
Peter Morley	University of Melbourne (Australia)	None	None	None	None	None	None	None
Naomi Kondo Nakagawa	Fundação de Amparo à Pesquisa do Estado de São Paulo and University of Sao Paulo Pro-Rectory of Graduation	Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP; investigating respiratory muscle weakness in patients with heart failure and basic life support competencies in school communities)*	None	None	None	None	None	None
Michael Parr	Liverpool Hospital, University of New South Wales and Macquarie University Hospital, Macquarie University (Australia)	None	None	None	None	None	None	None
Comilla Sasson	American Heart Association	None	None	None	None	None	None	None
Stephen M. Schexnayder	University of Arkansas/ Arkansas Children's Hospital	None	None	None	None	None	None	None
Daniel C. Schroeder	German Armed Forces Central Hospital of Koblenz (Germany)	None	None	None	None	None	None	None
Tommaso Scquizzato	San Raffaele Scientific Institute (Italy)	None	None	None	None	None	None	Resuscitation (Social media Editor)*; Resuscitation Plus (Social media Editor)*; European Resuscitation Council (member of Basic Life Support Science and Education Committee)*; Italian Resuscitation Council (member of the Scientific Committee)*
Wolfgang A. Wetsch	University Hospital of Cologne (Germany)	None	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Table – Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
Cristian Abelairas-Gómez	Faculty of Education Sciences, University of Santiago de Compostela (Spain)	None	None	None	None	None	None	None
Siraj Amanullah	Brown University	None	None	None	None	None	None	None
Neil Huerbin	AHA China	None	None	None	None	None	None	None
Daniel M. Rolston	Donald and Barbara Zucker School of Medicine at Hofstra/Northwell	None	None	None	None	None	None	None
Volker Wenzel	Medizin Campus Bodensee (Austria)	None	None	None	None	None	None	None

This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

children and schoolchildren (5–7 years of age) can follow the AED audio instructions and safely deliver a shock.[74,79,80] However, the proportions of schoolchildren who use an AED without errors vary largely (11%–17% at 6–7 years of age, 25% at 9–10 years, and 27%–51% at 13–16 years; Figures 2 and 3 and the Table).[29,74,81]

Suggestions for Schoolchildren Training

- Integrate AED education and practice in schoolchildren gradually.
- Emphasize proper positioning of the pads of an AED and order of BLS.
- Emphasize safety in delivering shock: "Do not touch the person."

Development of Cognitive Skills

There is a large scientific body of evidence that a combination of theoretical (cognitive) and practical (psychomotor) training significantly improves the level of theoretical knowledge.[44,70,82–86] These effects were observed across all age groups.[44,70,82–86]

Several theoretical training options such as lectures, video sessions, pamphlets, or face-to-face teaching are suitable to be combined with practical BLS training.[30,87,88] Even brief theoretical sessions result in effective knowledge transfer.[17,44,89] A combination of e-learning and face-to-face-teaching (blended training methods) seems to preserve retention of knowledge over a longer period.[66] The assessment should be provided in simulated scenarios rather than in formal testing.[43,90] Young children benefit from teaching material adapted to their psychological development such as a teddy bear (Figure 2).[90,91]

Suggestions for Schoolchildren Training

- Use a combination of theoretical lessons and practical skill training.
- Emphasize practical skill training and blended learning.

Retrieval of Theoretical Knowledge

Assessment of practical BLS skills is challenging in schoolchildren. Ethical concerns frequently impede studies in schoolchildren. Large numbers of schoolchildren must be evaluated over a short period, which requires personnel resources and uses teaching time. Thus, level of knowledge is commonly reviewed by comparison of theoretical precourse and postcourse knowledge assessments, including questionnaires[85] and multiple-choice tests.[44,84–86,92,93] This allows instructors to draw conclusions on retrieval of theoretical knowledge of schoolchildren.

Schoolchildren are able to retain knowledge better than young children.[44,84] On average, knowledge retention is maintained for 3 months[84] and augmented by annual refresher training (Figure 2).[65]

Suggestion for Schoolchildren Training

- Include evaluation of theoretical knowledge in BLS education.
- Provide annual theoretical and practical refresher training for maintenance of knowledge and skills.

Appropriate Starting Age

The KIDS SAVE LIVES proposal, endorsed by the World Health Organization in 2015, recommended 12 years as the starting age.[10,14] However, there is evidence that even children as young as 4 years of age are receptive to and capable of receiving BLS training.[20,43,46,79] Starting early BLS education, with repetition and extension of skills throughout schooling, provides members of society who are capable of responding to emergency situations, normalizes first aid learning, and increases the willingness to respond to real-life emergencies (Figure 2).[37,42,94]

Suggestion for Schoolchildren Training

- Train all schoolchildren in BLS annually, regardless of their age.
- Arouse interest in BLS in young children beginning at 4 years of age.

Innovative Technology-Enhanced Learning and Social Media Tools for BLS Education

Although the inclusion of innovative technology-enhanced learning and social media tools may represent a powerful approach for schoolchildren who are growing up in a technological environment, their effectiveness is still underestimated,[95] especially for the most effective digital learning methods such as virtual reality (VR).[96] Video lessons are commonly used to replace or complement theoretical on-site cognitive knowledge transfer.[34,82,83,85] In recent years, the use of VR, augmented reality, smartphone applications (apps), and social media to teach BLS has also increased.[96–100]

Use of VR and augmented reality in BLS education produced an improvement in BLS skills comparable to that with traditional classroom methods.[98,101,102] Quality of chest compressions in terms of

rate, depth, and hand position can be improved by a VR feedback system in schoolchildren.[101,103] In accordance, the combination of traditional training with VR and augmented reality increases the engagement of adult participants.[104,105]

"Serious games" are digital games serving the purpose of conveying knowledge. It has been shown that the application of serious games in schoolchildren is as effective as face-to-face, instructor-led teaching.[106,107] In addition, engagement of schoolchildren can be significantly increased by the promotion of competition among participants.[106–110] Serious games also have the potential to raise awareness of the importance of BLS.[106,107]

Several smartphone learning apps suitable for teaching BLS to schoolchildren have been identified.[97] The majority of the apps target young children >4 years of age and are developed as animated tutorials, simulations, or a virtual world. Most apps teach hands-only CPR, but some also include ventilation. Only 1 app includes teaching BLS with an AED.[97] Checking the airway, asking for an AED, and discharging the AED are significantly better after instructor-led courses compared with app-based learning.[60]

BLS and defibrillation courses in blended modality are increasingly common and achieve results that are noninferior to results from traditional BLS training programs.[111] E-learning platforms provide flexible training opportunities that allow students to complete the training online at their own pace. Students follow the traditional lecture of instructor-led courses on the e-learning platform. Afterward, students can attend a short instructor-led session that focuses on practical CPR and AED skills (Figure 2).[73]

Suggestions for Schoolchildren Training

- Use technology-enhanced learning, social media tools, and virtual learning environments to engage, motivate, and educate schoolchildren in BLS.
- Consider technology when time or resources do not permit formal instructor-led training sessions or in combination with traditional training methods.

Duration of Training Sessions and Group Size

Intensive practical training is important to consolidate BLS skills. Practical training can be intensified by the extension of training sessions and use of small training groups.[112]

The average duration proposed for schoolchildren BLS training that includes AED use is 50 minutes[113] to 3 days.[79,80] There is consensus that at least 2 hours of CPR training per year is required to sustainably increase CPR skills in schoolchildren.[14]

Groups of 3 to 5 students result in more effective theoretical and practical BLS skills in adult BLS training.[112] A group size of 6 adult students allows instructors to observe students' performance and to detect errors of BLS.[114] Although several studies evaluated BLS training approaches, data that focus on the adequate group size are scarce. Common practice is the use of groups of 5 to 10 pupils, which ties up considerable resources.[56,115] Others report teaching in a preexisting school class (Figure 2).[34,65,88]

Suggestions for Schoolchildren Training

- Use group sizes of 3 to 5 pupils for BLS training when possible.
- Ensure at least 2 hours of BLS training per year.

Use of BLS Training Manikins and Multiplier Effect

A wide range of similar BLS training manikins from different manufacturers are available for schoolchildren BLS training. However, a variation of compression characteristics such as chest resistance in different BLS training manikins was observed by the consensus group and has been reported by others.[116] Simulation of realistic cardiac arrest scenarios and scientific comparison of studies are therefore difficult.

An impactful and immediate consequence of teaching schoolchildren BLS is the potential for amplification of community preparedness as they become trainers for their families and neighbors. Therefore, take-home BLS training kits containing a simplified BLS training manikin are frequently used for BLS education.[26,52,117,118] Take-home BLS training kits have been used successfully by children in primary school[52,119,120] and students in high school[26,117,118,121] to pass on skills to third parties. The magnitude of the multiplier effect varies across studies, ranging from an average of 1.77 to as many as 4.9 people trained per student.[26,117] Schoolchildren as multipliers can also reach segments of the population more likely to witness a cardiac arrest. In a Norwegian study, 43% of the population trained by high school students were $\geq$50 years of age.[121] Moreover, widespread adoption of schoolchildren BLS training programs has the potential to bridge the disparity gap in bystander CPR rates in underrepresented communities. In one study from the United States, students from a high school serving a 99.8% Black and 61.8% income-limited community trained, on average, 4.9 people per kit (Figure 2).[117]

However, the use of take-home BLS training manikins to teach chest compressions may result in shallower compression depths,[34,122,123] which should be highlighted in training. Thus, instructor-led courses with professional BLS training manikins lay the foundation to guarantee effective BLS education before distribution of take-home BLS training kits.

Suggestions for Schoolchildren Training

- Consider professional BLS training manikins during BLS lessons to teach high-quality chest compressions.
- Distribute take-home BLS training kits for schoolchildren BLS training.
- Motivate schoolchildren to act as a multiplier.
- Use homework as an opportunity to consolidate knowledge and skills and to teach others BLS.

Who Should Teach?

Traditionally, schoolteachers and health care professionals, including physicians, nurses, and emergency medical services personnel, have taught BLS to schoolchildren.[45,56,124–126] Improved outcomes for any group of teachers with different backgrounds have not been demonstrated to date.[15,65]

Several studies report that schoolteachers can effectively teach BLS.[65,66,86,126–133] One study suggests that teachers are effective at improving training materials and expanding BLS training programs.[75] Teaching of schoolchildren by medical students results in higher theoretical knowledge compared with training by emergency physicians.[87] Adolescents (14–18 years of age) taught as peer BLS instructors are also able to effectively train practical BLS skills to their peers.[124,134]

International resuscitation councils such as the European Resuscitation Council and the American Heart Association have suggested that schoolteachers can be trained as BLS instructors.[10] Underlying reasons being considered include (1) the pedagogical background to effectively teach,[65,127] (2) simplification of annual repetition, and (3) conservation of medical resources. However, although motivation is high,[131] deficits in terms of BLS were demonstrated in schoolteacher trainees.[128] Thus, several authors recommend training student teachers as BLS instructors during their university education (Figure 2).[131,132,135,136]

Suggestions for Schoolchildren Training

- Train schoolteachers as BLS instructors.
- Include teaching BLS in the curriculum when training student teachers at universities.
- Specify that KIDS SAVE LIVES programs and resuscitation councils should serve as a contact for schoolteachers and support them as BLS instructors.

Integration of KIDS SAVE LIVES in School Curricula

To guarantee, develop, and extend effective schoolchildren BLS training, establishment of mandatory BLS curricula for schoolchildren is of major importance.[10]

In many communities, BLS training has not been systematically implemented in schools, and it has been legislated in only a few countries.[18,128,137–141] Implementation of schoolchildren BLS programs in curricula is a multilevel process requiring several components: (1) guarantee of financial support by the authorities to provide teaching and training material, (2) regular training of teaching personnel, and (3) assurance of correct implementation and appropriate use of training material.[142] Communities meeting these requirements have higher bystander CPR rates, as seen in some areas across the world such as Seattle, WA, and Norway, where BLS training has been part of the physical education component of the standard school curriculum for decades (Figure 2).[137]

Suggestions for Schoolchildren Training

- Promote schoolchildren BLS training as an effective instrument to increase survival after OHCA.
- Advocate to legislate schoolchildren BLS training as a graduation requirement at all levels of government.
- Use published principles by local resuscitation organizations as the underlying foundation for schoolchildren BLS training.

Role of Public Campaigns

Within the past decade, schoolchildren BLS training developed as a high-visibility measure to raise the population's awareness of bystander CPR. Various public events such as BLS training with up to 150 581 schoolchildren and Guinness World Records were organized.[143] Furthermore, a mobile phone app and videos were developed, and schoolchildren BLS training became the main topic of conferences and initiatives, including the European Restart a Heart Day and the International Liaison Committee on Resuscitation World Restart a Heart Day.[143] However, the exact contribution of initiatives containing schoolchildren BLS training to increase bystander CPR rates could not be clearly separated and shown to date.[4] Nevertheless, initiatives sensitizing the population for BLS are important to further develop efficient links in the chain of survival (Figure 2).[13]

Suggestion for Schoolchildren Training

- Include schoolchildren in campaigns initiated to increase bystander CPR rates.

Conclusions

- Establish a dedicated age-based BLS teaching curriculum at all schools.
- Use universally administered BLS training courses not only for training but also for research that allows studying the efficacy of schoolchildren-appropriate teaching strategies.

Supplement

Search Terms

The following key words were used: "adolescent AND AED" (1.699), "adolescent AND automated external defibrillation" (40), "adolescent AND basic life support" (1.777), "adolescent AND basic life support AND education" (584), "adolescent AND basic life support AND training" (627), "adolescent AND bystander cardiopulmonary resuscitation" (331), "adolescent AND cardiopulmonary resuscitation AND education" (552), "adolescent AND cardiopulmonary resuscitation AND training" (630), "adolescent AND resuscitation" (11.454), "adolescent AND resuscitation AND education" (1.319), "adolescent AND resuscitation AND training" (1.288), "KIDS SAVE LIVES" (43), "schoolchildren AND AED" (17), "schoolchildren AND automated external defibrillation" (3), "schoolchildren AND basic life support" (48), "schoolchildren AND bystander cardiopulmonary resuscitation" (23), "schoolchildren AND cardiac arrest" (45), "schoolchildren AND cardiopulmonary resuscitation" (58), "schoolchildren AND cardiopulmonary resuscitation AND theoretical knowledge" (9), "schoolchildren AND early medical intervention" (27), "schoolchildren AND emergency call" (5), "schoolchildren AND emergency number" (53), "schoolchildren AND helping behavior" (10), and "schoolchildren AND resuscitation" (67; Figure 1).

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