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Simulation and education

Kids save lives: a six-year longitudinal study of schoolchildren learning cardiopulmonary resuscitation: Who should do the teaching and will the effects last?

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ABSTRACT

Aims: This prospective longitudinal study over 6 years compared schoolteachers and emergency physicians as resuscitation trainers for schoolchildren. It also investigated whether pupils who were trained annually for 3 years retain their resuscitation skills after the end of this study.
Methods: A total of 261 pupils (fifth grade) at two German grammar schools received resuscitation training by trained teachers or by emergency physicians. The annual training events stopped after 3 years in one group and continued for 6 years in a second group. We measured knowledge about resuscitation (questionnaire), chest compression rate (min^{-1}), chest compression depth (mm), ventilation rate (min^{-1}), ventilation volume (mL), self-efficacy (questionnaire). Their performance was evaluated after 1, 3 and 6 years.
Results: The training events increased the pupils' knowledge and practical skills. When trained by teachers, the pupils achieved better results for knowledge ($92.86\% \pm 8.38$ vs. $90.10\% \pm 8.63$, $P = 0.04$) and ventilation rate ($4.84/min \pm 4.05$ vs. $3.76/min \pm 2.37$, $P = 0.04$) than when they were trained by emergency physicians. There were no differences with regard to chest compression rate, depth, ventilation volume, or self-efficacy at the end of the study. Knowledge and skills after 6 years were equivalent in the group with 6 years training compared with 3 years training.
Conclusions: Trained teachers can provide adequate resuscitation training in schools. Health-care professionals are not mandatory for CPR training (easier for schools to implement resuscitation training). The final evaluation after 6 years showed that resuscitation skills are retained even when training is interrupted for 3 years.

Introduction

Bystander cardiopulmonary resuscitation (CPR) is crucial for survival of out-of-hospital cardiac arrest.[1,2] The survival rates are two to four times higher when bystander CPR is provided.[1,3] Sudden cardiac arrest is a frequent but preventable cause of death throughout Europe,[4,5] and the European Resuscitation Council (ERC) has estimated that approximately 100,000 lives could be saved additionally each year if the quality of resuscitation and the incidence of lay resuscitation could be improved.[5–7] Although nearly half of all cases of out-of-hospital cardiac arrest in Germany are witnessed, the current bystander resuscitation rates are very poor (15–30%).[8,9] Other countries were reporting similarly low rates more than 10 years ago.[10,11] Regions in which the provision of resuscitation training in schools is mandatory have reported significantly better lay resuscitation rates.[12,13]

Training schoolchildren in CPR can form one part of a strategy for increasing bystander resuscitation rates and their quality. It is a successful method for training a large and highly motivated population group.[14,15] There is evidence that age-appropriate CPR training can be provided for a wide range of schoolchildren.[17–20] However, it is still unclear which profession is most suitable for

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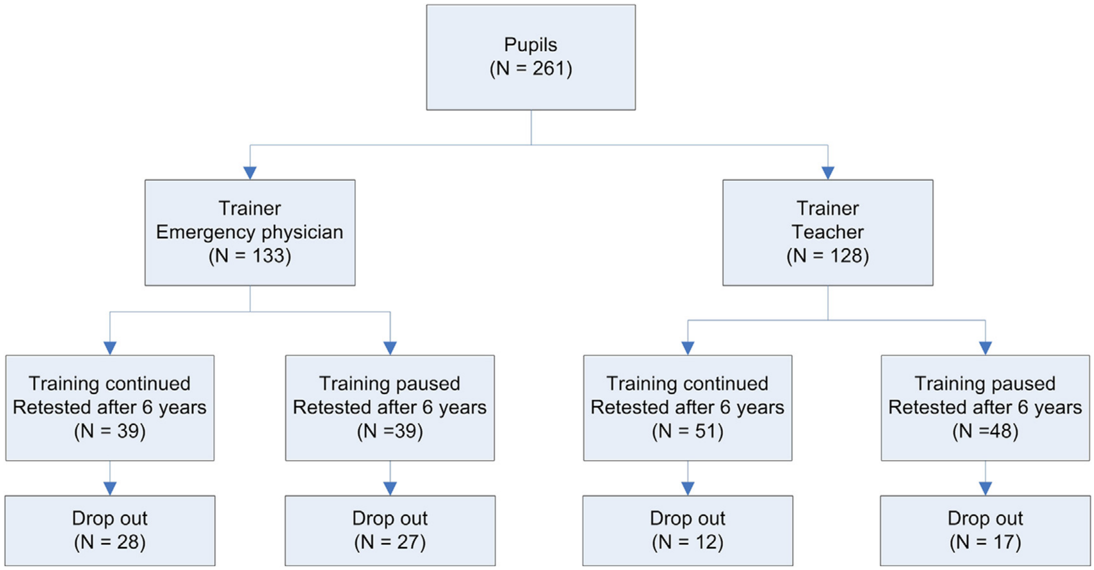

Fig. 1. Pupils flow chart.

teaching schoolchildren CPR and whether training has persistent effects when it is started early.[14,16] The present 6-year longitudinal study on CPR training in schools was conducted in order to investigate this issue.

Methods

Ethical approval

The study received approval from the Chamber of the Medical Association of Westphalia and was conducted under the auspices of the Ministry of Schools and Further Education of the state of North Rhine-Westphalia. Each of the participants (pupils) gave individual consent before the study was conducted.

Study design

The frequency of CPR training in schools and the appropriate starting age were evaluated in a previous study by our group, covering a period of 4 years in the same cohort.[21] The present prospective longitudinal study over 6 years included 261 pupils, starting from age 10, in two grammar schools (*Gymnasien*) in the cities of Münster and Aachen. Ages 10–16 represent the full period of compulsory secondary-school education in Germany.

One group received 6 years of annual training events, while the other had 3 years of annual training events followed by a 3-year interval until a final assessment after 6 years.

A total of 133 pupils received instruction from emergency physicians, while 128 pupils received training from trained teachers (Fig. 1). At each study site, the pupils were allocated as whole classes to each of the two training duration groups. Existing theoretical information that the pupils had about the topic, as well as their practical abilities, were noted at the start of the study. The training events and assessment time-points are listed in Table 1.

The end points used were as follows (Table 2):

- Knowledge about resuscitation (percentage of correct answers in a written test)
- Chest compression rate (min^{-1})
- Chest compression depth (mm)
- Ventilation rate (all ventilations of at least 500 mL were accounted for; min^{-1})
- Ventilation volume (mL)
- Self-efficacy (questionnaire).

Training materials

The same teaching materials were used in all of the groups. Resusci Anne® SkillReporter™ manikins (Laerdal Medical Ltd., Stavanger, Norway), adjusted to a medium chest stiffness, were used for training events and assessments involving practical skills. All of the training events were based on the 2005 European Resuscitation Council guidelines, including mouth-to-mouth ventilation and chest compression.

Training for teachers

Before the study, all of the teachers who acted as CPR trainers attended a 60-min theoretical and practical CPR update course based on the 2005 ERC guidelines. The instructors were emergency physicians experienced in teaching basic life support (BLS) and advanced life support (ALS). None of the schoolteachers had been a BLS instructor before the study. As part of their teacher-training studies (under German law), all of the teachers had attended one first-aid course (12 h) during the previous 10 years.

Training for pupils

Lessons in theory and hands-on training events were conducted during school hours. The pupils attended at least one training event per year. The teaching materials and manikins used were similar in all of the groups. The theory lessons consisted of a 1-h session, while hands-on training events lasted for 2 h and were held in small groups with a maximum of five pupils per manikin.

Written assessment of knowledge

The pupils' theoretical knowledge about CPR was tested using an 11-item multiple-choice questionnaire (online supplement 1). During the study, the same questions were used in a different order at each assessment. Points for correct answers were added up to provide an overall score.

Table 1
Sequence of assessment and training time-points: study timetable.

Date	Training continued for 6 years	Training paused after 3 years
August 2006	Assessment (baseline)	Assessment (baseline)
September 2006–January 2007	1. Training period	1. Training period
August 2007	Assessment (1 year)	Assessment (1 year)
September 2007–January 2008	2. Training period	2. Training period
September 2008–January 2009	3. Training period	3. Training period
August 2009	Assessment (3 years)	Assessment (3 years)
September 2009–January 2010	4. Training period	Training paused
September 2010–January 2011	5. Training period	Training paused
September 2011–January 2012	6. Training period	Training paused
August 2012	Assessment (6 years)	Assessment (6 years)

Written assessment of self-efficacy

In the present study, self-efficacy was used to represent the pupils' belief in their own ability to perform CPR. It was measured using a four-item questionnaire and a four-point scale (online supplement 2). The arithmetic mean was calculated and pooled, with a scale of 1 point (low) up to 4 points (high).

Practical assessment

The scenario-based assessment used was identical for all pupils at each time point. They were faced with an unconscious person lying on the ground at a bus-stop, and CPR data were recorded for 5 min (using the Laerdal PC SkillReporting System©).

Statistical analyses

Only the results for pupils who attended all of the training events and assessments were included. There were several reasons (such as moving to a different school or sick leave) for pupils missing a training event or assessment. With the 6-year longitudinal study design, this led to incomplete data, and the results for 84 pupils had to be excluded (Fig. 1). Data analyses were carried out using SPSS Statistics for Windows, version 17.0 (SPSS Inc., Chicago, USA). The data for the resuscitation skills measured (mean chest compression rate, mean chest compression depth, ventilation frequency and mean ventilation volume) were transferred directly from the Laerdal PC SkillReporting System, version 2.3.0, into SPSS Statistics.

Table 2
Results of measured abilities at all assessments: arithmetic means (M) and standard deviation (s) for all variables recorded.

	Baseline *M* (s)	After 1 year *M* (s)	After 3 years *M* (s)	After 6 years *M* (s)
Knowledge				
Percentage of correct answers				
Teacher	76.63 (±13.05)[†]	83.86 (±11.42)[*]	91.19 (±11.85)[*]	92.86 (±8.38)[†]
Physician	65.00 (±15.69)	84.40 (±11.28)[*]	92.27 (±7.79)[*]	90.10 (±8.63)
Continuous training over 6 yrs	71.36 (±15.37)	83.19 (±10.85)[*]	91.54 (±12.06)[*]	92.71 (±8.46)
Training paused after 3 yrs	72.50 (±15.20)	85.04 (±11.83)[*]	91.72 (±8.26)[*]	90.68 (±8.61)
Skills				
Compressions per min				
Teacher	34.24 (±39.23)[†]	72.01 (±21.12)[*,†]	75.61 (±16.63)[†]	72.73 (±12.63)
Physician	18.46 (±28.66)	52.01 (±17.35)	67.82 (±12.81)[*]	69.45 (±13.93)
Continuous training over 6 yrs	24.92 (±33.78)	62.40 (±22.41)[*]	72.17 (±15.66)[*]	72.57 (±12.11)
Training paused after 3 yrs	30.05 (±37.90)	64.37 (±21.45)[*]	75.31 (±15.51)[*]	69.98 (±14.36
Compression depth (mm)				
Teacher	11.93 (±12.15)	36.71 (±8.16)[*,†]	40.30 (±8.79)[*]	40.00 (±8.70)
Physician	11.01 (±13.32)	32.24 (±10.66)[*]	40.89 (±7.50)[*]	41.91 (±9.45)
Continuous training over 6 yrs	12.51 (±13.51)	34.86 (±10.22)[*]	40.88 (±7.99)[*]	41.65 (±7.59)
Training paused after 3 yrs	10.49 (±11.63)	34.69 (±8.86)[*]	40.22 (±8.53)[*]	39.95 (±10.35)
Ventilations of at least 500 mL per min				
Teacher	0.00 (±0.00)	7.24 (±7.91)[*,†]	5.62 (±4.52)	4.84 (±4.05)[†]
Physician	0.00 (±0.00)	4.24 (±5.89)[*]	4.89 (±4.45)	3.76 (±2.37)
Continuous training over 6 yrs	0.00 (±0.00)	4.99 (±5.69)[*]	5.06 (±3.87)	4.18 (±1.99)
Training paused after 3 yrs	0.00 (±0.00)	6.95 (±8.51)[*])[*]	5.57 (±5.08)	4.57 (±4.53)
Ventilation volume (mL)				
Teacher	0.00 (±0.00)	688.18 (±433.42)[*,†]	667.62 (±360.43)	723.61 (±367.81)
Physician	24.32 (±209.25)	508.41 (±484.32)[*]	858.80 (±445.43)[*,†]	841.23 (±608.67)
Continuous training over 6 yrs	0.00 (±0.00)	612.68 (±484.73)[*]	789.55 (±443.24)[*]	786.32 (±477.73)
Training paused after 3 yrs	21.69 (±197.58)	607.94 (±442.69)[*]	708.80 (±368.23)	761.99 (±502.83)
Self-efficacy (1 = low; 4 = high)				
Teacher	2.68 (±0.57)		3.18 (±0.60)[*]	3.31 (±0.58)
Physician	2.61 (±0.78)		3.28 (±0.55)[*]	3.45 (±0.50)[*]
Continuous training over 6 yrs	2.77 (±0.65)[#]		3.17 (±0.61)[*]	3.42 (±0.52)[*]
Training paused after 3 yrs	2.44 (±0.69)		3.34 (±0.50)[*]	3.32 (±0.59)

[*] Significantly different from the previous assessment time-point.
[†] Significantly different from the comparison group physician or teacher.
[#] Significantly different from the comparison group continuous training over 6 yrs and training paused after 3 yrs.

As the study was not a simple group comparison, but involved repeated measures, analysis of variance based on the general linear model (GLM) was used. The *F* test was used to evaluate whether two or more group means differed significantly from one other. *P* values of 0.05 were considered significant. Proof of reliability was tested using Cronbach's alpha coefficient.

Results

Independently of whether the instruction was provided by a teacher or by an emergency physician, the pupils' knowledge about resuscitation and their practical skills and self-efficacy all increased (Table 2).

Knowledge

In comparison with the baseline figures, the pupils' theoretical knowledge about CPR improved. Pupils who received instruction from teachers achieved better results than those who were trained by emergency physicians (92.86% ± 8.38 vs. 90.10% ± 8.63; $P = 0.04$). After 6 years, there were no significant differences between the results for pupils with 3 years of annual training events followed by a 3-year interval and pupils who attended annual training events for 6 years.

Compressions per minute

The chest compression rate improved over the 6 years in all of the groups, but did not reach the rate required in the guideline (ERC 2005).[29] There were no differences here between pupils who were trained by teachers and those who were trained by emergency physicians. At the end of the study, the results for pupils with 3 years of annual training events did not differ from those for pupils with 6 years of annual training events.

Compression depth

During the study period, all of the pupils were able to increase the chest compression depth achieved to the recommended minimum depth of 40 mm (ERC 2005). There were no differences between the group trained by teachers and the group trained by emergency physicians. Pupils with 3 years of annual training events had slightly poorer results with regard to chest compression depth in comparison with those with 6 years of annual training events (39.95 mm ± 10.35 vs. 41.65 mm ± 7.59), but the difference was not statistically significant.

Ventilations per minute

None of the pupils had been able to perform correct mouth-to-mouth ventilation before the study (at the baseline assessment). During the study period, the ventilation rate increased, but did not reach the level of the guideline recommendation. Pupils who were trained by teachers achieved better ventilation rates than those trained by emergency physicians (4.84 min^{-1} ± 4.05 vs. 3.76 min^{-1} ± 2.37; $P = 0.04$). No differences were observed at the test after 6 years between the groups with different periods of annual training events (3 years vs. 6 years).

Ventilation volume

An adequate ventilation volume was not detected in any of the groups at the baseline assessment. After CPR training, however, the volume improved significantly in all of the groups. After 3 years, the physician-trained groups achieved higher ventilation volumes in comparison with the teacher-trained groups (858.80 mL ± 445.43 mL vs. 667.62 mL ± 360.43 mL; $P = 0.001$). After 6 years, the tidal volumes detected were above those recommended in the 2005 ERC guidelines, at up to 841 mL. When the two training durations were compared (3 vs. 6 years), no differences were evident after 6 years.

Self-efficacy

CPR training at school strengthened the CPR self-efficacy of all the pupils who took part. Cronbach's alpha analysis showed an acceptable to good level of internal consistency, at $\alpha = 0.71$ at the baseline assessment, $\alpha = 0.81$ at the 3-year assessment and $\alpha = 0.83$ at the 6-year assessment. There were no differences between the groups who received instruction from teachers and those instructed by emergency physicians. At the end of the study, the findings in the group with 3 years of annual training events followed by a 3-year interval were equivalent to those in the group with 6 years of annual training.

Discussion

To the best of the authors' knowledge, this study is the most comprehensive longitudinal study so far conducted on the effects of CPR training in schoolchildren.

Differences in knowledge

General knowledge about CPR improved in all of the pupils after the theory lessons. The reason why the pupils who were trained by teachers performed better in the knowledge test is unclear. It can be assumed that teachers have greater practical expertise in education and can encourage better results than external tutors. No overall differences were noted regarding the other results, a finding that is consistent with those of previous reports.[14–16]

The extent to which knowledge was retained after 6 years was very good. Even following a 3-year interval with no training, the pupils were still able to recall information about the theory involved in resuscitation.

Differences in skills

Although guideline-compliant BLS skills were not achieved after 6 years of training, a significant improvement in all BLS skills was noted. There were no differences in the skills achieved between the groups with different instructors, with the exception of the results for ventilation volume. Adequate ventilation was not observed before the study. It can be assumed that a lack of information about how to open the airways was a major reason for the lack of adequate ventilation at baseline. As the study progressed, the ventilation volume reached levels beyond those required in the 2005 ERC guideline recommendations.[25] The instruction "do as much ventilation as you can" is likely to be problematic. According to other published studies, this result is not surprising; it is more difficult to teach ventilation than chest compression. Debate on this issue is continuing, and some evidence has been reported showing that it may be more effective to provide training in chest compression alone.[14,21,26–28]

Differences in self-efficacy

The psychological phenomenon of self-efficacy used in the present study is based on the work of Albert Bandura. In the field of social cognitive theory, "self-efficacy" describes the way in which people approach challenging tasks. When self-efficacy is low, people respond with denial. In contrast, if their self-efficacy is high, they are much more likely to initiate and succeed in challenging activities.[22–24]

It is the level of self-efficacy among individual bystanders that may make the difference between someone intervening in a witnessed cardiac arrest or not. The physical force capable of being applied is not the only factor that determines whether a layperson may be willing to start basic life support. The four-stage "sociocognitive learning theory" shows that an individual's behaviour, and his or her motivation to show that behaviour, are strongly dependent on the individual's degree of self-confidence.[22–24] Self-confidence in an activity and skill retention are significantly influenced by the teaching method used and the time point of learning.[29] It was therefore expected that it would be possible to teach the ability to initiate resuscitation to the pupils successfully during the present study. Over the whole study period, there was a significant increase in self-efficacy among the pupils participating. One important difference was detected between the groups with different training durations: the group that received annual training for the full 6 years showed significantly greater self-efficacy than the group with no training for 3 years after a 3-year period of annual training events. In view of this result, continuing the annual training events without intervals may be recommended. With regard to the other results, the interval without training did not lead to any deterioration in CPR skills.

Facilitator

Although the person who provides CPR training in schools may be an important topic in this context, this has rarely been studied so far.[14–16] This study provides evidence from a 6-year prospective longitudinal study that trained teachers are able to provide successful CPR training in schools. The use of teachers as facilitators has many advantages, as it is easy to motivate them on the basis of their own relevant CPR training.[30,31] Teachers are receptive to the topic and are role models, they have expertise in educational methods, and it is easier for schools to organise their work than it is to arrange for external personnel to conduct the training events.[14,15]

Other types of trainer, such as medical students or peer pupils with previous training (using the "jigsaw" model), have also been effectively used to facilitate BLS training.[14,19,32,33] In the framework of a national public awareness campaign conducted in Germany to increase the lay resuscitation rate – the "Resuscitation Week" (www.schuelerrettenleben.de) – Beck et al. examined the influence of different facilitators in a randomised controlled trial. They confirmed that when pupils were used as peer instructors, equally good resuscitation results were achieved in comparison with professional medical trainers. The peer instructors were interested pupils in their pre-final school year who had received 6 h of BLS training before the study.[20] This study also supports the present results, indicating that schools do not need external BLS instructors.

Skill retention

The issue of whether the relevant skills are capable of being retained over a period of more than 3 years has previously been unclear.[14] The present study shows that after 3 years of CPR training followed by a pause of 3 years, the same skills are retained as after 6 years of continuing CPR training. With the exception of self-efficacy, none of the other basic CPR skills deteriorates when training is interrupted for 3 years. This is in contrast to the finding reported by other groups that skills decline even a few months after a training event.[34,35] In view of the present results, it appears that the skills gained during 6 years of mandatory annual CPR training are unlikely to fade away after the pupils leave school.

Starting age

In the setting of Germany's educational system, the starting age in this study was the first year of secondary school (fifth grade, age 10). There is evidence that even younger children are able to achieve positive CPR learning results.[15,34] Studies have indicated that all age groups show progress in learning, regardless of the starting age.[14,16] It may be assumed that even younger pupils might be capable of being successfully taught BLS. Discussions on the best starting age for BLS training have mainly focused on the physical ability to perform CPR (physical fitness).

The ability of schoolchildren to disseminate attitudes towards bystander CPR in society has probably been underestimated. Stroobants et al. investigated the impact on people's attitudes towards bystander CPR when relatives were trained by children. For each child instructor, 1.7 adults showed a positive change in attitude. Interestingly, trainees among primary-school children scored better than trainees among secondary-school children.[18] Training grandchildren in BLS might therefore be an effective way of training their grandparents. However, discussions regarding the preferable starting age should not lead to any delay in the introduction of BLS training into schools.

Weaknesses of the study

Skills involving the chest compression rate, ventilation frequency and ventilation volume improved over the course of time in the present study, but it remains unclear why not all of them met the 2005 ERC guideline recommendation.[25] The results reported for ventilation skills are difficult to interpret in manikin studies. It is known that if the manikin's head is not tilted correctly, the airway remains blocked so that ventilation is not measured properly.[19] This technical cause might be responsible for failure to meet the recommended ventilation levels, in addition to a lack of knowledge among participants about how to open the airway. Theoretical knowledge was assessed in a written exam. The test used the same questions, only changing the order of the questions. Although students were not told the correct answers after the exam, we are unable to rule out weather changes in the results are due to remembrance of the answers to the questions from a previous test. Neither can we exclude that pupils might have looked up the correct answers after a test.

In view of these results and the 2010 ERC guidelines,[26] the emphasis in CPR training in schools should be placed on recognising cardiac arrest, detecting gasping or agonal breathing, and achieving high-quality chest compression. Chest compression has been shown to be more crucial than the more complex process of mouth-to-mouth ventilation in bystander CPR.[26,28,36,37,38]

It is not known whether conditions such as staff motivation and social structure in the participating schools influenced the results. It is not known whether any motivated pupils may have taken part in additional CPR courses despite this.

Recommendations and implications

Sufficient evidence is now available for resuscitation training programs to be started in schools using the existing teaching staff. The European Patient Safety Foundation (EUPSF) and other organisations have jointly published a statement entitled *Kids Save Lives* on training schoolchildren in CPR. In January 2015, the statement was approved and supported by the World Health Organisation (WHO) to promote the establishment of CPR training in schools throughout the world.[6] Despite the good evidence available, CPR training in schools has still not yet been widely implemented [39] and although various countries are starting to develop evidence-based curriculums on CPR training in schools,[27,40] there is currently a lack of a standardised Europe-wide curriculum.

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Conflict of interest statement

All of the authors hereby declare that no support was received from any organisation for the submitted work other than those listed above under "Funding"; that there were no financial relationships with any organisations that might have an interest in the submitted work during the previous 3 years; and that there were no other relationships or activities that could appear to have influenced the submitted work.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2016.01.028.

References

1. Holmberg M, Holmberg S, Herlitz J. Effect of bystander cardiopulmonary resuscitation in out-of-hospital cardiac arrest patients in Sweden. Resuscitation 2000;47:59–70.
2. Berdowski J, Berg RA, Tijssen JGP, et al. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation 2010;81:1479–87.
3. Strömsöe A, Svensson L, Claesson A, et al. Association between population density and reported incidence, characteristics and outcome after out-of-hospital cardiac arrest in Sweden. Resuscitation 2011;82:1307–13.
4. Taniguchi D, Baernstein A, Nichol G. Cardiac arrest: a public health perspective. Emerg Med Clin North Am 2012;30:1–12.
5. Nolan JP, Soar J, Zideman DA, et al. European Resuscitation Council guidelines for resuscitation 2010 Section 1. Executive summary. Resuscitation 2010;81:1219–76.
6. Böttiger BW, Van Aken H. Kids save lives: training school children in cardiopulmonary resuscitation worldwide is now endorsed by the World Health Organization (WHO). Resuscitation 2015;94:A5–7.
7. Böttiger BW. Cardiopulmonary resuscitation and postresuscitation care 2015: saving more than 200000 additional lives per year worldwide. Curr Opin Crit Care 2015;21:179–82.
8. Breckwoldt J, Schloesser S, Arntz HR. Perceptions of collapse and assessment of cardiac arrest by bystanders of out-of-hospital cardiac arrest (OOHCA). Resuscitation 2009;80:1108–13.
9. Gräsner JT, Wnent J, Seewald S, et al. First aid and trauma management: results from the German resuscitation registry. Anästhesiol Intensivmed Notfallmed Schmerzther 2012;47:724–32.
10. Vaillancourt C, Stiell IG, Canadian Cardiovascular Outcomes Research Team. Cardiac arrest care and emergency medical services in Canada. Can J Cardiol 2004;20:1081–90.
11. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. JAMA 1995;274:1922–5.
12. Wnent J, Bohn A, Seewald S, et al. Bystander resuscitation: the impact of first aid on survival. Anästhesiol Intensivmed Notfallmed Schmerzther 2013;48:562–5.
13. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310:1377–84.
14. Plant N, Taylor K. How best to teach CPR to schoolchildren: a systematic review. Resuscitation 2013;84:415–21.
15. Lukas RP, Bohn A, Möllhoff T, et al. Teaching resuscitation in schools: 'The earlier, the better. . ..'. Anästhesiol Intensivmed Notfallmed Schmerzther 2013;48:552–6.
16. Bohn A, Lukas RP, Breckwoldt J, et al. 'Kids save lives': why schoolchildren should train in cardiopulmonary resuscitation. Curr Opin Crit Care 2015;21:220–5.
17. Lorem T, Palm A, Wik L. Impact of a self-instruction CPR kit on 7th graders' and adults' skills and CPR performance. Resuscitation 2008;79:103–8.
18. Stroobants J, Monsieurs K, Devriendt B, et al. Schoolchildren as BLS instructors for relatives and friends: Impact on attitude towards bystander CPR. Resuscitation 2014;85:1769–74.
19. Charlier N, Van Der Stock L, Iserbyt P. Peer-assisted learning in cardiopulmonary resuscitation: the Jigsaw model. J Emerg Med 2015;50:67–73.
20. Beck S, Issleib M, Daubmann A, et al. Peer education for BLS-training in schools? Results of a randomized-controlled, noninferiority trial. Resuscitation 2015;94:85–90.
21. Bohn A, Van Aken HK, Möllhoff T, et al. Teaching resuscitation in schools: annual tuition by trained teachers is effective starting at age 10. A four-year prospective cohort study. Resuscitation 2012;83:619–25.
22. Bandura A. Social cognitive theory: an agentic perspective. Annu Rev Psychol 2001;52:1–26.
23. Bandura A. Self-efficacy: the exercise of control. New York, NY: Freeman; 1997.
24. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 1977;84:191–215.
25. Nolan JP, Deakin CD, Soar J, et al. European Resuscitation Council guidelines for resuscitation 2005. Section 4. Adult advanced life support. Resuscitation 2005;67:S39–86.
26. Deakin CD, Nolan JP, Soar J, et al. European Resuscitation Council guidelines for resuscitation 2010 Section 4. Adult advanced life support. Resuscitation 2010;81:1305–52.
27. De Buck E, Van Remoortel H, Dieltjens T, et al. Evidence-based educational pathway for the integration of first aid training in school curricula. Resuscitation 2015;94:8–22.
28. Nishiyama C, Iwami T, Kitamura T, et al. Long-term retention of cardiopulmonary resuscitation skills after shortened chest compression-only training and conventional training: a randomized controlled trial. Acad Emerg Med 2014;21:47–54.
29. Ettl F, Testori C, Weiser C, et al. Updated teaching techniques improve CPR performance measures: a cluster randomized, controlled trial. Resuscitation 2011;82:730–5.
30. McCluskey D, Moore P, Campbell S, et al. Teaching CPR in secondary education: the opinions of head teachers in one region of the UK. Resuscitation 2010;81:1601.
31. Mpotos N, Vekeman E, Monsieurs K, et al. Knowledge and willingness to teach cardiopulmonary resuscitation: a survey amongst 4273 teachers. Resuscitation 2013;84:496–500.
32. Breckwoldt J, Beetz D, Schnitzer L, et al. Medical students teaching basic life support to school children as a required element of medical education: a randomised controlled study comparing three different approaches to fifth year medical training in emergency medicine. Resuscitation 2007;74:158–65.
33. Toner P, Connolly M, Laverty L, et al. Teaching basic life support to school children using medical students and teachers in a 'peer-training' model—results of the 'ABC for life' programme. Resuscitation 2007;75:169–75.
34. Bollig G, Wahl HA, Svendsen MV. Primary school children are able to perform basic life-saving first aid measures. Resuscitation 2009;80:689–92.
35. Moore PJ, Plotnikoff RC, Preston GD. A study of school students' long term retention of expired air resuscitation knowledge and skills. Resuscitation 1992;24:17–25.
36. Bobrow BJ, Zuercher M, Ewy GA, et al. Gasping during cardiac arrest in humans is frequent and associated with improved survival. Circulation 2008;118:2550–4.
37. Berg RA, Sanders AB, Kern KB, et al. Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. Circulation 2001;104:2465–70.
38. Koster RW, Baubin MA, Bossaert LL, et al. European Resuscitation Council guidelines for resuscitation 2010 Section 2. Adult basic life support and use of automated external defibrillators. Resuscitation 2010;81:1277–92.
39. Lockey AS, Barton K, Yoxall H. Opportunities and barriers to cardiopulmonary resuscitation training in English secondary schools. Eur J Emerg Med 2015, http://dx.doi.org/10.1097/MEJ.0000000000000307 [Epub ahead of print].
40. Cave DM, Aufderheide TP, Beeson J, et al. Importance and implementation of training in cardiopulmonary resuscitation and automated external defibrillation in schools: a science advisory from the American Heart Association. Circulation 2011;123:691–706.