

# THE PROCESS OF IMPLEMENTING CARDIOPULMONARY RESUSCITATION TRAINING IN SCHOOLS: A REVIEW OF CURRENT RESEARCH

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## Abstract

*Cardiopulmonary resuscitation (CPR) education in European schools is recommended to increase the low or moderate rate of non-professional bystander CPR. The analysis of research focusing on success and problems with CPR education in schools is therefore useful for a broader realization. The aim of this review is to discuss quantitative and qualitative studies with respect to evidence on the implementation progress of CPR education in primary or secondary schools. Studies were retrieved from PubMed database (n=940) resulting in n=141 eligible articles with n=20 meeting specific inclusion criteria. The reviewed evidence reveals heterogeneous results. Teachers' perceived competency, CPR instructor training and funding as well as class time for CPR programs was predominantly limited, whereas the effect of legal obligation was interpreted differently. However, implementation barriers encompassed in this review emerged across different national education systems, but systematic and sufficient approaches seem to need further political support in general.*

**Key words:** Barriers; cardiopulmonary resuscitation (CPR); implementation; review; schools

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## 1. Introduction

In developed countries, the most common cause of death are diseases of the cardiovascular system (Benjamin et al., 2018; Statistisches Bundesamt [Destatis], 2017). One of the reasons is

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sudden cardiac death (SCD) due to a cardiac arrest (CA), which is prevalently caused by implications of acute myocardial infarction (Trappe, 2007; Waldecker, 2003). An estimated 84 to 86.4 cases of CA per 100000 habitants were treated by emergency medical services (EMS) in Europe (Berdowski, Berg, Tijssen, & Koster, 2010; Gräsner et al., 2016). The American Heart Association (AHA) reports for 2018 an incidence of 110.8 cases per 100000 habitants for the United States (US). Hence, 356000 people of the US population suffer from SCD (Benjamin et al., 2018). The survival rate of patients with CA to hospital discharge accounts only for 9 to 11 % (Atwood, Eisenberg, Herlitz, & Rea, 2005; Benjamin et al., 2018; Berdowski et al., 2010; Gräsner et al., 2016). To lower fatality rates of out-of-hospital CA and to increase the chances of survival by two- to fourfold, immediate cardiopulmonary resuscitation (CPR) or at least immediate chest compressions by non-professionals (i.e. bystanders) are required as Basic Life Support (BLS) measures (Hasselqvist-Ax et al., 2015; Holmberg, Holmberg, & Herlitz, 2001; Perkins et al., 2015; Wissenberg et al., 2013).

Bystander CPR rates account for approximately 70% in Norway (Lindner, Søreide, Nilsen, Torunn, & Lossius, 2011). However, the rate is significantly lower in Germany or in the US: 37% and 41%, respectively, in 2016 (Benjamin et al., 2018; Gräsner et al., 2017). The process of training bystanders to confidently perform qualitative CPR is crucial and has to be established long-lasting. Recently, high school and university students have been focused on as a target population to comprehensively increase the proportion of trained non-professionals (Bohn, Lukas, Breckwoldt, Böttiger, & van Aken, 2015; Böttiger et al., 2016; Böttiger, Semeraro, & Wingen, 2017; Cave et al., 2011). Most reviews about CPR in schools only focus on methods for and the quality outcome of high school student CPR training (Plant & Taylor, 2013; Schroeder, Ecker, Wingen, Semeraro, & Böttiger, 2017). Unlike the established evidence, this review aims to concentrate on quantitative and interview studies which focus on experiences and opinions of school teaching staff only. However, the prior results stated in the AHA science advisory statement were incorporated and acknowledged, and amended with recent literature (Cave et al., 2011).

Long-term implementation<sup>2</sup> of CPR education in schools poses a challenge for the school systems of many countries. In Germany for example, Schroeder et al. reported different strategies of support: the publication of a CPR curriculum in 2012 (German Resuscitation Council [GRC], 2014), a recommendation of the Conference of the Ministers of Education in Germany in 2014

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<sup>2</sup> i.e. regular application of an innovation in a social place, e.g. schools (Altrichter and Wiesinger, 2004).

and initiatives like KIDS SAVE LIVES (Böttiger et al., 2016; Böttiger & van Aken, 2015). However, the dissemination of student CPR training in German schools is inconsistent and overall still low (Schroeder et al., 2017).

School teachers were assigned as CPR instructors because they are comprehensively available and accessible. This decreases the need for a complex course organization (Cuijpers, Bookelman, Kicken, Vries, & Gorgels, 2016; Jiménez-Fábrega et al., 2009; Lukas et al., 2016), thus making this method of CPR teaching effective for a large number of primary and high school students (Bohn et al., 2012; Breckwoldt & Kreimeier, 2013; Rucker, 2010). Despite this pathway, alternative options are present for schools to teach CPR, e.g. teachers with AHA/Red Cross BLS instructor certificates or local agencies (e.g. Red Cross, EMS and healthcare professionals), using materials provided by their organizations (Brown, Lynes, Carroll, & Halperin, 2017; Hoyme & Atkins, 2017). However, it may not be possible for aid organizations and medical professionals, e.g. in Germany, to ensure permanent CPR education for all the high school students aged 6 to 18 years. In this respect, our review stresses evidence about regular teachers as CPR instructors in order to acknowledge potential worries and ideas that teachers and school administrations may have. The findings of this review are intended to provide suggestions for further CPR education measures in general.

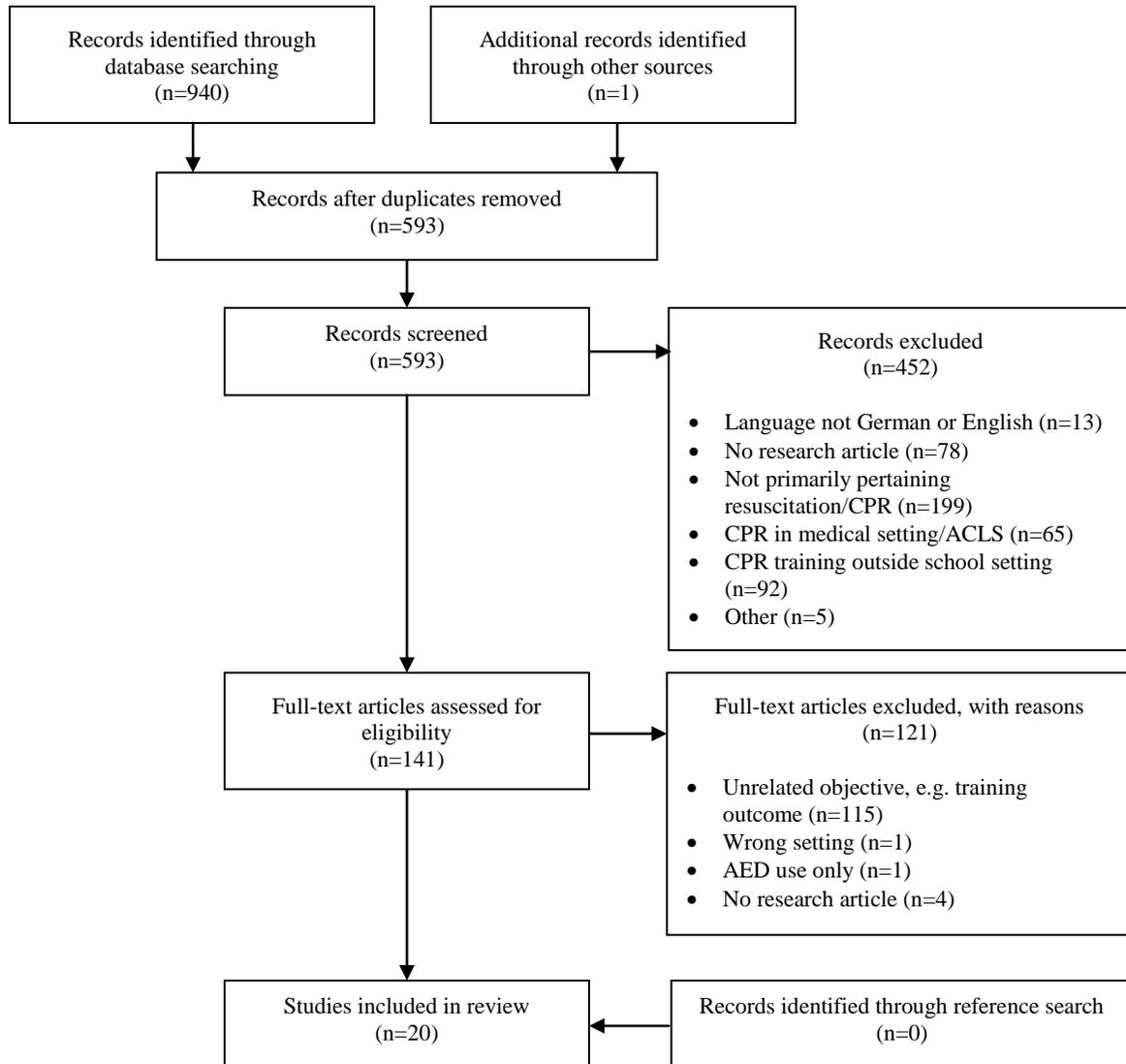
## **2. Data Acquisition**

We explored empirical literature for evidence about the implementation process of student CPR in schools from a teachers' and administrations' perspective. Specific review questions were

- (i) how school personnel perceive its competency and willingness,
- (ii) how the process is supported and,
- (iii) which complications are commonly reported by the school staff.

Study populations eligible for inclusion were teachers, assigned CPR or health coordinators, and administrations of primary or secondary schools (students most frequently aged 10 to 18 years). School nurses do not exist in all European countries and therefore were not considered. The studies' objectives had to be limited to school development in CPR education. Further, the original articles had to be published in English or German language and report cross-sectional (observational) studies or interventional designs at schools to be considered for inclusion. Publication dates and study designs (quantitative vs. qualitative) were not restricted to ensure that

all potentially relevant information on CPR implementation in schools and its improvement are covered.



**Figure 1.** Flow-chart for data reporting with exclusion criteria, modified according to Moher et al. (2009). Last search was performed on July 23<sup>rd</sup> 2018.

Only the PubMed database (NCBI, USA) was searched<sup>3</sup> due to restricted access to EMBASE. Data collection in PubMed was performed by one of the authors using search terms which were predefined by the working group. The publication period remained unlimited. The search process was conducted during June and July 2018, with a last search on July 23<sup>rd</sup> (cut-off date). Search terms were entered sequentially: *\*cpr + education + school + implementation (74); \*basic life support + education + school+ implementation (56); \*first aid training + education + school + implementation (46); \*cpr + training + teachers + students (45); \*first aid + training + teachers + students (56); \*basic life support+ training + teachers + students (18); \*cardiopulmonary + resuscitation + schools + learning (58); \*cardiopulmonary + resuscitation + schools + education (249); \*cardiac + arrest + schools + education (176); \*cpr + pupils + teaching (25); \*cardiopulmonary + resuscitation + pupils + teaching (25); \*basic life support + teachers (30); cardiopulmonary + resuscitation + schoolchildren (82).*

After completion of the electronic search, all reports were imported into Citavi reference manager (Swiss Academic, Switzerland) to screen title, key words, publication type and online available abstracts on eligibility. Any decisions for in- and exclusion were met collectively in the working group and disagreements were solved by reconsideration. In a second step, an in-depth full-text-analysis was performed for eligible publications. Studies which provided data corresponding to our review questions and criteria were marked and inclusion was again discussed by the investigators.

The included publications were scanned for results regarding the variables perceived competency and willingness of teachers, implementation rates (and how obligation is connected to it), barriers and supporting factors of CPR training. Quantitative outcome measures of studies were presented as relative frequencies, means and differences in means or odds ratios. Qualitative results were reported with reference to the major findings. Each publication was critically evaluated for potential bias based on sample characteristics and used methods. Thirdly, the effect of structural differences in the investigated school systems was taken into account to estimate limitations of the given results.

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<sup>3</sup> According to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman 2009).

### **3. Results**

#### ***3.1 Study selection***

The search resulted in n=940 articles with n=348 doublets. After eliminating doublets, one additional study was added, which was not indexed in PubMed (Felzen et al., 2018). In more detail, 452 of n=593 screened results were excluded due to different criteria indicated in Figure 1. Subsequently, n=141 studies fit criteria for a full-text analysis and n=20 records were incorporated into the review after excluding n=121 studies with said reasons (see Figure 1).

All studies except the study from Iserbyt et al. (cluster randomized controlled trial) and those of Zinckernagel et al. and Lockey et al. (qualitative interview studies) were cross-sectional studies with school- and teacher surveys (Iserbyt, Theys, Ward, & Charlier, 2017; Lockey, Barton, & Yoxall, 2016; Zinckernagel et al., 2016). For an overview of the characteristics and the main results of the incorporated studies in addition to the following presentation, please refer to Table 1.

#### ***3.2 Perceived competency and willingness***

The general willingness to teach CPR was evaluated from different perspectives: School administrations in Barcelona (n=100) expect frequent engagement (69%) of their teachers with this issue, however, only for theoretical lessons without exercises (Miró et al., 2006). Principals of Northern Ireland secondary schools (n=169) estimated that – in general – 55% of teachers are willing to teach CPR (contents were not specified) (McCluskey, Moore, Campbell, & Topping, 2010). Contrariwise, a 2013 Belgian investigation, addressed to teachers, reported that 61% of them are not willing to teach CPR, however another study in 2018 reported that 60% would or would probably do (Mpotos, Vekeman, Monsieurs, Derese, & Valcke, 2013; Smedt et al., 2018). According to a study Magid et al. conducted in the US, teachers who facilitated a CPR training program gave positive feedback: 99% evaluated the program as easy to implement, 98% were interested in implementing future sessions. Notably, only 18% of teachers had experience as CPR instructor before (Magid, Heard, & Sasson, 2018).

If teachers were not willing to teach CPR, the most frequently mentioned reasons were missing knowledge and limited skills to proficiently do CPR themselves (66%, n=4237; 74%, n=437), which was also the reason for an unwillingness to teach it (50%, n=4237; 77%, n =437) (Mpotos et al., 2013; Smedt et al., 2018). Teachers felt more confident and willing to teach if they took part in one or more first aid and life support courses in the last few years. (Mpotos et al., 2013; Patsaki et al., 2012).

Referring to Malta Hansen et al., the self-assessment of CPR competencies was distinctly lowered for many teachers in their sample (n=665): only 13% felt competent to teach CPR (Malta Hansen et al., 2017). In addition, another Danish qualitative study reports that a lack of willingness is connected with subjectively perceived incompetence (Zinckernagel et al., 2016). Teachers seem to transfer their own skill-related concerns to the classroom situation; thus, it is important for them to be medically proficient in order to give classes where medical competences are passed on to schoolchildren. As a core argument, their teaching may decide between life and death in case of a real CA, which is why Zinckernagel et al. report a discrepancy of medical demands as claimed by medical professionals opposed to those claimed by teachers (Zinckernagel et al., 2016).

### ***3.4 Obligation and Implementation rates***

There are conflicting opinions about mandatory CPR education in schools, resulting in 41% (Mptos et al., 2013) or, in contrast, 83% (Malta Hansen et al., 2017) of surveyed teachers and 80% of school administrations, who support obligatory programs (Malta Hansen et al., 2017; McCluskey et al., 2010). In a survey of Saudi Arabian teachers (n=305) 78% were willing to take a CPR free course and more than one third (37.4%) stated that CPR training should be mandatory in schools and even a necessity to obtain teachers' certification (54.1%) (Al Enizi et al., 2016).

Retrospective studies in areas with a mandatory CPR curriculum (e.g. Toronto, Canada; Iowa, USA; Washington State, USA; Denmark) showed a high heterogeneity of implementation rates. Only 50% of the responding schools taught CPR in Toronto (Hart, Flores-Medrano, Brooks, Buick, & Morrison, 2013). The rate was higher in Denmark and Washington State (60% and 65%, respectively) and reached 96% in Iowa (Hoyme & Atkins, 2017; Malta Hansen et al., 2017; Salvatierra, Palazzo, & Emery, 2017). The survey by Brown et al. on CPR education for schoolchildren in the entire US indicated an implementation rate of 77%. Noteworthy, all schools with CPR training were located in states with a mandatory CPR curriculum (Brown et al., 2017). Reflecting these heterogeneous results, the effect of an obligation remains indistinct: Hoyme et al. assume a four-year period for successfully implementing CPR training on the basis of Iowa's results, whereas Hansen et al. similar to Hart et al. did not observe any systematic implementation (Hart et al., 2013; Hoyme & Atkins, 2017; Malta Hansen et al., 2017).

Brown et al. report a positive development in the US and the fact that students are the largest population group which can be reached by CPR training in schools. Anyhow, they emphasize

that consistent guidelines for the instructor certification are missing and content, teaching time, and funding have to be determined to optimize effectiveness (Brown et al., 2017).

Furthermore, studies remain vague when it comes to the number of participating students; Is the entire school involved in CPR trainings or just a selected group of students, as Lockey et al. (2016) reported. Similarly, Saliccioli et al. (2017) pointed out that more than half (56%) of the interviewed schools in London offered CPR training, but 48% placed it during extracurricular programs or voluntary modules.

In a Norwegian study from 2017, Physical Education teachers at elementary and high schools were interviewed on the inclusion of first aid in their classes. First aid training is part of the syllabus for P.E. education in 7<sup>th</sup> and 10<sup>th</sup> grade (Bakke & Schwebs, 2017). Most teachers (64%) teach the content with an average of 2.7 hours per grade and year. In other grades, where the curriculum dictates first aid training, invested time was higher (2.3 vs. 3.0 hours;  $p < 0.01$ ) (Bakke & Schwebs, 2017).

### ***3.5 Barriers and supporting factors***

Multiple studies identified three major barriers in developing CPR education in schools: Firstly, adequate funding must be available for external instructors and special training materials (e.g. CPR manikins or automated external defibrillators) (Hart et al., 2013; Hoyme & Atkins, 2017; Lafferty, Larsen, & Galletly, 2003; Lockey et al., 2016; Malta Hansen et al., 2017; Miró et al., 2006; Saliccioli et al., 2017; Salvatierra et al., 2017). Teachers explicitly wished for more equipment (e.g. manikin, AED training kits) after a US nationwide teacher-based (“train the trainer”) CPR training intervention in schools – though the provided AHA kits contained 10 manikins, instruction DVD and print resources for teacher training and classroom activities (Magid et al., 2018). Even though national strategies on CPR education were already established in England (e.g. by the British Heart Foundation), a qualitative study in 2016 emphasized that an appropriate public budget alongside local engagement by the health care sector is crucial (Lockey et al., 2016).

A second barrier was a lack of opportunities to ensure CPR trainings by certified instructors (Hoyme & Atkins, 2017; Reder & Quan, 2003; Salvatierra et al., 2017). If CPR classes are to be taught by teachers, specialized trainings are inevitable to increase their first aid knowledge and CPR instructor proficiency (Bakke & Schwebs, 2017; Lockey et al., 2016; Miró et al., 2006). This barrier correlated with the lack of perceived competency expressed by interviewed teachers (Zinckernagel et al., 2016).

If trainings are offered, teachers will also need special training to develop and assess teaching methods for CPR education (Iserbyt et al., 2017). Iserbyt et al. compared two teacher training concepts in a cluster randomized trial and teachers participating in the test group additionally practiced giving feedback (by role-playing) and holding action-oriented training lessons. The test group achieved better results when considering the learning achievements of the high school students ( $p=.04$ ,  $\eta_p^2=.02$ ;  $n=203$ ) as well as their teaching performance (qualitative measures).

Another frequent difficulty was the teaching time shortage due to a full school curriculum (Bakke & Schwebs, 2017; Cuijpers et al., 2016; Hoyme & Atkins, 2017; Lockey et al., 2016; Reder & Quan, 2003; Salciccioli et al., 2017; Salvatierra et al., 2017). Teaching time is consumed by the topics and learning objectives of the main school subjects. If the additional time needed to teach CPR and this issue is perceived as unnecessary or ineffective, teachers' willingness tended to decrease and so does their effort (Hart et al., 2013).

Opposite to barriers, success factors included obtaining a coordinator who organizes CPR training at schools (OR 3.01; 95% CI 1.84-4.92) and having appropriate materials for the classes at one's disposal (OR 2.08; 95% CI 1.57-2.76) (Malta Hansen et al., 2017) These factors were similarly expressed in interviews with Danish teachers (Zinckernagel et al., 2016). Further positive effects resulted from the knowledge that other schools successfully offer CPR training and from present mandating legislation (OR 9.68; 95% CI 4.65-20.1 and OR 4.19; 95% CI 2.65-6.62, respectively) (Malta Hansen et al., 2017). The connection of CPR education with other learning objectives is a further strategy to improve implementation; some surveys suggest CPR to be integrated in Health Education, Physical Education, Vocational Preparations, and Biology Education. (Felzen et al., 2018; Reder & Quan, 2003).

**Table 1:** Overview of study characteristics and main results (alphabetical order)

| No. | Authors                | Study data and design  | (Selected) main results   |
|-----|------------------------|--|---|
| 1   | Al Enizi et al. (2016) | <p><i>Country/region:</i> Saudia Arabia (Al-Quassim)</p> <p><i>Year:</i> 2015</p> <p><i>Design:</i> Questionnaire survey</p> <p><i>Aims:</i> Determine the current level of knowledge, CPR-skills and secondary school teachers' willingness to participate in regular CPR training.</p> <p><i>School:</i> Secondary</p> <p><i>N:</i> 305 teachers</p> | <ul style="list-style-type: none"> <li>▪ Level of knowledge (10 questions) was low (Mean=4.02; SD=1.65) with no significant differences between participants with previous CPR training and those with no training.</li> <li>▪ Overall, teachers wanted more training (64.9%) and were willing to take a free course (78.4%).</li> <li>▪ 54.1% stated that CPR training should be mandatory for teachers' certification and 37.4% supported mandatory CPR training at schools.</li> </ul> |

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| 2 | Bakke et al. (2017)  | <p><i>Country/region:</i> Norway<br/> <i>Year:</i> 2016<br/> <i>Design:</i> Online questionnaire<br/> <i>Aims:</i> Investigate the duration and content of first aid measures provided by Physical Education teachers and vocational subject teachers. Secondly, reasons for reduced quantity and quality in first aid training were analysed.<br/> <i>school:</i> Primary and secondary<br/> <i>N:</i> 579 teachers</p> | <ul style="list-style-type: none"> <li>▪ Per year (asked for preceding year) teachers gave 2.7 lessons first aid training on average (median: 2; range 2-11), but more often when specified in the curriculum (<math>p &lt; 0.01</math>; 3.0 vs. 2.3 lessons).</li> <li>▪ 64% taught how to decide for starting CPR and how to perform CPR.</li> <li>▪ The four most important reasons for restricted quantity and quality of first aid training were: many other competence aims in the curriculum, insufficient specifications of first aid content, no mannequins available and missing first aid instructor training.</li> </ul> |
| 3 | Brown et al. (2017)  | <p><i>Country/region:</i> United States of America<br/> <i>Year:</i> 2016<br/> <i>Design:</i> Online closed survey<br/> <i>Aims:</i> Examine and categorize CPR legislation in 39 states of the United States.<br/> <i>School:</i> High schools<br/> <i>N:</i> 434 high schools</p>  | <ul style="list-style-type: none"> <li>▪ Even if surveyed schools were located in states with required CPR training at schools, only 77% of the responding schools provided CPR training.</li> <li>▪ CPR training was provided during regular school hours (97%) and in different levels. During school hours 70% of schools used health class, 11% P.E. for CPR training, which was commonly instructed by a certified teacher (47%) or professional (30%), but also by uncertified teachers in 11%.</li> <li>▪ 3% of the schools taught CPR only on a theoretical basis and 63% integrated AED use into training.</li> </ul>       |
| 4 | Felzen et al. (2018) | <p><i>Country/region:</i> Germany (City of Aachen)<br/> <i>Year:</i> 2017<br/> <i>Design:</i> Questionnaire survey<br/> <i>Aims:</i> Evaluate a 45 min basic BLS training as an option to motivate schools to establish their own short CPR program.<br/> <i>school:</i> Secondary schools<br/> <i>N:</i> 3649 students before, 3294 students afterwards; 79 teachers</p>  | <ul style="list-style-type: none"> <li>▪ 93.8% of the students in the survey preferred a physician as CPR instructor.</li> <li>▪ Biology or P.E. class was chosen to be the most suitable setting for CPR training by 60% (<math>n=47</math>) of the surveyed teachers.</li> <li>▪ Most teachers (81%) were willing to offer such CPR trainings to their students and participate in an own CPR training in their off-time.</li> <li>▪ On average, teachers felt 'more confident' (mean=3.85; SD: 1.2) to be CPR instructor for their classes.</li> </ul>  |
| 5 | Hart et al. (2013)   | <p><i>Country/region:</i> Canada (Toronto)<br/> <i>Year:</i> 2009<br/> <i>Design:</i> Telephone interviews with prespecified web-tool for standardization.<br/> <i>Aims:</i> Determine the rates of CPR/AED training, techniques and barriers to training<br/> <i>School:</i> Secondary<br/> <i>N:</i> 223 school representatives</p>  | <ul style="list-style-type: none"> <li>▪ 51% of the surveyed schools trained their students in CPR and 6% in AED use, whereas most trained staff in CPR (80%) and AED use (47%) (note: CPR is a compulsory part of the Toronto school curriculum).</li> <li>▪ Rates are higher in public than in catholic or independent schools.</li> <li>▪ Major barriers to student CPR training were cost (17%) and no perceived need (11%).</li> </ul>  |

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| 6 | Hoyme et al. (2017)    | <p><i>Country/region:</i> United States of America (Iowa)<br/> <i>Year:</i> 2015<br/> <i>Design:</i> Cross-sectional multiple-choice online survey<br/> <i>Aims:</i> Understand perceived barriers to providing CPR, implementation processes and practices in high schools.<br/> <i>School:</i> High schools<br/> <i>N:</i> 84 schools</p>  | <ul style="list-style-type: none"> <li>▪ When Iowa's unfunded CPR mandate (graduation requirement) took effect in 2011, 51% of surveyed schools had CPR programs in place, at the study's time point 96% finished implementation.</li> <li>▪ Important barriers were staffing (to schedule CPR instructors), time commitment and the available equipment as well as cost in descending priority.</li> <li>▪ 81% of participating schools set in school employees or volunteers as facilitators, but 19% had paid professionals as instructors.</li> <li>▪ 98% of schools had an AED available, but only 68% included its use into student training.</li> <li>▪ Estimated average costs were 1000 \$ for the start up and 500 \$ annual maintenance costs, which were taken from school district budgets in 67%.</li> </ul>   |
| 7 | Iserbyt at al. (2017)  | <p><i>Country/region:</i> Belgium (Flanders)<br/> <i>Year:</i> Not given.<br/> <i>Design:</i> Cluster randomized controlled trial<br/> <i>Aims:</i> Investigate the effect of a specialized content workshop (CPR learning and practice teaching CPR) on teaching behaviour, lesson context, and student learning (vs. common content workshop with learning CPR only).<br/> <i>School:</i> Primary<br/> <i>N:</i> 10 teachers, 203 students</p> | <ul style="list-style-type: none"> <li>▪ CPR assessment of teachers after specialised and common content workshop showed no differences (<math>p=0.41</math>).</li> <li>▪ On average, teachers who participated in a specialised content workshop gave more feedback and more instructions, whereas common content workshop teachers perform more demonstrations.</li> <li>▪ Specialised content workshop teachers spent more time on practical exercises (56% vs. 30%) and less on theoretical knowledge (29% vs. 56%).</li> <li>▪ Primary students taught by specialised content workshop teachers demonstrated higher BLS performance (62% vs. 57%; <math>p = 0.04</math>, <math>\eta_p^2 = 0.02</math>).</li> </ul>  |
| 8 | Lafferty et al. (2003) | <p><i>Country/region:</i> New Zealand<br/> <i>Year:</i> 2001<br/> <i>Design:</i> Questionnaire survey<br/> <i>Aims:</i> Evaluate the frequency and factors influencing CPR teaching as an optional curriculum component.<br/> <i>School:</i> Primary (5-12y) and secondary (12-18y)<br/> <i>N:</i> Primary: 754; secondary: 1173 (by health coordinator statement)</p>   | <ul style="list-style-type: none"> <li>▪ Of primary and secondary schools, 37.5% and 81%, respectively, taught resuscitation skills.</li> <li>▪ Secondary schools most often chose year 12 (corr. 17y) for CPR training but offers were optional and reached only 10-30% of students (since CPR training depends on school's discretion in New Zealand and is only <i>suggested</i> in the curriculum since 1999).</li> <li>▪ CPR teaching positively correlated with school size (<math>p&lt;0.001</math>).</li> <li>▪ Notable general barriers were time restrictions (overfull curriculum) and funding problems for instructors, teacher training and material. That CPR training is not mandatory and not suitable for age groups was more important for primary than secondary schools (<math>p=0.01</math> and <math>0.001</math>, respectively).</li> </ul> |

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| 9  | Lockey et al. (2016)       | <p><i>Country/region:</i> Great Britain (Calderdale area)</p> <p><i>Year:</i> Not given.</p> <p><i>Design:</i> Semi-structured interviews, qualitative analysis</p> <p><i>Aims:</i> Identify barriers to CPR training and develop strategies for improvement of delivery.</p> <p><i>School:</i> Secondary</p> <p><i>N:</i> 13 schools</p>   | <ul style="list-style-type: none"> <li>▪ Two out of 14 schools provided CPR training to the entire year group, all others targeted smaller groups in optional learning settings (e.g. sport award participants).</li> <li>▪ Most of the schools which delivered first aid training ignore CPR training, in the majority because no manikins are available.</li> <li>▪ Main barrier (9/13 schools) was a perceived lack of financial and teaching resources. For seven out of thirteen schools instructor training lacked and half felt uncomfortable with the topic CPR (6/13). Only two schools knew about external offers.</li> </ul>   |
| 10 | Magid et al. (2018)        | <p><i>Country/region:</i> United States of America</p> <p><i>Year:</i> 2014-2015</p> <p><i>Design:</i> Electronic feedback assessment with closed-ended questions</p> <p><i>Aims:</i> Examine the feasibility of teaching middle-school students CPR using the train-the-trainer/teacher method and AHA training kits and resources/materials.</p> <p><i>School:</i> Secondary (in low income regions)</p> <p><i>N:</i> 1131 schools (N of teachers sent feedback is not given)</p> | <ul style="list-style-type: none"> <li>▪ Facilitating teachers, who were willing to serve as CPR instructors, reported a first aid course within the last five years, 18% previous experience.</li> <li>▪ The implementation of the CPR program was easy (99%) and interest in a repetition within two years stated 98% of the facilitators.</li> <li>▪ As a recommendation, the surveyed instructors suggest additional equipment to train more students in a class period and increase learning effects (e.g. more manikins and AED).</li> </ul>  |
| 11 | Malta Hansen et al. (2017) | <p><i>Country/region:</i> Denmark</p> <p><i>Year:</i> 2013</p> <p><i>Design:</i> Cross-sectional electronic questionnaire survey</p> <p><i>Aims:</i> Assessing CPR training and implementation in schools 8 years following legislation.</p> <p><i>School:</i> Secondary</p> <p><i>N:</i> School leadership: 240; teachers (9<sup>th</sup> grade): 1381</p>   | <ul style="list-style-type: none"> <li>▪ Only 28.4% of teachers reported a completion of the CPR training despite legislation in the school curriculum.</li> <li>▪ 13.1% of teachers and 28.7% of leaderships reported CPR training was not mandatory for graduation; however mandatory CPR training was supported by the majority of both (82.7% and 79%).</li> <li>▪ Only 13.1% of surveyed teachers rated their competency to train students in CPR as sufficient and 60% of schools had no or few competent staff members.</li> <li>▪ Completed CPR training was associated positively (logistic regression analysis, decreasing effect size) with believing that other schools provide CPR training, the awareness of a compulsory CPR curriculum, having a school CPR coordinator, feeling competent to teach CPR and having access to CPR teaching materials.</li> </ul> |

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| 12 | McCluskey et al. (2010) | <p><i>Country/region:</i> United Kingdom (Northern Ireland)</p> <p><i>Year:</i> 2010</p> <p><i>Design:</i> Questionnaire survey</p> <p><i>Aims:</i> Obtain the opinions of principals in secondary education regarding CPR in schools</p> <p><i>School:</i> Secondary</p> <p><i>N:</i> 169 principals</p>  | <ul style="list-style-type: none"> <li>▪ 99% of headteachers in the survey were convinced that pupils would benefit from the CPR training and 96% were willing to teach CPR in their school in the future.</li> <li>▪ 83% stated CPR training should be part of the curriculum.</li> <li>▪ Heterogeneous opinions on who should provide the training as instructor were given; only 55% believe that their colleagues are willing to teach CPR to pupils, 24% do not know and 21% prefer other instructors, e.g. healthcare workers.</li> </ul>  |
| 13 | Miró et. al (2006)      | <p><i>Country/region:</i> Spain (Barcelona)</p> <p><i>Year:</i> 2003-2004</p> <p><i>Design:</i> Questionnaire survey (per email)</p> <p><i>Aims:</i> Determine the opinion of head teachers on educational or logistical factors concerning a basic CPR program</p> <p><i>School:</i> secondary (students' age: 12-16y)</p> <p><i>N:</i> 100 headteachers</p>  | <ul style="list-style-type: none"> <li>▪ 82% of headteachers considered a basic CPR programme in their school as highly useful</li> <li>▪ Interested head teachers expected more support from school staff and parents than non-interested headteachers. (<math>p &lt; 0.001</math>).</li> <li>▪ Theoretical and practical training should rather take place in schools (than in hospitals), in grades 3 or 4 with a duration of less than 5 hours.</li> <li>▪ Healthcare workers and medical staff was preferred as instructors for practical and theoretical teaching (97% and 78%), but headteachers assume that teachers are willing to teach theoretical CPR lessons (69%) if trained beforehand.</li> <li>▪ Implementation problems were program costs (60%), the inability to train teachers (32%) and missing time for CPR training (31%; uninterested teachers: 50%).</li> </ul>                                      |
| 14 | Mpotos et al. (2013)    | <p><i>Country/region:</i> Belgium (Flanders)</p> <p><i>Year:</i> 2012</p> <p><i>Design:</i> Questionnaire survey</p> <p><i>Aims:</i> Examine teacher's CPR knowledge, preparedness to perform, and teach CPR and attitude towards self-learning strategies.</p> <p><i>School:</i> Primary, secondary and higher education</p> <p><i>N:</i> 4273 teacher<br/>primary school: 856;<br/>secondary school: 2562;<br/>higher education: 855</p> | <ul style="list-style-type: none"> <li>▪ 69% of primary and 56% of secondary school teachers received former CPR training, with 75% finished it more than two years ago and the highest proportion of teachers with training was 21-30y old.</li> <li>▪ 73% of the teachers liked to receive more training.</li> <li>▪ Only 41% of the teachers thought CPR should be mandatory in the school and 36% were aware that CPR education is mandatory in the secondary school curriculum in Flanders since 2003.</li> <li>▪ Of all teachers, 34% felt competent to provide CPR themselves, with a higher uncertainty if they had no previous CPR training (<math>p &lt; 0.01</math>).</li> <li>▪ 61% of the surveyed teachers did not feel capable to teach CPR to students (main reason: lack of knowledge, 50%); this group had an advanced age (<math>&gt; 21y</math>), no previous training and lower self-efficacy.</li> </ul> |

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| 15 | Patsaki et al. (2012)     | <p><i>Country/region:</i> Greece (Athens)</p> <p><i>Year:</i> 2009</p> <p><i>Design:</i> Questionnaire survey</p> <p><i>Aims:</i> Evaluate theoretical knowledge of high school teachers regarding cardiopulmonary resuscitation, i.a.</p> <p><i>School:</i> Secondary</p> <p><i>N:</i> 310</p>  | <ul style="list-style-type: none"> <li>▪ Of the responding teachers, only 21% participated in a BLS/AED course before.</li> <li>▪ Overall theoretical knowledge on CPR and associated skills were only mediocre, with a positive correlation to prior BLS course participation (recognition of cardiac arrest and checking unresponsiveness, <math>p=0.013</math> and <math>0.043</math>, respectively).</li> <li>▪ 40% did not participate in a BLS course because of insufficient free time, 27.8% had no information on course time and place. However, 4.1% considered the courses to be not essential for their daily work.</li> <li>▪ 93% preferred nurses as CPR instructors for teachers and school students.</li> </ul>   |
| 16 | Reder et al. (2003)       | <p><i>Country/region:</i> United States of America (Washington State)</p> <p><i>Year:</i> 1999</p> <p><i>Design:</i> Mail and telephone questionnaire survey</p> <p><i>Aims:</i> Determine the best approaches for increasing CPR in schools by surveying provided CPR training, barriers and strategies.</p> <p><i>School:</i> Secondary</p> <p><i>N:</i> 276 schools</p> | <ul style="list-style-type: none"> <li>▪ 35% of high schools reported the provision of CPR training and 70% of the schools stated that they have one or less CPR trained teacher (<math>n=211</math>).</li> <li>▪ The preferred setting for CPR training was at school in general (68%) or in health class (12.5%; <math>n=152</math>) and the linking of CPR education to existing school goals, e.g. health education, employment preparation) was extremely important for 70% of respondents (<math>n=159</math>).</li> <li>▪ Major barriers were the time to teach more curriculum (24%), funding (16%) and non-available instructor training/scheduling (17%) (<math>n=148</math>).</li> <li>▪ Major conditions for more encouragement to CPR training were funding (24%), requirement or credit of CPR training (17%), more time (14%) and more certified instructors (10%) (<math>n=146</math>).</li> </ul> |
| 17 | Salciccioli et al. (2017) | <p><i>Country/region:</i> Great Britain (London)</p> <p><i>Year:</i> 2014</p> <p><i>Design:</i> Telephone interviews with standardized data recording</p> <p><i>Aims:</i> Assess current practices of BLS training in London secondary schools.</p> <p><i>School:</i> Secondary</p> <p><i>N:</i> 65 schools</p>  | <ul style="list-style-type: none"> <li>▪ Of all schools responding, 8% provided universal BLS training programs and 48% only extracurricular training or training in chosen modules (optional – since BLS training for students is not part of the educational curriculum in the UK).</li> <li>▪ Reasons for no BLS education were the requirement of additional class time (28%) and unavailable funding (28%).</li> <li>▪ BLS education was commonly provided from specialist First Aid and CPR educators from outside the responding schools (15%).</li> </ul>  |

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| 18 | Salvatierra et al. (2017)  | <p><i>Country/region:</i> United States of America (Washington State)<br/> <i>Year:</i> 2015<br/> <i>Design:</i> Web-based questionnaire survey<br/> <i>Aims:</i> Describe CPR/AED rates and perceived barriers in schools after passage of legislation mandating CPR/AED training<br/> <i>School:</i> secondary<br/> <i>N:</i> 148 schools</p>  | <ul style="list-style-type: none"> <li>▪ Of all responding schools, 64% trained their students in CPR, with a higher rate in public than in private schools (70% vs. 17%).</li> <li>▪ Predominant training methods were didactic speakers and Power Point presentations (75.7%).</li> <li>▪ Schools which provided CPR training, stated that the availability of CPR instructors, the costs and the necessary equipment were main barriers for implementation.</li> <li>▪ Schools without CPR training most commonly reported that equipment and resources, access to trainers, funding and available class time prevented their implementation.</li> </ul>   |
| 19 | Smedt, de et al. (2018)    | <p><i>Country/region:</i> Belgium (Flanders)<br/> <i>Year:</i> 2015<br/> <i>Design:</i> Online questionnaire survey<br/> <i>Aims:</i> Question schoolchildren, teachers and principals about the awareness of CPR and the willingness to perform or teach bystander CPR.<br/> <i>School:</i> Primary (n=2424); secondary (n=945)<br/> <i>N:</i> 390 students; 439 teachers; 100 principals</p> | <ul style="list-style-type: none"> <li>▪ 35% of the participating teachers and only 5% of the principals were willing to teach CPR and 10% and 52%, respectively, denied teaching CPR themselves. However, only 28% of the teachers feel not capable to explain AED use and over 60% of both teachers and principals were convinced that they are able to perform CPR adequately.</li> <li>▪ Reasons for an implementation to fail were a lack of knowledge (77% and 83%, respectively, for teachers and principals), not enough time (13% and 22%) and a lack of resources (17% and 36%).</li> <li>▪ Digital self-learning alternatives were supported by 70% of the participating teachers.</li> <li>▪ Of the principals, 88% were convinced that schoolchildren should learn CPR and were on average willing to spend three hours of time for CPR education.</li> </ul>  |
| 20 | Zinckernagel et al. (2016) | <p><i>Country/region:</i> Denmark<br/> <i>Year:</i> 2012/2013<br/> <i>Design:</i> qualitative analysis of interviews<br/> <i>Aims:</i> Explore barriers to implementation of CPR training because despite legislation low rates of implementation were observed.<br/> <i>School:</i> Secondary (12-16y)<br/> <i>N:</i> 16 teachers; 9 headmasters (schools n = 8)</p>                          | <p>Three main themes of concerns were identified within the interviews.</p> <ul style="list-style-type: none"> <li>▪ <u>Insecurity about instruction skills:</u> Although teachers considered the implementation of CPR student training important, they expressed their current incapability to teach CPR. A CPR course would not necessarily enable teachers to teach this “matter of life and death” (p. 4). Teaching CPR skills to students requires extraordinary (medical) knowledge. Specialized CPR courses of a certain length were therefore considered for teacher training.</li> <li>▪ <u>Insecurity about CPR performance skills:</u> Teachers and principals expressed the general feeling of a moral obligation to help in cardiac arrest but also a lack of confidence in CPR performance. Main concerns were CPR algorithm changes during lifetime and the decline of CPR skills after visiting a course. The own perceived requirements regarding CPR performance were transferred to their opinion on</li> </ul> |

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|  |  |  | <p>student CPR education.</p> <ul style="list-style-type: none"> <li>▪ <b>Organisation of CPR training:</b> Although teachers and principals believed they have greater pedagogical skills, the majority preferred professional instructors. For the organisation in schools a CPR coordinator should be established as well as self-instruction media in order to reduce the teacher's responsibility during training.</li> </ul> |
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#### 4. Discussions

This review has identified the teachers' perceived competency and the acceptance of and belief in CPR education in schools as individual barriers. Specialized training programs for teachers, appropriate funding, and available class time are common organizational key factors to promote an implementation.

##### ***4.1 Challenge A: Teachers' competency and willingness***

The willingness to teach CPR training and to feel competent enough to teach it is moderate or low (Malta Hansen et al., 2017; McCluskey et al., 2010; Mpotos et al., 2013). A Swedish dissertation published in 2017 by Nord supports the evidence: one third of the teachers interviewed believed that they were not confident enough to answer students' questions and 70% judged their competency as only moderate (Nord, 2017).

Considering the results of Zinckernagel et al. (2016) and the lack of medical content (e.g. about first aid) in teachers' professional training (as it is in Germany), an explicit definition of competency requirements may contribute to making CPR education more achievable and transparent for schools. This consistency would further minimize the potential stress perceived by involved teachers. Information flow from initiators and supervisory boards to every school is an important factor during the initiation phase of innovation processes in general, in order to reduce the tension between the level of conception and application (Altrichter & Wiesinger, 2004; Fullan, 1994).

##### ***4.2 Challenge B: Concepts for further instructor training***

If teachers are deployed as facilitators for CPR education, a commonly available and easily accessible training for teachers is necessary; in parts of Germany and other European countries reliable training concepts are however missing. Improvements in conception and availability of these trainings would very likely lead to a greater acceptance and to teachers feeling more comfortable with teaching CPR (Nord, 2017). Specialized teacher qualification programs with

consistent duration, appropriate methodology, and transparent competence objectives could improve the knowledge transfer into school classes. However, evidence is limited regarding this topic. Iserbyt et al. (2017) advocate that interactive interdisciplinary trainings for teachers may be promising: a combination of medical knowledge input, hands-on exercises, and units of didactic reflection and practice. They stated that “knowing how to perform BLS is not the same as knowing how to teach BLS” (Iserbyt et al., 2017). This format has to be tested and evaluated in further studies. Similar concepts, combining information transfer, training and coaching, were reported to be successful in general educational research literature (Holtappels, 2013).

A “train the trainer” concept was established by the AHA. It provides self-instruction kits and teaching material to interested school teachers which may also be beneficial for implementation. The use of approved materials and instruction videos reduces the teachers’ own responsibility to give life-saving, health-related advice, thus it will increase their willingness and reduce their concerns on competency (Magid et al., 2018).

#### ***4.3 Challenge C: The connection with other school subjects and training of pre-service teachers***

A connection with learning objectives of other subjects is favoured or accompanies the implementation in schools (Felzen et al., 2018; Reder & Quan, 2003). In the US, CPR trainings are most often part of “health classes” (Brown et al., 2017). Provided that in Germany no health classes are offered, CPR could be integrated into subjects like Biology and Physical Education and build on topics of an existing curriculum, thus contextualizing high school students’ knowledge. Moreover, CPR contents can add on established health prevention programs (e.g. cardiovascular diseases, fitness or drug abuse).

Another step forward is integrating BLS knowledge and competencies in university programs, specifically to enhance the proficiency of teacher students (Breckwoldt & Kreimeier, 2013). However, research concerning the subject discipline and schedule for when CPR training could be integrated is rarely found. Most likely would be an integration in Biology or Sport Science Didactics departments, alongside with a cooperation of the Medical department if available. Jorge-Soto et al. recently conducted a simulation trial testing practical skills, knowledge and attitudes with university students in “Educational Science and Sports”. Participants improved their CPR skills, 78.6% supported mandatory first aid training during academic studies, and 76.5% were willing to transfer CPR to schoolchildren (Jorge-Soto et al., 2018). Nonetheless, similar pilot programs will be needed to generate suggestions for future long-term CPR training

of teacher students at universities. Until (all) teacher students are regularly trained in first aid or CPR at universities, other solutions with healthcare professionals and local engagement or e-learning modules must bridge the gap.

#### ***4.4 Challenge D: Resources and funding***

Next to further organizational barriers, funding was reported as a key factor. CPR training conducted by school teachers reduces per-year personnel costs as external organizations do not have to be paid for courses. However, costs for teacher trainings and materials are incurred initially and periodically. Realistic materials (e.g. manikins) for exercises are expensive and can only partly be funded by schools, depending on the number of students. As alternative, the funding by local partners (e.g. universities, EMS-systems) or organizations (e.g. AHA, Red Cross) was useful in the past (Hoyme & Atkins, 2017; Magid et al., 2018). On the other hand, regional solutions will be very different depending on whether regional partners are located nearby or sufficient instructors actually are available in one area after all (Salvatierra et al., 2017). Thus, funding programs by the government are necessary to comprehensively and equivalently support all schools to educate their students in CPR.

#### ***4.5 Challenge F: Legal obligation of in-school CPR trainings***

Based on screened literature, CPR training often showed moderate implementation results when it was initiated following legal obligation acts, such as in Belgium or Denmark (Malta Hansen et al., 2017; Mpotos et al., 2013), although Denmark was able to double its bystander CPR-rate after the legal obligation act in 2005 (in addition to many other changes to improve the entire chain of survival) (Wissenberg et al., 2013). This suggests that besides law enactment, (unexplored) state-specific and local variables of school systems still have an even more meaningful influence on schools' decisions for implementation (Brown et al., 2017). Hence, diverse conditions affect the implementation process in schools, such as the staff's perception of necessity and feasibility, external support or the compatibility with other curricular duties (Brown et al., 2017; Hoyme & Atkins, 2017; Lockey et al., 2016; Miró et al., 2006; Salvatierra et al., 2017). However, they are, according to educational research, *all* closely linked to school development (Fullan, 1994). If one factor is limited, it is likely that the whole process is inhibited. Moreover, an obligation targets to enforce the implementation by external enactment (applying a top-down-strategy), but this does not guarantee a successful realization in schools and is often seen as failure-prone and exhausting (Gräsel & Parchmann, 2004). Thus, alternatives would be the combination of a standardized action plan for schools with information about CPR, programs for special teacher

trainings, definitions of first aid teaching content and recommended equipment (Brown et al., 2017). It is the responsibility of researchers, authorities and schools to explore these options in practice and systematically introduce them in schools, e.g. by a national online network or apps for teachers to sign in and stay informed.

In conclusion, an educational policy decision to introduce mandatory CPR teaching might increase the attention of school staff but must be established in line with precise support. Legislation can ideally boost and justify public financial resources, but resuscitation initiatives and education authorities accountable for these measures must ensure more carefully that schools receive information and support.

## **5. Limitations**

The studies analysed in this review are based on diverse educational system structures and conditions framed by national educational policies, alongside varying regional and national CPR training initiatives. It is important to bear in mind that the studies may be compared with caution. However, some common factors can be found across countries and school systems despite these differences; thus, a general validity can be assumed.

Selection bias may be caused by incomplete retrieval of all relevant publications, but the variety of keywords was chosen to avoid this bias. Additionally, reporting bias may be relevant for the presentation of studies included. Since relevant evidence was selected due to review questions, not all data in every possible context of CPR implementation and training at schools was provided, e.g. for the effect of teachers vs. professional instructors or training outcomes and limitations of high school students, see previous works (Lukas et al., 2016; Plant & Taylor, 2013; Schroeder et al., 2017).

## **6. Conclusions**

A consistent implementation of CPR education in schools has recently been initiated in many Western countries, for example, in Germany. This paper reviews novel evidence focussing on the implementation procedure. Across countries, certain barriers could be identified; in general, there is often little to no funding and limited class time. Based on the condition that teachers act as instructors, they feel incapable to some extent, which alludes to insufficient teacher training.

Legislation to enact CPR training in schools would *facilitate* the implementation but is *not* sufficient when provided as the only support.

A mandatory action plan at the state or even national level should be authorized to regulate school children's learning and teachers' qualification: transparent guidelines for teacher training contents and approved teaching materials can substantially support the engagement of headmasters and teachers. As a recommendation, medics, educationalists and teachers should develop biological, medical and health-related class content within improvable cooperation.

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R. Dumcke, C. Wegner L. Kucknat and N. Rahe-Meyer declare no conflicts of interest.

Bernd W. Böttiger is European Resuscitation Council (ERC) Board Director Science and Research; Associated Editor, European Journal of Anaesthesiology (EJA); Speakers honorarium from Medupdate, FoMF, Baxalta, Bayer Vital, Bard; Chairman, German Resuscitation Council (GRC); Board Member, German Society of Interdisciplinary Intensive Care and Emergency Medicine (DIVI); Associated Editor, Resuscitation.

### **References**

- Al Enizi, B. A., Saquib, N., Zaghoul, M. S. A., Alaboud, M. S. A., Shahid, M. S., & Saquib, J. (2016). Knowledge and Attitudes about Basic Life Support among Secondary School Teachers in Al-Qassim, Saudi Arabia. *International Journal of Health Sciences*, 10(3), 415–422.
- Altrichter, H., & Wiesinger, S. (2004). Der Beitrag der Innovationsforschung im Bildungswesen zum Implementierungsproblem. In H. Mandl & G. Reinmann-Rothmeier (Eds.), *Psychologie des Wissensmanagements: Perspektiven, Theorien und Methoden* (pp. 220–233). Göttingen [u.a.]: Hogrefe.

- R. Dumcke, C. Wegner, B. W. Böttiger, L. Kucknat, N. Rahe-Meyer/ *Journal of Innovation in Psychology, Education and Didactics*
- Atwood, C., Eisenberg, M. S., Herlitz, J., & Rea, T. D. (2005). Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. *Resuscitation*, 67(1), 75–80. <https://doi.org/10.1016/j.resuscitation.2005.03.021>.
- Bakke, H. K., & Schwebs, R. (2017). First-aid training in school: Amount, content and hindrances. *Acta Anaesthesiologica Scandinavica*, 61(10), 1361–1370. <https://doi.org/10.1111/aas.12958>.
- Benjamin, E. J., Virani, S. S., Callaway, C. W., Chamberlain, A. M., Chang, A. R., Cheng, S., et al. (2018). Heart Disease and Stroke Statistics—2018 Update: A Report From the American Heart Association. *Circulation*, 137(12), e67. <https://doi.org/10.1161/CIR.0000000000000558>.
- Berdowski, J., Berg, R. A., Tijssen, J. G. P., & Koster, R. W. (2010). Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. *Resuscitation*, 81(11), 1479–1487. <https://doi.org/10.1016/j.resuscitation.2010.08.006>.
- Bohn, A., Lukas, R. P., Breckwoldt, J., Böttiger, B. W., & van Aken, H. (2015). 'kids save lives': Why schoolchildren should train in cardiopulmonary resuscitation. *Current Opinion in Critical Care*, 21(3), 220–225. <https://doi.org/10.1097/MCC.0000000000000204>.
- Bohn, A., van Aken, H. K., Möllhoff, T., Wienzek, H., Kimmeyer, P., Wild, E., . . . Weber, T. P. (2012). Teaching resuscitation in schools: Annual tuition by trained teachers is effective starting at age 10. A four-year prospective cohort study. *Resuscitation*, 83(5), 619–625. <https://doi.org/10.1016/j.resuscitation.2012.01.020>.
- Böttiger, B. W., Bossaert, L. L., Castrén, M., Cimpoesu, D., Georgiou, M., Greif, R., . . . Wingen, S. (2016). Kids Save Lives - ERC position statement on school children education in CPR: "Hands that help - Training children is training for life". *Resuscitation*, 105, A1-3. <https://doi.org/10.1016/j.resuscitation.2016.06.005>.
- Böttiger, B. W., Semeraro, F., & Wingen, S. (2017). "Kids Save Lives": Educating Schoolchildren in Cardiopulmonary Resuscitation Is a Civic Duty That Needs Support for Implementation. *Journal of the American Heart Association*, 6(3), e005738. <https://doi.org/10.1161/JAHA.117.005738>.
- Böttiger, B. W., & van Aken, H. (2015). Kids save lives -Training school children in cardiopulmonary resuscitation worldwide is now endorsed by the World Health Organization (WHO). *Resuscitation*, 94, A5-7. <https://doi.org/10.1016/j.resuscitation.2015.07.005>.
- Breckwoldt, J., & Kreimeier, U. (2013). Ausbildung von Schülern zu Ersthelfern bei der Reanimation. *Notfall + Rettungsmedizin*, 16(5), 356–360. <https://doi.org/10.1007/s10049-012-1669-3>.

- R. Dumcke, C. Wegner, B. W. Böttiger, L. Kucknat, N. Rahe-Meyer/ *Journal of Innovation in Psychology, Education and Didactics*
- Brown, L. E., Lynes, C., Carroll, T., & Halperin, H. (2017). CPR Instruction in U.S. High Schools: What Is the State in the Nation? *Journal of the American College of Cardiology*, 70(21), 2688–2695. <https://doi.org/10.1016/j.jacc.2017.09.1101>.
- Cave, D. M., Aufderheide, T. P., Beeson, J., Ellison, A., Gregory, A., Hazinski, M. F., . . . Schexnayder, S. M. (2011). Importance and implementation of training in cardiopulmonary resuscitation and automated external defibrillation in schools: A science advisory from the American Heart Association. *Circulation*, 123(6), 691–706. <https://doi.org/10.1161/CIR.0b013e31820b5328>.
- Cuijpers, P., Bookelman, G., Kicken, W., Vries, W., & Gorgels, A. P.M. (2016). Medical students and physical education students as CPR instructors: An appropriate solution to the CPR-instructor shortage in secondary schools? *Netherlands heart journal*, 24(7-8), 456–461. Retrieved from 10.1007/s12471-016-0838-2.
- Felzen, M., Lambrecht, L., Beckers, S. K., Biermann, H., Heussen, N., Rossaint, R., & Lenssen, N. (2018). Konzept und Evaluation eines 45- minütigen BLS-Trainings an Schulen. *Notfall + Rettungsmedizin*, 83(5), 619. <https://doi.org/10.1007/s10049-017-0404-5>.
- Fullan, M. G. (1994). Innovations, Implementation of (Art.). In T. Husén & T. N. Postlethwaite (Eds.), *The International Encyclopedia of Education* (2nd ed., Vol. 5, pp. 2839–2847). Oxford u.a.: Pergamon Press (Elsevier Science).
- German Resuscitation Council (2014). Ausbildungskonzept für einen Reanimationsunterricht innerhalb der Schul-Curricula in Deutschland: Veröffentlicht im Oktober 2012. Kommentierte Ausgabe November 2014. Retrieved from <https://www.grc-org.de/wissenschaft/grc-schulcurriculum>.
- Gräsel, C., & Parchmann, I. (2004). Implementationsforschung - oder: der steinige Weg, Unterricht zu verändern. *Unterrichtswissenschaft*, 32(3), 196–214. Retrieved from <http://www.pedocs.de/volltexte/2013/5813>; <http://nbn-resolving.de/urn:nbn:de:0111-opus-58134>.
- Gräsner, J.- T., Wnent, J., Seewald, S., Brenner, S., Jantzen, T., Fischer, M., . . . Bohn, A. (2017). Jahresbericht Außerklinische Reanimation 2016 des Deutschen Reanimationsregisters. *Anästhesiologie & Intensivmedizin*, 58, 365–366.
- Gräsner, J.- T., Lefering, R., Koster, R. W., Masterson, S., Böttiger, B. W., Herlitz, J., . . . Bossaert, L. L. (2016). Eureka ONE-27 Nations, ONE Europe, ONE Registry: A prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. *Resuscitation*, 105, 188–195. <https://doi.org/10.1016/j.resuscitation.2016.06.004>.
- Hart, D., Flores-Medrano, O., Brooks, S., Buick, J. E., & Morrison, L. J. (2013). Cardiopulmonary resuscitation and automatic external defibrillator training in schools: "is anyone learning how to save a life?". *CJEM*, 15(5), 270–278.

- R. Dumcke, C. Wegner, B. W. Böttiger, L. Kucknat, N. Rahe-Meyer/ *Journal of Innovation in Psychology, Education and Didactics*
- Hasselqvist-Ax, I., Riva, G., Herlitz, J., Rosenqvist, M., Hollenberg, J., Nordberg, P., . . . Svensson, L. (2015). Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. *The New England Journal of Medicine*, 372(24), 2307–2315. <https://doi.org/10.1056/NEJMoa1405796>
- Holmberg, M., Holmberg, S., & Herlitz, J. (2001). Factors modifying the effect of bystander cardiopulmonary resuscitation on survival in out-of-hospital cardiac arrest patients in Sweden. *European Heart Journal*, 22(6), 511–519.
- Holtappels, H. G. (2013). Innovation in Schulen - Theorieansätze und Forschungsbefunde zur Schulentwicklung. In M. Rürup & I. Bormann (Eds.), *Educational governance: Vol. 21. Innovationen im Bildungswesen: Analytische Zugänge und empirische Befunde* (pp. 45–69). Wiesbaden: Springer Fachmedien Wiesbaden.
- Hoyme, D. B., & Atkins, D. L. (2017). Implementing Cardiopulmonary Resuscitation Training Programs in High Schools: Iowa's Experience. *The Journal of Pediatrics*, 181, 172-176.e3. <https://doi.org/10.1016/j.jpeds.2016.10.037>.
- Iserbyt, P., Theys, L., Ward, P., & Charlier, N. (2017). The effect of a specialized content knowledge workshop on teaching and learning Basic Life Support in elementary school: A cluster randomized controlled trial. *Resuscitation*, 112, 17–21. <https://doi.org/10.1016/j.resuscitation.2016.11.023>.
- Jiménez-Fábrega, X., Escalada-Roig, X., Miró, O., Sanclemente, G., Díaz, N., Gómez, X., . . . Sánchez, M. (2009). Comparison between exclusively school teacher-based and mixed school teacher and healthcare provider-based programme on basic cardiopulmonary resuscitation for secondary schools. *Emergency Medicine Journal : EMJ*, 26(9), 648–652. <https://doi.org/10.1136/emj.2008.062992>.
- Jorge-Soto, C., Abilleira-González, M., Otero-Agra, M., Barcala-Furelos, R., Abelairas-Gómez, C., Szarpak, L., & Rodríguez-Núñez, A. (2018). Schoolteachers as candidates to be basic life support trainers: A simulation trial. *Cardiology Journal*. Advance online publication. <https://doi.org/10.5603/CJ.a2018.0073>.
- Lafferty, C., Larsen, P. D., & Galletly, D. (2003). Resuscitation teaching in New Zealand schools. *The New Zealand Medical Journal*, 116(1181), U582.
- Lindner, T. W., Søreide, E., Nilsen, O. B., Torunn, M. W., & Lossius, H. M. (2011). Good outcome in every fourth resuscitation attempt is achievable--an Utstein template report from the Stavanger region. *Resuscitation*, 82(12), 1508–1513. <https://doi.org/10.1016/j.resuscitation.2011.06.016>.
- Lockey, A. S., Barton, K., & Yoxall, H. (2016). Opportunities and barriers to cardiopulmonary resuscitation training in English secondary schools. *European Journal of Emergency Medicine : Official Journal of the European Society for Emergency Medicine*, 23(5), 381–385. <https://doi.org/10.1097/MEJ.0000000000000307>.

- R. Dumcke, C. Wegner, B. W. Böttiger, L. Kucknat, N. Rahe-Meyer/ *Journal of Innovation in Psychology, Education and Didactics*
- Lukas, R.- P. , van Aken, H., Molhoff, T., Weber, T., Rammert, M., Wild, E., & Bohn, A. (2016). Kids save lives: A six-year longitudinal study of schoolchildren learning cardiopulmonary resuscitation: Who should do the teaching and will the effects last? *Resuscitation*, *101*, 35–40. <https://doi.org/10.1016/j.resuscitation.2016.01.028>.
- Magid, K. H., Heard, D., & Sasson, C. (2018). Addressing Gaps in Cardiopulmonary Resuscitation Education: Training Middle School Students in Hands-Only Cardiopulmonary Resuscitation. *The Journal of School Health*, *88*(7), 524–530. <https://doi.org/10.1111/josh.12634>.
- Malta Hansen, C., Zinckernagel, L., Ersboll, A. K., Tjornhoj-Thomsen, T., Wissenberg, M., Lippert, F. K., . . . Folke, F. (2017). Cardiopulmonary Resuscitation Training in Schools Following 8 Years of Mandating Legislation in Denmark: A Nationwide Survey. *Journal of the American Heart Association*, *6*(3), e004128. <https://doi.org/10.1161/JAHA.116.004128>.
- McCluskey, D., Moore, P., Campbell, S., & Topping, A. (2010). Teaching CPR in secondary education: the opinions of head teachers in one region of the UK. *Resuscitation*, *81*, 1601(11), 1601. Retrieved from <https://www.livivo.de/doc/M20727654>.
- Miró, O., Jiménez-Fábrega, X., Espigol, G., Culla, A., Escalada-Roig, X., Díaz, N., . . . Sánchez, M. (2006). Teaching basic life support to 12-16 year olds in Barcelona schools: Views of head teachers. *Resuscitation*, *70*(1), 107–116. <https://doi.org/10.1016/j.resuscitation.2005.11.015>.
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, *6*(7), e1000097. <https://doi.org/10.1371/journal.pmed.1000097>.
- Mpotos, N., Vekeman, E., Monsieurs, K., Derese, A., & Valcke, M. (2013). Knowledge and willingness to teach cardiopulmonary resuscitation: A survey amongst 4273 teachers. *Resuscitation*, *84*(4), 496–500. <https://doi.org/10.1016/j.resuscitation.2013.01.023>.
- Nord, A. (2017). *Bystander CPR: New aspects of CPR training among students and the importance of bystander education level on survival*. Linköping: Linköping University Electronic Press.
- Patsaki, A., Pantazopoulos, I., Dontas, I., Passali, C., Papadimitriou, L., & Xanthos, T. (2012). Evaluation of Greek high school teachers' knowledge in basic life support, automated external defibrillation, and foreign body airway obstruction: Implications for nursing interventions. *Journal of Emergency Nursing: JEN : Official Publication of the Emergency Department Nurses Association*, *38*(2), 176–181. <https://doi.org/10.1016/j.jen.2010.09.002>.
- Perkins, G. D., Handley, A. J., Koster, R. W., Castrén, M., Smyth, M. A., Olasveengen, T., Soar, J. (2015). European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support

- R. Dumcke, C. Wegner, B. W. Böttiger, L. Kucknat, N. Rahe-Meyer/ *Journal of Innovation in Psychology, Education and Didactics*
- and automated external defibrillation. *Resuscitation*, 95, 81–99. <https://doi.org/10.1016/j.resuscitation.2015.07.015>
- Plant, N., & Taylor, K. (2013). How best to teach CPR to schoolchildren: A systematic review. *Resuscitation*, 84(4), 415–421. <https://doi.org/10.1016/j.resuscitation.2012.12.008>
- Reder, S., & Quan, L. (2003). Cardiopulmonary resuscitation training in Washington state public high schools. *Resuscitation*, 56(3), 283–288.
- Rücker, G. (2010). Wiederbelebungunterricht bei Schülern: Ab der siebten Klasse sinnvoll. *Dtsch Arztebl*, 107(11), A 492–3. Retrieved from <https://www.livivo.de/doc/C952307578>
- Salciccioli, J. D., Marshall, D. C., Sykes, M., Wood, A. D., Joppa, S. A., Sinha, M., & Lim, P. B. (2017). Basic life support education in secondary schools: A cross-sectional survey in London, UK. *BMJ Open*, 7(1), e011436. <https://doi.org/10.1136/bmjopen-2016-011436>
- Salvatierra, G. G., Palazzo, S. J., & Emery, A. (2017). High School CPR/AED Training in Washington State. *Public Health Nursing (Boston, Mass.)*, 34(3), 238–244. <https://doi.org/10.1111/phn.12293>
- Schroeder, D. C., Ecker, H., Wingen, S., Semeraro, F., & Böttiger, B. W. (2017). „Kids Save Lives“ – Wiederbelebungstrainings für Schulkinder: Systematische Übersichtsarbeit [“Kids Save Lives“-resuscitation training for schoolchildren: Systematic review]. *Der Anaesthetist*, 66(8), 589–597. <https://doi.org/10.1007/s00101-017-0319-z>
- Smedt, L. de, Depuydt, C., Vekeman, E., Paepe, P. de, Monsieurs, K. G., Valcke, M., & Mpotos, N. (2018). Awareness and willingness to perform CPR: A survey amongst Flemish schoolchildren, teachers and principals. *Acta Clinica Belgica*, 1–20. <https://doi.org/10.1080/17843286.2018.1482087>
- Statistisches Bundesamt (2017). Gesundheit: Todesursachen in Deutschland 2015. Retrieved from [https://www.destatis.de/DE/Publikationen/Thematisch/Gesundheit/Todesursachen/Todesursachen2120400157004.pdf?\\_\\_blob=publicationFile](https://www.destatis.de/DE/Publikationen/Thematisch/Gesundheit/Todesursachen/Todesursachen2120400157004.pdf?__blob=publicationFile)
- Trappe, H.- J. (2007). Plötzlicher Herztod. *Der Kardiologe*, 1(4), 261–271. <https://doi.org/10.1007/s12181-007-0030-4>
- Waldecker, B. (2003). Zur Epidemiologie des plötzlichen Herztodes. *Notfall + Rettungsmedizin*, 6(5), 313–317. <https://doi.org/10.1007/s10049-003-0577-y>
- Wissenberg, M., Lippert, F. K., Folke, F., Weeke, P., Hansen, C. M., Christensen, E. F., . . . Torp-Pedersen, C. (2013). Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. *JAMA*, 310(13), 1377–1384. <https://doi.org/10.1001/jama.2013.278483>

R. Dumcke, C. Wegner, B. W. Böttiger, L. Kucknat, N. Rahe-Meyer/ *Journal of Innovation in Psychology, Education and Didactics*

Zinckernagel, L., Malta Hansen, C., Rod, M. H., Folke, F., Torp-Pedersen, C., & Tjørnhøj-Thomsen, T. (2016). What are the barriers to implementation of cardiopulmonary resuscitation training in secondary schools? A qualitative study. *BMJ Open*, 6(4), e010481. <https://doi.org/10.1136/bmjopen-2015-010481>