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Review

Implementation of school-based CPR training – A systematic review and mixed-methods *meta*-analysis

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Abstract

Aim: Despite initiatives like "Kids Save Lives", CPR trainings are often poorly implemented, and bystander CPR rates remain low. This systematic review and mixed-methods *meta*-analysis of qualitative and quantitative studies aims to identify enablers and barriers to the implementation of school-based CPR training.

Methods: A systematic search was conducted across seven databases. Qualitative data were analyzed using thematic synthesis, and findings were evaluated with GRADE-CERQual. Quantitative data were synthesized through qualitative findings, providing deeper context using a convergent qualitative *meta*-integration approach.

Results: A total of 18 reports (7 qualitative and 11 quantitative) on school-based CPR training were included from an initial pool of 7914 records. Key enablers of successful school-based CPR training implementation were related either to program characteristics or to environmental factors, with both being equally important. Generally, programs are better implemented if they include high-quality resources, incur low costs in terms of funds, time and staffing, show adaptability to the setting in which they are implemented, and provide standardized training for teachers or implementers. Regarding environment factors, implementation is facilitated by broad support from school stakeholders (leadership, teachers, and parents) and is more successful where, supported by mandatory legislation and government endorsement, health is framed as a core business of schools.

Conclusion: The successful implementation of school-based CPR training depends on both program characteristics and environmental factors, operating together in a "seed and soil" manner. Addressing both aspects is essential for effective program planning. Future research should more broadly explore health outcomes beyond CPR-related measures and investigate how CPR training can be integrated into wider health-promoting school initiatives.

Keywords: CPR-training, School, Children, Kids, Implementation, Systematic Review, Qualitative

Introduction

Immediate bystander CPR is a critical factor in the survival and neurological outcome of individuals experiencing cardiac arrest. It is widely recognized as one of the most effective lifesaving interventions that can be initiated before emergency medical services arrive.[1–4] Despite its significance, rates of bystander CPR vary significantly on a global scale[5] and even within regions[6] or countries,[7] with some alarmingly low rates representing a major missed opportunity to save lives.[8] With this being mostly due to a lack of knowledge and skills as well as due to critical misconceptions,[7,9] education is key, and schools which provide access to large parts of the population[10] are a promising setting for CPR training. The potential of school-based programs has been emphasized by the WHO-supported "Kids Save Lives" initiative launched in 2009, which called for the integration of CPR training into school curricula.[11,12] Numerous approaches to teaching CPR in schools have been proposed, and a variety of training methods have been evaluated for their effectiveness.[13] However, despite these efforts, programs are seldom sustained, and bystander CPR rates remain suboptimal, even in countries where initiatives like Kids Save Lives have been

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popularized.[14] One potential explanation for this is the existence of a gap between the controlled environment of pilot programs being evaluated in studies on the one hand, and real-world implementation on the other, where logistical and structural challenges often hinder the sustained adoption of initiatives.[15–17] It is unclear why some programs are better implemented than others and what factors may influence this. Previous reviews have examined different designs and outcomes of school-based CPR training but did not evaluate stakeholder views or analyze sustainable ways to conduct such trainings on a wide scale.[13,18] This review aims to address this literature gap by identifying enablers and barriers to implementation as perceived by school staff, students, and other relevant stakeholders, and by integrating qualitative and quantitative data to offer guidance for future research and practice.

Methods

Design and search strategy

We conducted a systematic review of qualitative and quantitative research on the implementation of school-based CPR training. A protocol was published on PROSPERO before start of the review process (CRD42021250540). Dedicated ethical approval was not required for this work.

The following databases were initially searched on 26 April 2021 before being searched again for an update on 20 March 2024: MEDLINE (via Ovid), CINAHL (via EBSCO), SCI-EXPANDED, SSCI, A&HCI, CPI-SSH, and ESCI (via Web of Science), and CENTRAL.

No date or language restrictions were applied. In addition to the systematic searches, we hand-searched references of included studies and tracked citations. Authors of studies were contacted for additional information. The full search strategy can be found in Supplementary File 1.

Inclusion and exclusion criteria

We included studies containing qualitative or quantitative data on the barriers and facilitators to the implementation of school-based CPR training. School-based CPR training was defined as encompassing interventions related to CPR that were set within or had substantial elements based in schools, or for which schools were a main factor or distributor. Examples of included study types are process evaluations, quantitative indicators from surveys that were undertaken as part of an intervention, or qualitative studies. These data had to be provided by students, school staff or other persons involved with or affected by the participation in or delivery of school-based CPR training interventions. Studies only including data on non-school settings and from persons not involved with or affected by the participation in or delivery of school-based CPR training were excluded.

Data extraction

Retrieved records were imported into Zotero 5.0 and de-duplicated. Two reviewers independently screened titles and abstracts against the inclusion criteria. A 90% raw initial agreement was achieved, and discrepancies were discussed to reach consensus. For references not excluded on title and abstract, we retrieved and studied full texts, with 95% raw initial agreement and ultimate consensus following discussion between two reviewers. Any remaining conflict was resolved by including a third reviewer. Data were extracted by two reviewers independently on setting, intervention type, study design, sample size, and study aim, as well as any content or data points pertinent to the research question. Data extraction was done using two standardized forms in Microsoft Word.

Quality assessment and synthesis of findings

For qualitative study designs, the quality of all included studies was assessed by two reviewers independently using the Critical Appraisal Skills Programme (CASP) assessment tool for qualitative research.[19] No study was excluded based on poor quality but we considered quality in our reporting of review findings using GRADE-CERQual.[20]

For the analysis of qualitative data, we used thematic synthesis methodology adapted from Thomas and Harden.[21] Each report was studied in-depth and text passages pertinent to the research question were coded line by line. Participant statements quoted in research reports were treated as first-order data and analysis or interpretation by researchers as second-order data. Finally, these data were compared by the reviewers across studies to identify third order themes based on initial in-vivo and subsequent axial coding. Differences between reviewers' analyses were discussed with a third reviewer until consensus was reached. The third-order themes were treated as the review's findings. Confidence in each finding was assessed using the GRADE-CERQual approach, based on methodological limitations, relevance, coherence, and adequacy of data. The quality assessment previously performed using CASP contributed to the weighing of the "methodological limitations" category. CASP questions rated "no" or "unclear" resulted in a reduction of confidence. Medium or high confidence ratings were to be attributed when themes were corroborated by multiple studies of which at least one was of high quality (defined has having no significant concerns regarding study design, recruitment, data collection and analysis). The coherence between the themes and supporting first- and second-order quotes, as well as the final confidence ratings were double-checked by a third reviewer. The analytic approach and results were discussed among all authors.

For quantitative studies, quality was evaluated using the AXIS tool.[22] Confidence in findings from studies with significant quality concerns, generally those with an AXIS score below 15, was considered to be lower, analogous to considerations in the GRADE-CerQUAL approach. Formal *meta*-analysis was foregone due to the heterogeneity of study designs and instruments used. Instead, quantitative data and researchers' conclusions are summarized narratively in a convergent qualitative *meta*-integration approach.[23] In practice, convergence was achieved through the development of a data matrix that aligned key themes and findings from qualitative studies with the narrative summaries of quantitative results. This matrix facilitated systematic comparisons, allowing for cross-validation of evidence and integration of data into a coherent overall synthesis. Based on this, the review's main findings are presented in a combined table where GRADE-CERQual is applied to qualitative studies in the traditional manner and quantitative studies in a supplementary, convergent approach. In this approach, quantitative studies, summarized narratively, also contribute to the strength-of-evidence ratings.

This review follows the PRISMA[24] and ENTREQ[25] reporting guidelines.

Results

In total, 7912 records were retrieved (Fig. 1). Two additional reports were identified by searching references. After deduplication, 4131

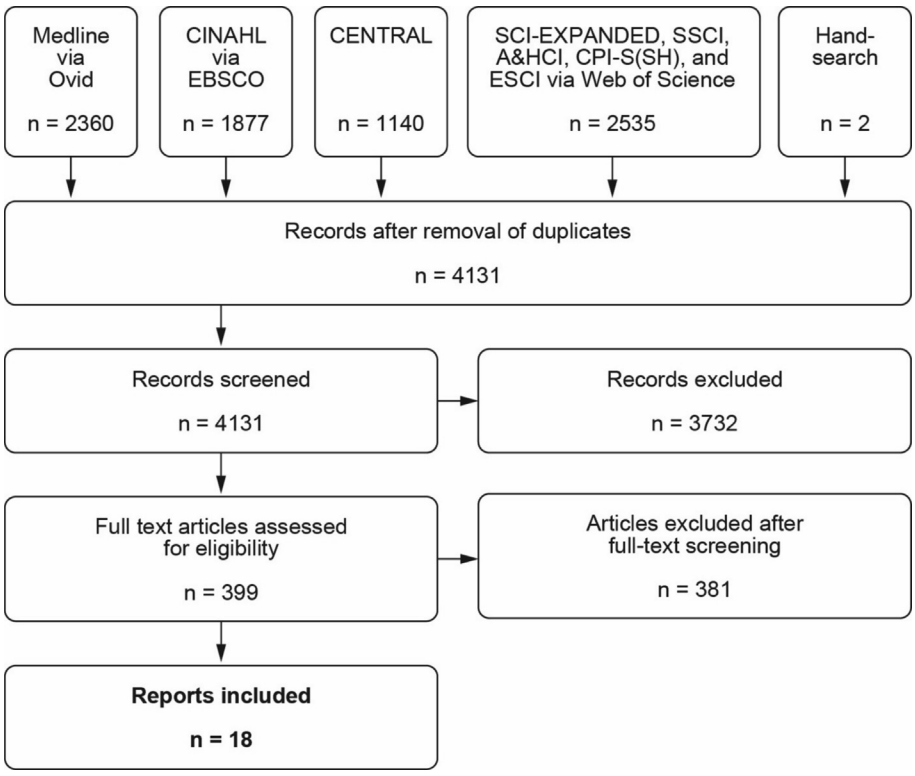

Fig. 1 – Study flowchart.

titles and abstracts were screened. In total, 399 reports remained for full-text screening. Eighteen reports (7 qualitative and 11 quantitative) were included in the systematic review.

Qualitative data and thematic synthesis

Qualitative data from 7 reports (on 5 separate studies) contributed to the thematic synthesis in this review. Of the included studies, one was set in England, two were set in Australia, two reports concerned one study conducted in Denmark and another two studies concerned a study done in Slovenia. Five studies were concerned with CPR training in high schools and two with elementary school-based training. Six reports included teachers' and training providers' perspectives, one included student perspectives and one was on recent high-school graduates. In one report, semi-structured interviews were used, three of them used focus group discussions, and three combined interviews and focus group discussions. An overview of the included studies along with their respective quality assessment ratings can be found in Table 1.

Included reports were mostly of good or acceptable quality. However, four reports lacked a detailed description of their recruitment strategy, and three studies had unclear or high risk of bias in three or more CASP categories (see Table 1). All studies contributed to the thematic analysis, but study quality was explicitly considered in the GRADE-CerQUAL ratings (Table 3).

Factors that affect the implementation of CPR training in schools are related to one of two broad aspects, the characteristics of the training or program on the one hand, and the environment that the program is implemented in on the other hand. A full list of synthesized concepts and studies they are derived from is presented in Supplementary Table 1 along with their GRADE-CERQual confidence rating.

Program characteristics

First, teachers and other persons involved in the delivery of CPR training in schools ask that programs be standardized and easy to deliver.[26,27]

As one teacher involved in delivering a program targeting 13- and 14-year-olds put it,

> *"Just the structure made it really easy to work through. It was self-explanatory, clear, it was easy for the students, it was easy for the teachers, and you know with the written components as well as the prac. The kids actually enjoyed doing it... Getting up and actually getting involved, and doing it, and practising, and you know role playing stuff was really good."*[27]

Similarly, providers have an easier time delivering interventions when group sizes are small, as summarized by one professional involved in the delivery of trainings in primary schools[26]:

> *"It is definitely easier and of higher quality if you have a small group. A maximum is 10 per workshop for me to say, that is quality teaching."*[26]

With regard to program aspects that are key enablers of implementation, the availability of high-quality resources and equipment is frequently emphasized[26–28]:

"If you don't have the equipment, it is absolutely ineffective.".[26]

In addition, teachers require state-of-the-art training enabling them to teach current guidelines.[26,28–30]

Table 1 – Characteristics of included qualitative studies and CASP quality rating. FGD, focus group discussion; SSI, semi-structured interview. For the Quality Appraisal: Y, yes; N, no; U, unclear. The order of criteria follows the order in the CASP tool (1. clear statement of aims, 2. appropriate qualitative methodology, 3. appropriate research design, 4. appropriate recruitment, 5. appropriate data collection, 6. reflexivity, 7. ethical considerations, 8. rigour of data analysis, 9. clarity of statement of findings, 10. value of research).

Intervention	Study	Sample	Design	Setting	Aims	Quality Appraisal (CASP)
CPR training in high schools	Andrews 2018[32]	28 recent high-school graduates aged 18–21	SSI	Australia	To obtain data surrounding the perceptions of Australian youths toward mandatory high school CPR programs	N-Y-Y-N-Y-N-Y-U-U-Y
CPR training in secondary schools	Lockey 2016[28]	Representatives from 14 secondary schools	SSI & FGD	England	To examine barriers faced by schools in delivering CPR training to students and successful programs already in place	Y-Y-U-U-Y-U-U-U-U-Y
CPR training in elementary schools	Pivac 2020[29]	children aged 12–14 years from 15 schools as well as 8 CPR instructors	FGD	Slovenia	To explore the training instructors' experiences and opinions on the effects of implemented CPR training	Y-Y-Y-U-Y-U-U-U-Y-Y
CPR training in elementary schools	Pivac 2022[26]	8 CPR training providers	FGD	Slovenia	To identify the experiences, obstacles and self-reflective opinions regarding the competence of CPR training providers in the field of nursing for third-cycle primary school students	Y-U-Y-N-Y-Y-Y-Y-Y-Y
Skills for Preventing Injury in Youth (SPIY) program	Reveruzzi 2020[27]	12 teachers and 152 high-school students	FGD	Australia	To develop an understanding of teachers and students experience of first aid delivery, and ultimately examine effective ways to deliver first aid training in schools	Y-Y-Y-Y-Y-N-Y-Y-Y-Y
CPR/AED Training in secondary schools	Zinckernagel 2017[31]	9 school leaders and 16 teachers	SSI & FGD	Denmark	To identify barriers to the implementation of defibrillator training of students and deployment of defibrillators in schools	Y-Y-Y-Y-Y-Y-Y-Y-Y-Y
CPR training in secondary schools	Zinckernagel 2016[30]	9 school leaders and 16 teachers	SSI & FGD	Denmark	To explore barriers to implementation of CPR training in Danish secondary schools	Y-Y-Y-Y-Y-Y-Y-Y-Y-Y

> *"I think that the training provider should follow the new guidelines, update their knowledge with their colleagues who also train and share experience of good practices."*[26]

This should encompass changes in the world they live in. As an example, while implementation data on AED use was generally scarce, teachers who have had access to AED training believe training of students should include the use of this now widely available tool.[26,31]

> *"It's natural because there are more and more AEDs around. Thus, it would be completely illogical to do without it."*[31]

The frequency of trainings should be adequate so teachers' own knowledge and skills are refreshed regularly[30]:

> *"I have actually completed a big first aid course three times with exams and everything, and I have done it again, because I simply cannot remember it. Now, I cannot remember it again, because it has been ten years since my last course."*[30]

The expectation is that this should result in adequate expertise of instructors and give them the confidence to deliver the program correctly. This is exemplified by one teacher's fear of their insufficient knowledge causing problems[26,30]:

> *"Imagine if I taught the students something wrong. I could not bear that. Imagine if I had shown a student something wrong, and they performed CPR that actually made it worse. I would never be able to forgive myself."*[30]

Students on the other hand emphasize the importance of real-world applicability and practical aspects in the program designs[27]. As one student put it, what helped them engage most with the training was

> *"the fact that it related to real life circumstances."*[27]

They also appreciate interactivity[27]:

> *"I like them (role plays). I wish there were more. It gives you a feel of the situation... It made me pay more attention, I think."*[27]

Finally, apart from believing that generally, all programs need adequate funding[28,30], emphasis is also placed on the importance of adaptability of programs to factors like student age, class structure and school characteristics[27,29]:

> *"You can get ten classes in a role play and it'll work for one of them. If you've got a class that's sort of, a bit out there and wanting to do it, they'll do it, whereas for a lot of kids, especially year 9 s now, not many, well I find not many are really going to get up and do it how it should be done. I just pick and choose what's going to work and what's not going to work, depending on your clientele. I just felt that in a couple of the areas you could have had options."*[27]

Environment factors

As far as environment factors are concerned, one important facilitating factor for implementation is to frame health as a core business of schools, meaning that any training should occur within a framework of health and responsibility which includes emphasizing the importance of helping others[26,28,29]:

> *". . . the first thing that is important is to help a fellow human being, to encourage one another to be a little bit more attentive and help a person that is in need, to know how to help them, not to be afraid."*[26]

This key facilitator of program implementation is further supported by mandatory legislation and higher-level support of such programs, including government support[26,29,32].

> *"I think it's important that topics on resuscitation are included in the school curriculum as mandatory, it has to be done at the national level and everything connected to it"*[29]

To ensure this is possible, training providers advocate for increasing general awareness, establishing senior support, for example from school leadership, and alleviating curriculum pressure and time constraints, if possible[28,30].

Quantitative data and convergent meta-integration

Quantitative data from 11 reports contributed to the review's findings. Of the included studies, two were set in the USA, two in Hong Kong, and one each in Belgium, Canada, Denmark, Kuwait, Norway, Spain and the United Kingdom. A total of 9021 persons concerned with implementing CPR training at schools, mostly teachers or school leadership personnel, were surveyed. Four surveys each were web- and paper-based, two were telephone-based, and one was conducted in person. Ten studies were concerned with CPR training in secondary schools, and one with training in both primary and secondary schools. An overview of the included studies along with their respective AXIS quality assessment ratings can be found in Table 2.

Included reports were of mixed quality, with one study fulfilling all quality criteria and two studies only fulfilling 55% of criteria. All studies contributed to the narrative synthesis. Due to study heterogeneity, formal *meta*-analysis was foregone. Instead, findings are synthesized narratively and reported whilst taking into account the quality of studies that contributed to them, analogous to our approach for synthesizing qualitative data.

Like the findings from qualitative studies, quantitative data contributed to concepts that are either related to program characteristics or environment factors.

Program characteristics

The three main program-related facilitators for successful implementation in the eyes of staff concerned with the delivery of programs are the availability of resources like manikins etc.,[33–35] high quality of teacher training,[33,36–40] as well as low costsin terms of finances, time and staffing.[34,37,39–42]

Environment factors

Key environmental facilitators to the implementation of school-based CPR training according to teachers and other respondents are framing health as core business of schools and linking CPR training with additional benefits,[35,39–41] integrating trainings into the school curriculum and prioritizing them,[33,35,40,41] and this being promoted by mandatory legislation and government support.[35,40,43]

In addition, implementation is facilitated by support from the different stakeholders at schools, namely school leadership,[33,35] staff,[35,40] and parents.[39,40]

Combined findings from qualitative and quantitative studies are summarized in Table 3, with confidence ratings, analogous to the GRADE-CerQUAL approach.

Discussion

Summary of key findings

The successful implementation of all health promotion initiatives, including programs that are delivered in schools, depends on the buy-in of key stakeholder groups. This is influenced by characteristics of the specific programs as well as a range of factors outside of program design.[44–46] This review corroborates the importance of these factors with regard to school-based CPR training. To enable implementation, programs should be standardized and easily delivered, use high-quality resources and include standardized training for teachers or other staff delivering the intervention. Different types of cost, including financial, time and staffing, should be accounted for and adequately compensated.

Outside of program-specific aspects, broad efforts should be made to optimize environment factors to ensure that well-designed programs are well implemented. This can be achieved by framing health as a core business of schools and linking CPR training with additional benefits. That in turn is facilitated by mandatory legislation and higher-level government support to integrate trainings into school curricula. All these factors come together to increase support for the programs on the part of school leadership, staff and parents. Efforts like this are in line with the WHO's Health Promoting Schools approach, a framework for school-based projects that builds on curricular integration, changes to the physical and social environment, and going beyond school borders to engage with families and their communities.[10,47]

The effective implementation of school-based CPR training may ultimately increase bystander CPR rates and therefore improve outcomes of people who suffer cardiac arrest, potentially saving countless lives.

Table 2 – Characteristics of included quantitative studies and AXIS quality rating.

Intervention	Study	Sample	Design	Setting	Aims	Quality Appraisal (AXIS)
CPR training in secondary schools	Alhasan 2022[43]	88 teachers	Web-based questionnaire	Kuwait	To survey the willingness of teaching staff in Kuwait to embark on such a project, in addition to perceived barriers and other factors influencing CPR training in high schools	13/20
CPR training in primary and secondary schools	Bakke 2017[33]	579 teachers	Web-based questionnaire	Norway	To establish how much time is spent on first-aid training, which first-aid measures are taught, and which factors prevent teachers from providing the quantity and quality of first-aid training that they wish to give	16/20
CPR training in secondary schools	Fan 2019[36]	557 secondary school teachers	Paper questionnaire	Hong Kong	To evaluate the readiness of Hong Kong secondary teachers to teach CPR in schools	15/20
CPR & AED Training in secondary schools	Hart 2013[41]	268 secondary schools	Telephone questionnaire	Canada	To determine rates of CPR and AED training in Toronto secondary schools and to identify barriers to training and training techniques	18/20
CPR Training in high schools	Hoyme 2017[34]	84 schools	Web-based questionnaire	USA	To understand perceived barriers to providing CPR education, implementation processes, and practices in high schools	12/20
CPR Training in high schools	Malta Hansen 2016[35]	1240 school leaders and 1381 teachers	Web-based questionnaire	Denmark	To assess contemporary rates, barriers, and facilitators of student CPR training in middle schools	20/20
CPR Training in high schools	Miró 2006[37]	100 head teachers	Paper questionnaire	Spain	To determine the opinion of head teachers on the educational and logistical characteristics required for a basic cardiopulmonary resuscitation programme for secondary school teenagers to succeed	15/20
CPR training in schools	Mpotos 2013[38]	4273 teachers	In-person questionnaire	Belgium	To learn about CPR knowledge, preparedness to perform and teach CPR as well as attitude towards an alternative self-learning strategy among Flemish teachers	17/20
CPR Training in high schools	Reder 2002[39]	276 school representatives	Paper questionnaire	USA	To determine the best approaches to increase CPR training opportunities for high school students	15/20
CPR training in secondary schools	Salciccioli 2017[42]	65 schools	Telephone survey	UK	To assess current practices of BLS training in London secondary schools	12/20
CPR training in secondary schools	Yim 2021[40]	110 school representatives	Paper questionnaire	Hong Kong	To explore secondary school cardiopulmonary resuscitation programs and better understand school principals' attitudes	17/20

Conceptual framework: the seed-and-soil hypothesis

Findings from our review indicate that successful implementation depends on program characteristics on the one hand and environmental factors on the other. In essence, an exemplary program design alone does not guarantee successful implementation or improved outcomes as it may be entirely rejected by the stakeholders within the environment in which it is to be executed. This can be viewed as a seed-and-soil type of concept where program-related factors (*seed factors*) and environmental aspects (*soil characteristics*) must come together to ensure success (see Fig. 2). It would be futile to optimize one element while neglecting the other as whichever aspect is sub-optimal will ultimately constrain overall success. This principle should guide both implementation strategies, which should always account for environment factors, and resource allocation decisions.

Implications for research and practice

Since the start of the Kids Save Lives initiative and its endorsement by the WHO, many studies have evaluated CPR training in schools, usually looking at outcomes like quality markers of CPR and whether children are able to achieve those. However, arguably, the most important research question in this field is not whether children are able to perform CPR (they are, but that is beside the point); what researchers in this field and related fields may need to decipher is how such programs have to be designed to be well implemented, and how implementation can be optimized to be wide and deep

Table 3 – Summary table of review findings and confidence assessment using the GRADE-CerQUAL approach. SG, stakeholder groups; ST, school types; C, countries.

Review Finding	Studies (N)	Confidence (analogous to CERQual)	Notes on confidence rating
Program Characteristics			
High-quality program resources / equipment. Programs should use high-quality, accessible resources and equipment; however, the focus is not necessarily on high-fidelity CPR mannequins but rather on the content and how it is delivered.	N = 6[26–28,33–35]	High	Qualitative Evidence from 2 stakeholder groups and 2 school types in 3 countries. High coherence, adequacy and relevance. Significant methodological concerns partly compensated by one high-quality study. Quantitative Evidence from 2 stakeholder groups in 3 countries. Some methodological concerns compensated by one high-quality study.
Excellent teacher training. Where teachers are used as multipliers and deliverers of interventions, special attention should be paid to ensuring they are excellently trained as this may not only improve intervention quality but also their buy-in and dedication to the program.	N = 10[26,28–30,33,36–40]	High	Qualitative Evidence from 3 SG, 2 ST, 3C. High coherence, adequacy and relevance. Significant methodological concerns partly compensated by one high-quality study. Quantitative Evidence from 2 SG in 5C, minor methodological concerns.
Adequate Funding. Programs are likely better implemented when they are adequately funded, ensuring that financial concerns don't stand in the way of implementation.	N = 8[28,30,34,37,39–42]	High	Qualitative Evidence from 2 SG, 1 ST, 2C. High coherence and relevance, limited adequacy. Mixed methodological quality. Quantitative Evidence from 2 SG in 5C. minor methodological concerns.
Perceived adequacy of resource use. Efforts should be made to ensure stakeholders feel that resources (time and staffing) are allocated in a meaningful manner.	N = 5[34,37,39,40,42]	Moderate (−)	Quantitative Evidence from 2 SG in 4C. Moderate methodological concerns in some studies.
Program adaptability. Programs may be better implemented when designed to be adaptable to the settings in which they are delivered, both regarding the target audience as well as factors like place, culture and any specific limitations that may be present at a site.	N = 2[27,29]	Low	Qualitative Evidence from 2 SG, 2 ST, 2C. High coherence and relevance, limited adequacy. Mixed methodological quality.
Inclusion of AEDs. Given their near-ubiquitous availability, it may be beneficial to include AEDs in program syllabi.	N = 2[26,31]	Low	Qualitative Evidence from 2 SG, 2 ST, 2C. High coherence and relevance, limited adequacy. Mixed methodological quality.
Small Groups & Interactivity. Programs may be better implemented where groups are small and the content is designed to be interactive.	N = 2[26,27]	Low	Qualitative Evidence from 2 SG, 2 ST, 2C. High coherence and relevance, limited adequacy. Mixed methodological quality.
Real-world applicability. Programs may be better implemented and received if they contain real-world applications.	N = 1[27]	Very Low	Qualitative Evidence from 2 SG, 1 ST, 1C. Limited adequacy. High methodological quality.
Addressing misconceptions. Programs may be better implemented if they actively address and rectify common misconceptions.	N = 1[30]	Very Low	Qualitative Evidence from 2 SG, 1 ST, 1C. Limited adequacy. High methodological quality.
Ease of delivery of Program. Programs may be better implemented if their delivery is easy.	N = 1[27]	Very Low	Qualitative Evidence from 2 SG, 1 ST, 1C. Limited adequacy. High methodological quality.
Environment Factors			
Framing Health as core business of schools. Efforts should be made to frame health as a core business of schools.	N = 7[26,28,29,35,39–41]	High	Qualitative Evidence from 2 SG, 2 ST, 2C. High coherence, adequacy and relevance. Significant methodological concerns for all studies. Quantitative Evidence from 2 SG, 4C. Some methodological concerns, compensated by a high-quality study.

(*continued on next page*)

Table 3 (continued)

Review Finding	Studies (N)	Confidence (analogous to CERQual)	Notes on confidence rating
Mandatory legislation & government support. Efforts should be made to ensure the introduction of mandatory legislation and/or government support as these support local implementation of programs.	N = 6[26,29,32,35,40,43]	Moderate	Qualitative Evidence from 2 SG, 2 ST, 2C. High coherence, adequacy and relevance. Significant methodological concerns for all studies Quantitative Evidence from 2 SG, 3C. Some methodological concerns, compensated by a high-quality study.
Establishing Senior support. Programs are likely better delivered if the environment is shaped by senior personnel that is in favour of programs and implementation efforts.	N = 3[28,33,35]	Moderate	Qualitative Evidence from 1 SG, 1 ST, 1C. Limited adequacy. Significant methodological concerns. Quantitative Evidence from 2 SG, 2C.. One high quality study, one with minor concerns.
Alleviating Curriculum pressure. Programs may be better implemented if curriculum pressures in other areas are alleviated and trainings can	N = 2[28,30]	Low	Qualitative Evidence from 2 SG, 2 ST, 2C. High coherence and relevance, limited adequacy. Mixed methodological quality.
Curriculum integration. Programs may be better implemented if trainings become part of the standard curriculum.	N = 2[33,40]	Low	Quantitative Evidence from 2 SG, 2C. Minor methodological concerns.
Staff buy-in. Programs may be better implemented if the staff believes in and supports them.	N = 2[35,40]	Low	Quantitative Evidence from 2 SG, 2C. One high quality study, one with minor concerns.
Parent support. Programs may be better implemented if parents believe in and support them.	N = 2[39,40]	Low	Quantitative Evidence from 2 SG, 2C. Minor methodological concerns.
Linking CPR with additional benefits. Programs may be better implemented if trainings are linked with additional benefits beyond proficiency in the physical act of performing CPR, e.g. increased self-sufficiency and health awareness.	N = 2[35,39]	Low	Quantitative Evidence from 2 SG, 2C. One high quality study, one with minor concerns.
Alignment of training supply with perceived demand. Programs may be better implemented if stakeholders perceive the need for training and its availability to be aligned.	N = 2[35,41]	Low	Quantitative Evidence from 2 SG, 2C. High quality studies.
Increasing General Awareness for the issue may contribute to the creation of an environment in which implementation is facilitated.	N = 1[28]	Very Low	Qualitative Evidence from 2 SG, 1 ST, 1C. Limited adequacy. Unclear methodological quality.

enough to ultimately change bystander CPR rates. Findings from this review further suggest that beyond isolated CPR-focused programs, these trainings may be better implemented in a holistic health promoting schools approach. As far as future research is concerned, one important area of inquiry would be the implementation of AED use in trainings, especially considering the wide availability of AEDs and the role of early defibrillation in improving outcomes. Overall, major gaps in the literature are long-term outcomes of such trainings, especially outcomes beyond the mere capability to perform chest compressions.

Limitations

While the review has some key strengths and implications for future practice and research, it is not without limitations. First, there are at least some methodological concerns for most of the included studies, and some of the themes are only corroborated by one study or multiple studies with significant quality concerns. We have tried to address this by reporting study quality precisely and including quality considerations in our assessment of strength of review findings. Second, the external validity is limited by the heterogeneity of studies on the one hand as well as the limited range of countries the studies were conducted in on the other, as education is notoriously diverse across borders. Third, publication bias might have affected findings since studies in countries with established mandatory CPR training may report more positive outcomes. Fourth, the perspectives of parents, who are an important stakeholder group, and an indirect target audience of health promotion efforts at schools, are not represented in the studies. Finally, the views of students, who are supposed to be the main beneficiaries of these trainings, are also underrepresented, as, regrettably, is often the case in both study and real-world settings. Future studies in the field should address these gaps.

CRediT authorship contribution statement

Mahan Sadjadi: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rebecca Brülle:** Writing – review & editing, Validation, Formal analysis, Data curation. **Umut Onbasilar:** Writing – review & editing, Data curation. **Hendrik Booke:** Writing – review & editing. **Christian Strauß:** Writing – review & editing. **Thilo von Groote:** Writing – review & editing. **Hugo van Aken:** Writing – review & editing. **Antje Gottschalk:** Writing – review & editing.

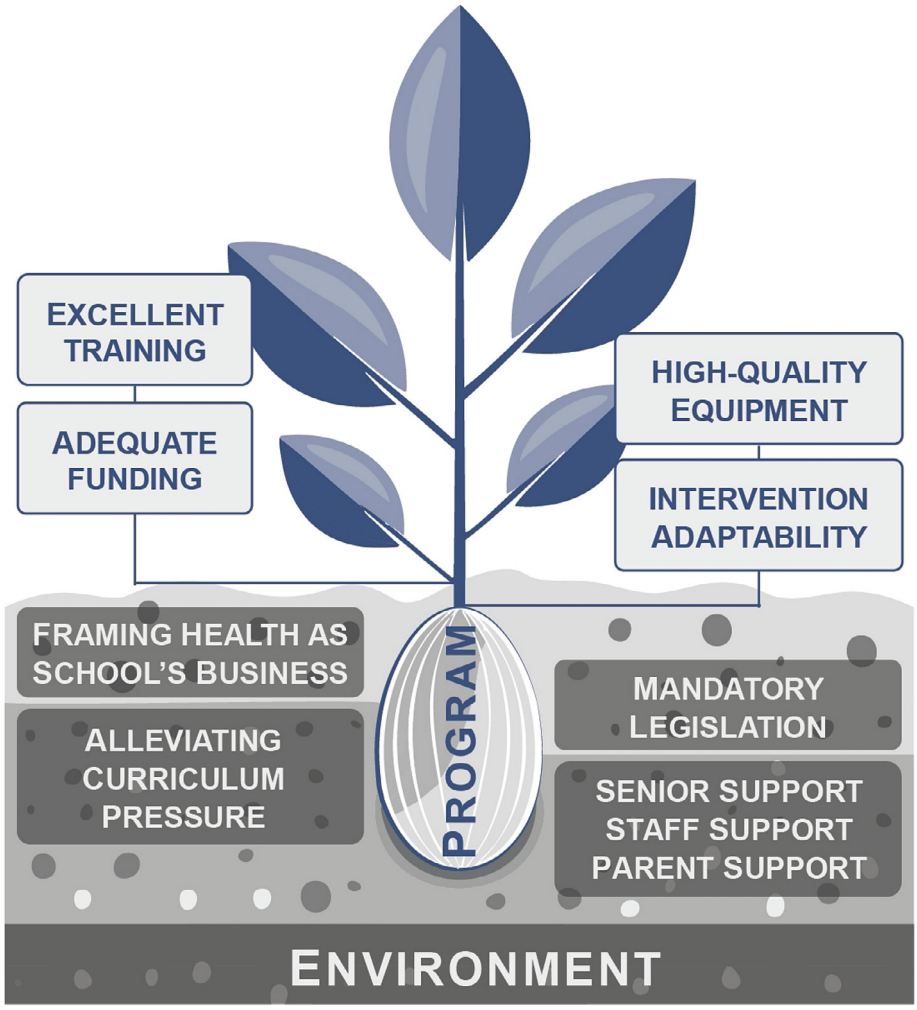

Fig. 2 – Summary of Review Findings: Seed-and-Soil Hypothesis of Implementation. The successful implementation of school-based CPR training depends on program characteristics (*seed factors*) on the one hand and environmental factors (*soil characteristics*) on the other. Based on our review findings, we propose a seed-and-soil type hypothesis of implementation where program-related factors and environmental aspects must come together to ensure successful implementation.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2025.100955.

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