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RESEARCH

Evaluation of a 90-minute School-based Resuscitation Course with 340 Middle School Students – A Multicenter Intervention Study

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ABSTRACT

Background: This study aimed to exploratorily evaluate the learning success of a 90-minute resuscitation class taught by recently trained teachers in the German state of Brandenburg before a statewide implementation of these classes.

Methods: In five public schools, teachers, trained by professional first aid instructors, taught 90-minute resuscitation courses to 340 seventh (7^{th}) grade students. We surveyed the students' knowledge immediately before their course and their knowledge, self-confidence, and willingness to perform resuscitation one month afterward using standardized self-report questionnaires. The practical skills were assessed in randomly selected subgroups.

Results: One month after the course, up to 25% more of the students were able to answer questions correctly regarding relevant CPR parameters. More than half of the students felt confident in their skills and were willing to perform CPR.

Conclusions: Middle-school students can benefit from a single short resuscitation course taught by their trained teachers. Future research should include the development of the teaching methods for these classes and the timing of refresher courses later in the curriculum. The findings of this study support the statewide implementation of resuscitation training for middle school students as part of a greater ambition to increase bystander assistance in out-of-hospital cardiac arrest.

Keywords: Cardiopulmonary resuscitation training; Lay training; Middle school; First aid education; School students; Basic life support

KURZZUSAMMENFASSUNG

Hintergrund: Ziel dieser Studie war es, den Lernerfolg eines 90-minütigen Reanimationsunterrichts, der von zuvor speziell ausgebildeten Lehrkräften in Brandenburg unterrichtet wurde, vor einer landesweiten Einführung dieser Kurse explorativ zu evaluieren**.**

Methoden: In fünf öffentlichen Schulen unterrichteten Lehrkräfte, die von professionellen Erste-Hilfe-Ausbildern geschult wurden, 340 Schüler der siebten Klasse (7. Klasse) in 90-minütigen Wiederbelebungskursen. Unmittelbar vor dem Kurs wurde das Wissen der Jugendlichen erhoben, einen Monat danach wurden das Wissen, das Selbstvertrauen und die Bereitschaft der Jugendlichen, Wiederbelebungsmaßnahmen durchzuführen, mit standardisierten Fragebögen erhoben. Die praktischen Fertigkeiten wurden in zufällig ausgewählten Subgruppen einen Monat nach dem Kurs bewertet.

Ergebnisse: Einen Monat nach dem Kurs waren bis zu 25% mehr Jugendliche in der Lage, Fragen zu relevanten Parametern der Herzlungenwiederbelebung richtig zu beantworten. Mehr als die Hälfte der Jugendlichen fühlte sich sicher in ihren diesbezüglichen Fähigkeiten und bereit, eine Reanimation durchzuführen.

Schlussfolgerungen: Schülerinnen und Schüler der Mittelstufe können von einem einmaligen kurzen Wiederbelebungskurs, der von entsprechend dafür ausgebildeten Lehrkräften durchgeführt wird, profitieren. Künftige Forschungsarbeiten sollten sich mit der (Weiter-)Entwicklung von Lehrmethoden für diese Kurse und der zeitlichen Planung von Auffrischungskursen zu einem späteren Zeitpunkt im Lehrplan befassen. Die Ergebnisse dieser Studie unterstützen die landesweite Einführung von Reanimationsunterricht in der Mittelstufe mit dem langfristigen Ziel, die Hilfeleistung durch Laien bei Herzstillstand, der außerhalb des Krankenhauses auftritt, zu verbessern.

Schlüsselwörter: Ausbildung in Herz-Lungen-Wiederbelebung; Laienausbildung; Mittelschule; Erste-Hilfe-Ausbildung; Basic Life Support

STRESZCZENIE

Wprowadzenie: Celem badań było ocenienie efektów wiedzy nabytej podczas 90-minutowego kursu resuscytacji, prowadzonego przez wcześniej przeszkolonych nauczycieli w Brandenburgii. Badanie pozwoliło przeprowadzić eksploracyjną ocenę przed wprowadzeniem kursów RKO na arenie krajowej.

Metodologia: W pięciu publicznych szkołach nauczyciele, przeszkoleni wcześniej przez profesjonalnych instruktorów pierwszej pomocy, przeprowadzili 90-minutowe kursy resuscytacji dla 340 uczniów siódmej klasy. Bezpośrednio przed kursem za pomocą ustandaryzowanych ankiet oceniono wiedzę uczniów, a miesiąc po nim wiedzę, pewność siebie i gotowość do przeprowadzania resuscytacji. Umiejętności praktyczne oceniano w losowo wybranych podgrupach.

Wyniki: Miesiąc po kursie nawet o 25% więcej młodzieży potrafiło odpowiedzieć na pytania dotyczące istotnych parametrów resuscytacji. Ponad połowa uczniów czuła się pewna swoich umiejętności i była gotowa do wykonania resuscytacji.

Wnioski: Uczniowie szkół średnich mogą odnieść korzyści, biorąc udział w jednorazowym kursie resuscytacji przeprowadzonym przez przeszkolonych wcześniej w tym celu nauczycieli. Przyszłe badania powinny skupić się na opracowaniu metod nauczania stosowanych podczas kursów i harmonogramu odświeżania wiedzy w późniejszym terminie zawartym w planie nauczania. Wyniki tego badania popierają ogólnokrajowe wprowadzenie nauczania resuscytacji w szkołach średnich jako części celu głównego, tj. poprawy częstotliwości udzielania pierwszej pomocy przez osoby cywilne w przypadku zatrzymania krążenia poza szpitalem.

Słowa kluczowe: Szkolenie z resuscytacji krążeniowo-oddechowej; szkolenie laików; szkoła średnia; szkolenie w zakresie pierwszej pomocy; podstawowe wsparcie życiowe

Sudden cardiac arrest is one of the leading causes of death in industrialized countries. In Germany, out-of-hospital cardiac arrests (OHCA) affect approximately 60,000 patients every year with a survival rate of only 10% (i.e., those that will be discharged from the hospital) (Fischer et al., 2021). This rate is higher in other European countries like Norway where cardiac arrest survival rates reached 15% (Tjelmeland et al., 2020). To improve patient outcomes in the context of emergency medicine all links of the Chain of Survival Behaviors (Prevent and Prepare, Early recognition, Provide First aid, Access help, and Self-recovery/Early medical care) (IFRC, 2016) must be in place. Often the weakest links are those before the involvement of professional emergency medicine staff. In Germany for example, the lower bystander cardiopulmonary resuscitation (CPR) rate, which is approximately 40% compared to 80% in Norway, may contribute to the lower survival rates (Fischer et al., 2021; Tjelmeland et al., 2020). Our study is based on improving preparedness and provision of "First Aid", strengthening this aspect of the Chain of Survival Behaviors by increasing layperson CPR training through school courses.

According to a British study, one in five adults witnesses at least one OHCA in their lifetime (Hawkes et al., 2017). To ensure a breadth of CPR skills across the general population, comprehensive lay training is necessary. One possible measure to reach most of the population over time is to include resuscitation as a mandatory part of the school curriculum. This may have a long-term impact on adult bystander CPR rates, but also a direct positive effect as young students and teenagers might witness OHCA (e.g., at home or in public places such as malls and residential areas where cardiac events commonly occur) (Cave et al., 2011; Sondergaard et al., 2019).

The World Health Organization (WHO) recommends two hours of annual CPR training for students from age 12 onwards (Böttiger & Aken, 2015). This recommendation has been endorsed in Germany by the Standing Conference of Ministers of Education and Cultural Affairs (KMK) and

should be implemented in all federal states (Pieper, 2014). While there have been initiatives to test the effectiveness of different teaching approaches (Felzen et al., 2021), there are still no comprehensive resuscitation classes in most federal states in Germany (Rücker et al., 2022).

Most earlier studies evaluated CPR courses for students taught by medical professionals (Plant & Taylor, 2013). However, schoolteachers also seem to be able to teach CPR to school students successfully (Plant & Taylor, 2013; Reveruzzi et al., 2016). Our study evaluated the pilot phase of the "Herzensretter" (English: Heart Saver) concept that was intended to be implemented in 33 schools in the German state of Brandenburg. The aim of the study was to explore the effects of the 90-minute resuscitation course taught by trained schoolteachers to seventh (7^{th}) grade (12–13-years-old) students in terms of their CPR knowledge and practical skills as well as their willingness to apply this knowledge in emergencies.

METHODS

Study Setting and Design

"Herzensretter" is a teaching concept developed by the German Federal Association for First Aid (BAGEH). In this concept, the students are supposed to participate in 90-minute resuscitation courses once a year over three consecutive school years (see Figure 1). In the first year, the course focuses on hands-only resuscitation, whereas the second one also includes ventilation, and the third one adds in using an automated external defibrillator (AED). Please see the supplemental material for detail on the Herzensretter concept and curriculum.

This study aimed to evaluate the first-year course, therefore the intervention we examined only includes hands-only resuscitation. This first-year course was led by schoolteachers who had been trained in resuscitation and corresponding teaching methods by professional first aid instructors in a six-hour course. This course was based on standardized first aid instructor courses, but more was more concise. The curriculum only included CPR; other first aid topics (e.g., bandages) were not included (see supplemental material). To reduce their workload, the teachers were encouraged to seek assistance from students with first aid training experience. One of the participating schools already had a student group for first aid training that was involved in the courses for the seventh grade. In the other schools, the participating teachers trained a few selected students from the seventh or higher grades to assist. Regardless of the age or experience of assisting students, the class was led and supervised by the schoolteacher. Part of the course consisted of practical training where 2–4 participants gathered

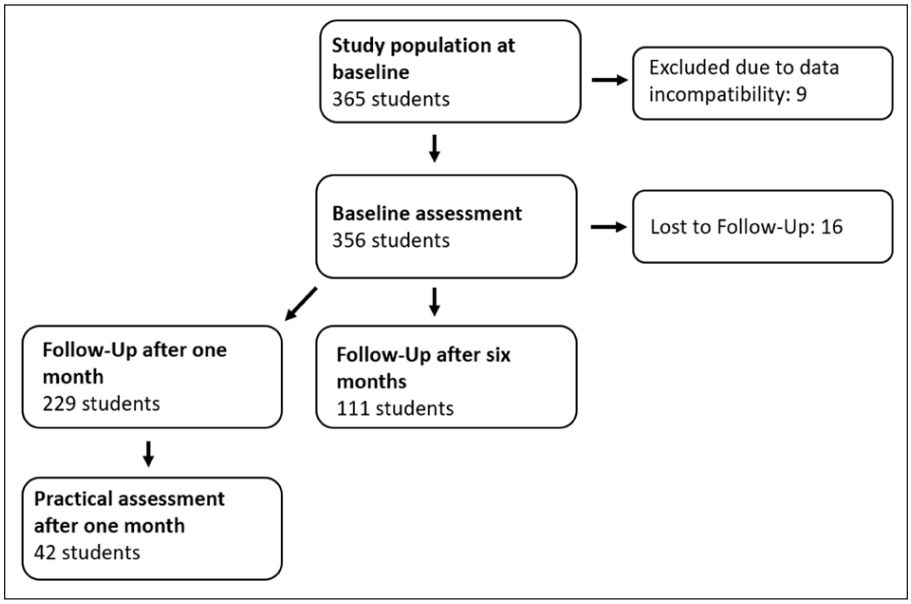

Figure 1: Flowchart of the Selection Process of the Study Population in the "Herzensretter" Study.

around one resuscitation mannequin and were trained by a student aid under supervision by the responsible teacher (see supplement material) (Sick et al., 2018).

At the beginning of 2020, we trained one or two teachers from each of the 33 participating schools in the rural German state of Brandenburg. Originally it was planned to randomly select five of these schools, one from each school district. Due to the COVID-19 pandemic, the project was implemented and evaluated in only five of the participating schools until the end of the field phase (November 2021).

We assessed the students' knowledge immediately before the course started (baseline) and one month afterward using self-report questionnaires. Immediately after the written assessment, we also evaluated the practical skills of 42 randomly selected students. During the COVID-19 pandemic, the one-month-assessment was only delayed in one school (by five months) whereas in the other four schools, it took place after one month. In this school, no practical assessments took place (see Figure 2).

Ethical approval for this study was obtained from the local ethics committee of Charité Universitätsmedizin Berlin, Campus Virchow-Klinikum (application number: EA2/041/20).

Study participants

From the five participating schools we included all present seventh grade students whose parents provided

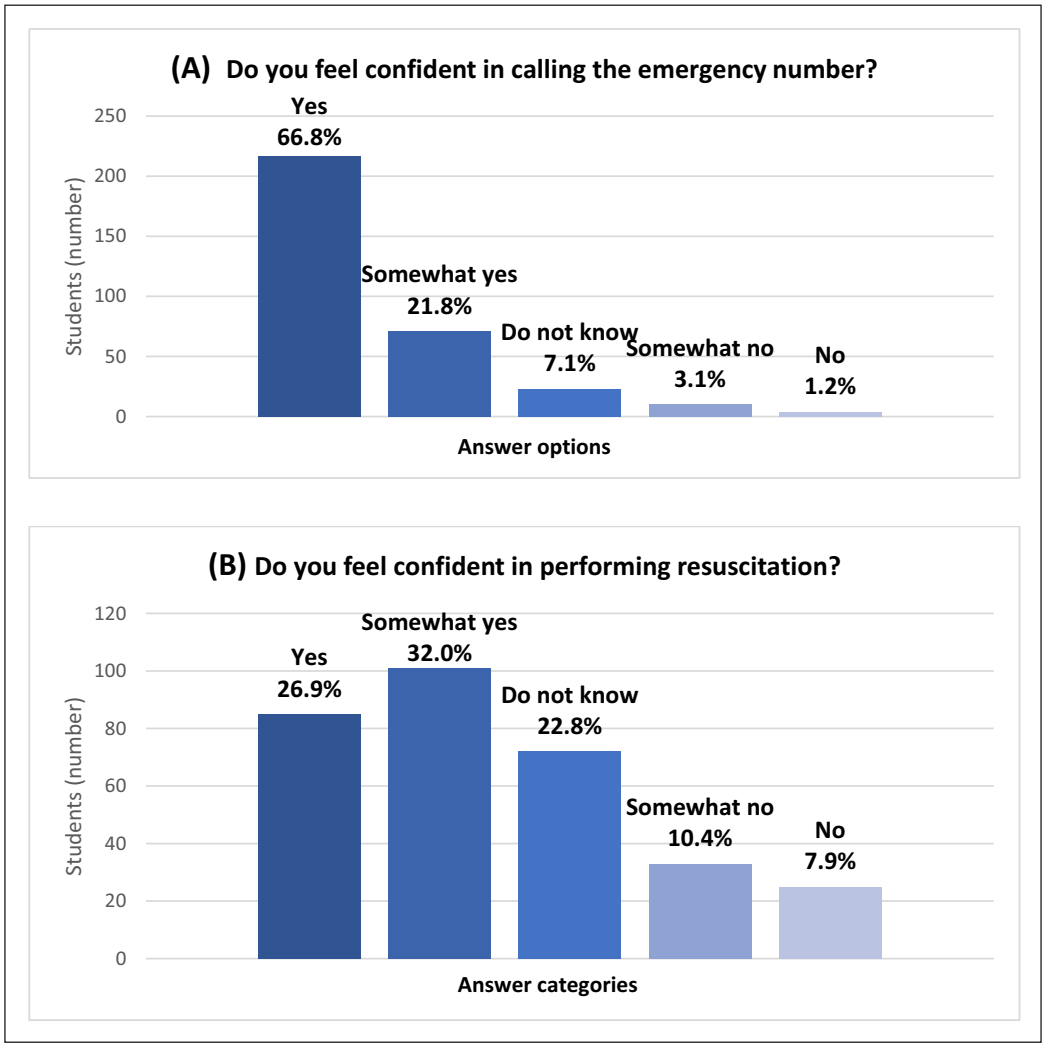

Figure 2: Self-reported Confidence of **(A)** Calling the Emergency Number, and **(B)** Performing Resuscitation, among 325 Students (15 Missing) and 316 Students (24 Missing) Respectively, one Month after a 90-minute Resuscitation Course.

written informed consent for the evaluation. Follow-up questionnaire data from students who were not present for the baseline assessment, or the resuscitation course were excluded from the evaluation.

Questionnaire assessment

Resuscitation knowledge was assessed using standardized questionnaires including demographic data (age, sex, language spoken at home, number of siblings) and previous first aid experience. No personal information to identify individuals was collected. The baseline and follow-up questionnaires were anonymized and not linked on an individual level. The open questions assessed depth and rate of chest compression and duration to check for breathing. The students were asked to order the four steps of what to do for an unconscious person. The steps were (1) self-protection, (2) check breathing, (3) call the emergency number, (4) perform cardiopulmonary resuscitation.

In the assessment one month after the course, the students were also asked whether they would help (and would perform resuscitation) only for someone familiar to them, or if they would also help a stranger in an emergency. Further, they were asked whether they felt confident in taking appropriate actions in an emergency.

The questionnaire (same for pre- and post-course assessment for knowledge but with extra questions on confidence and willingness post-course) was developed through the collaborative efforts of the responsible department of the Ministry of Education of the state of Brandenburg, health scientists from the medical faculty of the Charité Berlin, and medical professionals including doctors and trainers from emergency services, and organizations that provide first-aid training to adults, youth and children. The survey, just like the course content, was based on guidelines for first aid education and used age-appropriate language adapted to the children's experience (De Buck et al., 2015; International Federation of Red Cross Red Crescent Societies, 2016). Soon after the start of our study, the Global First Aid Reference Center published a new guideline including an Outcome Measurement Toolkit. Fortunately, we recognized many concepts and elements we used in the new guidelines (Boase et al., 2021; Global First Aid Reference Center, 2020).

Practical assessments

For the practical skills examination, the students were randomly selected and assessed individually without the presence of other children. The assessor asked each child to show in a role play with a resuscitation manikin how they would act if they found an unconscious person. The assessors of the practical assessment had a medical background and strictly followed a standard operating procedure developed for this assessment.

Without the presence of other children, the assessor recorded whether the student (i) paid attention to their safety and (ii) checked the manikin for consciousness and breathing. The breathing was assessed as correct if the student tilted the manikin's head backward, observed the torso, and approached an ear to the manikin's mouth to hear and feel for breathing for 10 seconds. The assessor also recorded whether the student (iii) called the emergency number, (iv) started resuscitation on their own using the correct chest compression rate and depth, and (v) performed continuous resuscitation until the arrival of medical professionals.

Statistical Methods

For the statistical analysis, we used IBM SPSS Statistics 28 (Armonk, New York, USA). We followed an explorative approach to examine various research questions and did not test specific a-priori hypotheses and did not adjust for multiple testing. Due to this approach and their limited ability to measure the actual importance of a result, we refrained from using p-values or the term 'statistically significant' (Wasserstein & Lazar, 2016).

We did not use a statistical test to conclude that the samples of the theoretical and the practical assessments are similar. In this context, it does not seem reasonable to specify equivalence bounds for an appropriate equivalence test. Therefore, we interpreted these results with caution.

The results of continuous variables were presented using median, minimum, and maximum values of categorical variables with absolute and relative frequencies. To estimate statistical uncertainties, we calculated 95% confidence intervals using bootstrapping with 1,000 samples.

RESULTS

Basic Characteristics of Study Participants

Out of 356 students who completed the baseline questionnaire immediately before the course, 340 participated in the follow-up assessment by questionnaire and 42 students (a randomly selected subgroup from 4 schools) participated in the practical examination one month after the course. Most participants were 12–13 years old (age range 10 to 15 years). Between one-third and half of the students had previously participated in a first-aid course (Table 1).

All participating teachers taught the course on their own with 20–30 students per class. They previously instructed selected students to help supervise the practical training (see supplemental material). In one school, students with previous first-aid training from extracurricular activities supported the teacher. The results of all schools were similar.

Assessment of Resuscitation Knowledge Before and After the Course

To assess knowledge on resuscitation we asked the students about the numerical values of resuscitation rate, depth, and the necessary duration to check for breathing. They were also asked to describe the correct procedure when finding an unconscious person. Although a good proportion of students improved their resuscitation knowledge, more than half of the students did not improve (Table 2).

All participating students spoke German fluently and passed their regular exams in German. However, students who spoke only or partly German at home seemed to perform better than those who spoke no German at home, although the latter subgroup was too small to draw conclusions. Overall, there were no considerable differences between girls and boys (see Table 2).

	Baseline	**Follow-Up after**	**one month**
	Questionnaire assessment	**Questionnaire assessment**	**Practical examination (random sample)**
All students (number)	356	340	42
Boys (%)	53.7	55.0	61.9
Age (in years)			
Median (with interquartile range)	12 (1)	13 (1)	13 (0)
Mean (with standard deviation)	12.5 (0.68)	12.81 (0.68)	13.0 (0.75)
Min/Max	10/14	12/15	12/15
<12	1.8%	0	0
12–13	90.2%	88%	82.9%
>13	8%	12%	17.1%
Language spoken at home (%)			
German	82.8	79.2	59.5
German and other languages	11.2	16.0	26.2
Only other languages	6.0	4.8	14.3
Participated in previous first aid course (%)	37.9	–	38.1
Already provided first aid in real life (%)	8.3	9.6	11.9

Table 1: Basic Characteristics of Seventh Grade Students Participating in the Evaluation of a 90-minute Resuscitation Class.

	Baseline assessment N = 356 (95%-CI)	Follow-Up assessment				
		All students N = 340 (95%-CI)	Male n = 186	Female n = 150	German was spoken at home (only or partly) n = 316 (95%-CI)	Only other languages were spoken at home n = 15 (95%-CI)
Emergency number	98.9% (97.7%–99.7%)	99.4% (98.5%–100%)	99.5%	99.3%	99.4% (98.4%–100%)	100% (100%–100%)
Chest compression rate	2.5% (1.1%–4.6%)	27.4% (22.9%–32.3%)	26.6%	24.1%	28.4% (21.2%–31.2%)	7.7% (0–21.4%)
Chest compression depth	17.2% (12.3%–22.1%)	36.8% (31.1%–42.8%)	33.3%	40.8%	38.1% (32.2%–44.1%)	11.1% (0–39.9%)
Duration to check for breathing	12.8% (8.8%–17.3%)	17.7% (13.2%–22.3%)	20.7%	12.4%	18.1% (13.2–22.9%)	8.3% (0–30%)
Identification of self-protection as the first step of the correct procedure for resuscitation	24.4% (17.4%–25.8%)	49.7% (44.4%–55.0%)	47.3%	53.3%	50.9% (45.8%–56.3%)	25% (5.9%–47.4%)
Report of the complete procedure for resuscitation	11.1% (7.6%–14.6%)	30.7% (25.8%–35.3%)	30.3%	31.5%	31.2% (26.1%–36.6%)	20% (10.7%–42.9%)

Table 2: Resuscitation Knowledge Before and One Month After a 90-minute Resuscitation Class for Seventh Grade Students.

N/n = number of participants, 95%-CI = 95%-confidence interval.

Self-Reported Knowledge of the Emergency Call and Resuscitation

Most of the students (89%, 95%-CI 79–98%) felt confident to call the emergency number and report relevant information. Regarding performing resuscitation, slightly more than half of the students (59%, 95%-CI 49–69%) felt confident regarding their specific knowledge (see Figure 2).

Willingness to Help

Most of the students reported that they were willing to help others in emergencies, especially people whom they knew (see Table 3). This attitude did not differ considerably between different sociodemographic groups.

Practical Assessment in a Subgroup 1-month Post-course

The demographic factors of the 42 randomly selected students were similar to those of the whole study population, except that there were slightly more male students and students who did not speak German at home in the subgroup (see Table 1). The practical results of the subgroup were considerably better than the results of the theoretical assessment of the whole sample (see Tables 2 and 4), especially regarding chest compression rate (69% versus 27%) and depth (71% versus 37%). In the practical assessment, 81% checked for breathing, but only 26% did this completely correctly. The most frequent error was not tilting the manikin's head backward.

DISCUSSION

Main Findings

One month after the 90-minute resuscitation course conducted by schoolteachers, depending on the item, up to 25% more students were able to correctly answer questions on relevant resuscitation parameters than before the course. However, about 50% of the participants did not show any improvement in their resuscitation knowledge. This is lower than the 59% of students who indicated confidence in their knowledge. This could be because they were instructed that if a patient requires resuscitation and they are the only bystanders, they should attempt resuscitation even if

All participants (N = 340) Willing to…	**All students "Yes" (95%-CI)**	**German was spoken at home (only or partly) n = 316 (95%-CI)**	**German was not spoken at home n = 15 (95%-CI)**
help a familiar person	98.8% (97.3%–99.7%)	98.7% (97.2%–99.7%)	100% (100%–100%)
help a stranger	95.7% (93.2%–97.8%)	95.4% (93.0%–97.7%)	100% (100%–100%)
call the emergency number for a familiar person	97.2% (95.4%–98.8%)	97.4% (95.5%–99%)	92.9% (73.7%–100%)
call the emergency number for a stranger	95.4% (92.9%–97.5%)	95.4% (92.8%–97.7%)	92.9% (73.3%–100%)
perform resuscitation on a familiar person	93.1% (89.9%–95.9%)	93.9% (91%–96.6%)	85.7% (64.3%–100%)
perform resuscitation on a stranger	84.7% (80.1%–88.5%)	84.7% (80.3%–88.5%)	84.6% (63.2%–100%)

Table 3: Willingness to Help in Emergencies Assessed one Month After a 90-minute Resuscitation Class for Seventh-Grade Students. The Responses are Stratified by Language Spoken at Home.

N/n = number of participants, 95%-CI = 95%-confidence interval.

	Total subgroup sample (95%-CI) n = 42	Male students n = 26	Female students n = 16	German was spoken at home (only/partly) n = 36	Only other languages were spoken at home n = 6
Correct checking for consciousness	59.5% (45.2%–73.8%)	57.7%	62.5%	66.7%	16.7%
Correct checking for breathing	26.2% (12.0%–40.5%)	26.9%	25%	30.6%	0%
Correct hand positioning for resuscitation	76.2% (61.9%–88.1%)	76.9%	75%	83.3%	33.3%
Correct compression rate during resuscitation	69.0% (54.8%–83.3%)	76.9%	56.3%	77.8%	16.7%
Correct compression depth during resuscitation	71.4% (57.1%–83.3%)	84.6%	50%	77.8%	33.3%
Correct emergency number called	66.7% (52.4%–81.0%)	73.1%	56.3%	69.4%	50%
Giving all relevant information in an emergency call	75.0% (57.1%–89.3%)	68.4%	88.9%	72%	50%

Table 4: Practical Skills Assessment in a Subgroup with 42 students from Seventh Grade (Stratified by Demographic Groups) one Month After a 90-minute Resuscitation Course.

they have doubts on how to do so. Some students may feel confident to initiate chest compressions while still having uncertainties about the exact parameters. In the practical assessment with a randomly selected subgroup, the students seemed to perform much better compared to the theoretical assessment. It is not clear why this occurred. It may be due to the emphasis on practical training of the course, or because students in this age group might remember movement patterns more easily than numerical values. More than two-thirds of them followed the correct procedure for resuscitation and performed sufficient resuscitation on a manikin. The proportion of children with previous first aid training in the whole sample (37.9%) seemed similar to the proportion of those with such experience in the randomly selected subsample for practical assessment (38.1%). Still, due to the small sample size of students doing the practical assessment, these results should be interpreted with caution.

Students that did not speak German at home seemed to have more difficulty with the material, however we cannot draw definitive conclusions. The sample size of these students was very small; therefore the 95%-confidence intervals were overlapping with the whole study population (see Table 2). As these students were able to speak German fluently, different reasons apart from possible language barriers, for example, social status and integration into the class should be explored in future evaluations. Regarding attitude to help in emergencies, over 80% of the participating students were willing to perform resuscitation on strangers and more than half of them were confident that they would do this correctly.

Comparison with Previous Studies

Type of Instructor

Our study showed that schoolteachers trained by medical professionals were able to successfully teach their students basic resuscitation. Previous courses in other settings were longer than our single 90-minute course, which may explain their better results. A German study compared annual CPR courses taught either by schoolteachers or by emergency physicians over three and six years. Both groups performed similarly well in a multiple-choice test (92% and 90% correct answers, respectively) (Lukas et al., 2016). This was much higher than the 30% of

our students who remembered the correct procedure for resuscitation. This difference may be explained by the repeated courses over several years and by the assessment method with multiple-choice questions as compared to the open questions with free-text answers that we used. In the practical assessment of the study by Lukas and colleagues, the average compression rates were similar in both groups but too slow to current recommendations of 100–120 (69 and 72 per minute, respectively). The compression depth in both groups (40 mm and 42 mm) was close to the recommended compression depth by the European Resuscitation Council (ERC) of 5 cm (Lukas et al., 2016). The results of our study's practical assessment were similar, where 69% of students applied the correct compression rate and 71% the correct compression depth. The better results in the previous two studies compared to our study support the importance of repetition either in longer courses (up to six hours) or annual refreshers (Böttiger et al., 2020; Fleischhackl et al., 2009; Lukas et al., 2016).

A British study found no considerable difference comparing students' performance and CPR knowledge between those who were trained by peers versus by teachers (69% vs 66%, respectively) (Lester et al., 1997). This was slightly lower than the 76% in our study. However, compression rate and depth were not taken into consideration. In our study, we observed that only 52% of the students performed CPR correctly including all relevant aspects. While this study by Lester et al. does not show a significant advantage of peer teaching, it supports the inclusion of student aids. They may facilitate practical training in larger groups. Therefore, we think the approach to combine the instruction of CPR by schoolteachers with the supervision of student aids in smaller groups for practical training may help to get the most out of peer involvement.

Age of Students

When developing content for school-based courses, age-related factors should be taken into consideration. This should be reflected in the density of the curriculum and the materials used. Students' ability to perform sufficient chest compressions directly correlates with their age, weight, and height. In a British study using a 20-minute training, the 9–10-year-old students did not achieve the correct chest compression depth, where 19% of the 11–12-year-old students and 45% of those aged 13–14 were able to do so (Jones et al., 2007). In our study, 71% of students aged 12–15 years achieved the correct chest compression depth. The short duration of the 20-minute training might be a reason for the lower performance. In a German study, where students were trained for two consecutive school days, about 80% of the 10–13, 60% of the 8–9, and 40% of the 6–7-year-old students achieved the correct compression depth (Humbsch et al., 2023). Another German study compared the age groups 11–13 and 14–17 years and found that while the older students achieved a higher accuracy and a higher mean depth of chest compressions, all students benefited from the intervention (Dumcke et al., 2021).

Duration of Teaching Course and Refreshers

The WHO recommendation for CPR training in schools is two hours (Böttiger & Aken, 2015). However slightly shorter durations, such as 90 minutes in our study may also be sufficient for students aged 12 years or older. In a study from the U.S.A., 76% of 12–14-year-old students were able to perform sufficient CPR after a condensed 1-hour course, which was higher than the 52% in our study (Kelley et al., 2006).

Computer-based training may be beneficial especially when combined with practical training, as shown in a study from U.S.A. high school students from 9th to 12th grade were divided into four study groups: (i) control group, (ii) watching a movie about CPR and a practical training course, both in total for 90 minutes, (iii) a computer course and practical training course, both in total for 90 minutes, and (iv) a computer course for 45 minutes. The mean percentages of correct chest compression rates were 9%, 29%, 28%, and 21%, respectively (Reder et al., 2006). This was lower than in our study, where 69% achieved the correct chest compression rate. An advantage in our study setting may be the time students had during the practical training. As they were training in smaller groups with guidance from peers, each student had enough time to practice and receive feedback during the 45-minute session.

Type of Evaluation Method

Comprehensive resuscitation training in schools has been increasingly implemented in several countries. In Germany, only two of the 16 states offer regular training in their schools (Rücker et al., 2022). The evaluation of regular resuscitation training over six years in North-Rhine Westphalia showed that over 85% of the students were able to answer all questions on resuscitation correctly (Felzen et al., 2021). In our study, 99% of the students were able to report at least one of two emergency numbers correctly whereas the percentage of correct answers for other items ranged only from 18% to 51%. This may be because our questionnaires did not include multiple-choice questions on assessing resuscitation techniques but only open questions with free-text answers. This lack of a well-established guideline to measure the outcomes of first-aid interventions makes comparisons difficult and should be addressed in further research (Pellegrino et al., 2017).

Implications for Teaching Concepts

While the WHO recommendation gives a useful direction for resuscitation training in schools (Böttiger & Aken, 2015), different regions all over the world need teaching concepts adapted to their specific circumstances and school systems. With our results embedded in the currently available literature on the issue, we concluded a few directives for the development of teaching concepts:

- Schoolteachers with adequate training are capable of instructing students in resuscitation, the involvement of medical staff is not necessary. To facilitate training in larger groups, previously trained students may assist teachers by supervising practical training.
- As suggested by WHO, the starting age for resuscitation courses should be at least 12 years (Böttiger & Aken, 2015) when a significant proportion of students is physically able to perform sufficient resuscitation and old enough to understand the concepts behind resuscitation. We did not compare the resuscitation performance of children of different age groups with adults, therefore we cannot conclude an ideal starting age for resuscitation classes solely based on our research. However, we observed that students mainly aged 12–13 years benefited from this training.
- Course durations shorter than 2 hours may be sufficient if they are more practical in the school setting. In Germany, for example, school lessons generally last 45 minutes. The disruption of the normal timetable might be an obstacle to the implementation of resuscitation courses. Therefore 90-minute courses as investigated in our study may be an option.

An important aspect, that we did not cover in our research, is the importance of regular refresher courses. There is a German study that suggests annual refreshers over three years are sufficient for long-term skill retention (Lukas et al., 2016).

Strengths and Limitations

The strengths of our study include a relatively large sample size with 340 grade seven students. Further, we were able to complete the study during the recent COVID-19 pandemic with several long periods of school closure in Germany. We noted an overall high willingness to perform resuscitation despite the increased awareness of contagious diseases in the context of the pandemic. Almost all invited students agreed to participate in theoretical as well as practical assessments. Thus, our results can be considered representative of the participating schools and their catchment area.

Our study had some limitations. First, the resuscitation courses were planned to take place in 33 different schools, and for their evaluation, we planned to randomly select 5–6 schools from the 4 different districts of the state. However, due to the pandemic, this was not possible. Nonetheless, five schools implemented the resuscitation course. All of them agreed to participate in the evaluation. The schools and teachers implementing the project under such difficult conditions were likely to be the most enthusiastic institutions (and teachers) among all 33 schools that had sent teachers to the special training. Thus, we cannot rule out a selection bias and may have overestimated the benefits of the course. On the other hand, we might have underestimated the benefits of the course, considering that 38% of the participating students had previous first-aid training experience.

Secondly, to respect possible data protection concerns of the parents and schools, we did not collect personal data like names or addresses from the students and collected only anonymous data. Therefore, we were not able to link the baseline with the follow-up questionnaires on an individual level. As the time between both assessments was relatively short and the number of students did not differ much, we assume that this should not have influenced our results considerably. On the other hand, the anonymous approach helped us to include almost all eligible students and achieve a high participation rate. Any differences in individual learning ability that we were unable to detect in this anonymous approach are not relevant to scaling across the breadth of the school landscape anyway, as students' learning readiness and ability are routinely heterogeneous across classes. Such a teaching concept must be robust in this regard.

Thirdly, as the baseline and follow-up questionnaires on knowledge were identical in design, some students may have memorized the correct answers without any real understanding. The questionnaires were collected a day before the course and not discussed in class. The students did not receive any feedback on the baseline questionnaires. Further, the questionnaires were not part of the material used during the course. Therefore, we do not expect a considerable impact on the follow-up questionnaires.

Fourthly, while the high willingness to help in emergencies that we observed is a pleasing result, in its appraisal social desirability bias must be considered. Some children may be inclined to choose the more socially acceptable answer to feel competent and brave instead of indicating their actual feelings toward the situation. Our study staff informed the students that this questionnaire was anonymous, and that no teacher would have access to the questionnaires. Furthermore, we ensured privacy while the questionnaires were being filled out. We also expressed the importance of accurate statements for a realistic evaluation of the course.

Finally, the very positive results of the practical examination were only based on a small subgroup. While the theoretical assessment was delayed for some students, the subgroup with practical examinations was assessed one month after the course without exception. Due to the smaller sample size, the results of this part of the evaluation may be regarded as less representative. As we conducted an anonymous assessment to achieve high participation rates, we were not able to compare the individual results of the subgroup's self-report questionnaire results with the whole sample to examine if the subgroup may have also performed better in the theoretical assessment. However, we selected all subgroup students randomly, therefore the results of the practical assessment may suggest that students of this age group learn resuscitation at least as well or better by watching the instructors and imitating their performances rather than by theoretical teaching methods. As the state-wide role out of the Herzensretter concept is planned, further theoretical and practical evaluations of larger samples in different settings are necessary and were recommended to the state ministry of education.

CONCLUSIONS

Overall, the 90-minute resuscitation course of the German "Herzensretter" project had several positive effects. The large proportion of students who were willing to help others in emergencies was remarkable. However, at least half of the students were not able to answer any of the questions on how to perform chest compressions for cardiopulmonary resuscitation correctly one month after the course. The lower proportion of correct answers in the theoretical compared to the practical assessment may have been due to the short duration of the training (90 minutes), the size of the classes (more than 20 children per class), or the emphasis on practical training.

Future studies should balance the theoretical and practical content of the courses and include larger samples for practical assessments. They should also accompany the students from an early stage to collect prospective data on long-term retention and examine the benefits of refresher courses. The implementation of resuscitation training in schools should be evidence-based in development and practice.

DATA ACCESSIBILITY STATEMENT

The data used in this study is available upon reasonable request from the corresponding author and agreement of the Brandenburg State Ministry of Education.

COMPETING INTERESTS

Josephina Kehlert received a student research grant by the Pépinière Foundation, Frankfurt (Oder), Germany. This research grant was partially funded by the Ministry of Science, Research and Culture of the federal State of Brandenburg, Germany. Beyond that she is a member of the Pépinière Association, which is a local voluntary organization that carries out first aid projects in primary schools in the state of Brandenburg.

Philipp Humbsch is a co-founder of the Pépinière Foundation and the Pépinière Association, which are voluntary organizations that carry out first aid projects in primary schools in the state of Brandenburg.

Ralf Sick and Carsten Cüppers work for the voluntary humanitarian organization Johanniter-Unfall-Hilfe e.V. (Berlin, Germany). Ralf Sick is the division manager of the Business Unit Education. Carsten Cüppers is the department manager for lay first aid training. Both were involved in the development of the "Herzensretter" concept of the current study including the training of the participating teachers.

Ilknur Ergeç and Malte Bödeker are with the Federal Centre for Health Education (BZgA), a specialist authority within the portfolio of the German Federal Ministry of Health, which funded the study. Malte Bödeker is the head of unit for "Children and adolescents, school and daycare, layperson CPR" and Ilknur Ergeç is the consultant responsible for layperson CPR at the BZgA.

Katja Icke, Anne Berghöfer and Thomas Keil stated that they do not have a conflict of interest to disclose.

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