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Trained Teachers Are Noninferior to Healthcare Professionals in Delivering Compression-Only CPR and AED Training to Secondary School Students: A Multicenter Randomized Trial

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Abstract

The long-term rollout of basic life support (BLS) instruction in secondary schools faces numerous obstacles. It remains uncertain whether school teachers who receive instructor training can deliver BLS education that is no more than 20% inferior (noninferiority margin) to that provided by healthcare professionals when assessing simulated BLS performance among secondary school students. A two-arm, parallel, blinded, noninferiority randomized controlled study was undertaken in four secondary schools in Hong Kong after teachers completed BLS instructor preparation. Students were assigned to either a trained-teacher group or a healthcare-instructor group for a 2-hour compression-only CPR plus automated external defibrillator (CO-CPRAED) session. Evaluators who assessed BLS performance six months after the course remained blinded to group allocation. Among the 33 teachers who received training, 13 (39.4%) agreed to instruct the CO-CPRAED classes. A total of 311 students (median age 15 years; 67% male) were randomized to the teacher-led arm (n = 161) or the healthcare-led arm (n = 150). At the six-month follow-up, both groups demonstrated high passing rates for BLS skill performance (teacher: 88% vs. healthcare: 91%; mean difference −3%, 95% CI −11% to 5%; P = 0.22). Knowledge retention stayed high (>90%) in each group and showed no significant difference between them (P = 0.91). Teachers expressed mildly favorable attitudes toward future BLS instruction, whereas students showed extremely strong enthusiasm for learning and carrying out BLS. A short 2-hour CO-CPRAED lesson delivered by trained teachers was noninferior to instruction by healthcare professionals and was linked to highly positive student attitudes, as well as strong retention of BLS knowledge and practical skills.

Keywords: Adolescent, Education, Out-of-hospital cardiac arrest, Hong Kong

Introduction

Out-of-hospital cardiac arrest (OHCA) remains a major contributor to mortality worldwide [1]. In Hong Kong, survival to hospital discharge or 30 days stands at 2.3% [2], markedly lower than the global benchmark of roughly 9.9–13.3% [3]. Factors that may explain this limited survival include the low frequency of bystander CPR (<30%) and the extremely limited use of automated external defibrillators (AEDs) (<2%) [2, 4]. By comparison, Denmark reported 2019 bystander CPR rates of 80% and a 30-day survival of 14% [5].

Because students are typically receptive, quick to acquire new psychomotor skills and able to retain them for extended periods, integrating BLS instruction within school curricula could help cultivate an entire generation capable of responding effectively to cardiac arrest events [6]. Our earlier work demonstrated that 13- to 15-year-old students could successfully complete a brief 2-hour CO-CPRAED course taught by healthcare professionals [7].

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Nevertheless, routinely relying on volunteer healthcare staff to deliver such training is logistically demanding and unsustainable. Additional barriers to widespread BLS education in secondary schools include inadequate funding for equipment, heavy curriculum demands, limited administrative support, and insufficient teacher training [8–10].

Both school administrators and teachers have indicated that teachers must receive updated BLS training if school-based BLS programs are to be maintained long term [9–11]. A survey assessing Hong Kong teachers' preparedness to teach CPR found low willingness (32%) [8], attributed to limited BLS knowledge, discomfort with performing or teaching CPR, and fears about potential legal consequences in the absence of Good Samaritan protections [8, 12]. Conversely, European observational research has reported beneficial outcomes associated with teacher-delivered BLS instruction [13, 14]. In view of these mixed findings, we conducted a multicenter noninferiority randomized trial to determine whether teacher-led instruction, after dedicated training, is within 20% of healthcare-led CO-CPRAED training in terms of simulated BLS performance among secondary school students.

Methods

Trial design and participants

A two-arm, parallel, blinded, noninferiority randomized controlled trial (RCT) was implemented in four secondary schools in Hong Kong. Approval for the protocol was granted by the Survey and Behavioural Research Ethics Committee of The Chinese University of Hong Kong (SBRE(R)-21-020). Written consent was obtained from school principals, teachers, and parents of enrolled students. The study was prospectively registered in the Chinese Clinical Trial Registry (ChiCTR1900027130). This manuscript follows the CONSORT requirements.

From July 2019 to October 2022, teachers at five schools were invited to complete the American Heart Association (AHA) BLS provider course, delivered on school premises at no cost prior to the student CO-CPRAED sessions. Students aged 14–18 years—regardless of earlier exposure to BLS or AED training—were eligible once the school confirmed additional timetable availability for both the BLS course and the 6-month follow-up. No other exclusion criteria were applied.

Randomization and blinding

At each participating site, students were randomized in a 1:1 ratio into either the trained-teacher instructor arm or the healthcare-instructor arm using computer-generated allocation codes. The randomization list was created by an author (AL) who had no role in recruitment, teaching, or data handling. Each student received an envelope (prepared by HHTC, also not involved in recruitment, training, or assessment) containing their assigned group and a numbered label to wear on the training day. Blinded assessors—AHA-certified BLS instructors who did not participate in teaching the CO-CPRAED course—evaluated outcomes at the 6-month mark. Students who completed both the training and follow-up evaluation were issued a CUHK "CPR for Schools Participation Certificate" to help minimize dropout.

Instructor groups for CO-CPRAED training

Teachers in the intervention arm held a valid AHA BLS provider certificate and consented to teach the CO-CPRAED session. They were supplied with a teaching video and materials from the CPR in School Training Kit™ one week before the student training to support lesson planning. In the comparator arm, all volunteer instructors were AHA BLS–qualified clinical staff working in Emergency Medicine, Intensive Care, or Anesthesiology.

On the training day, both instructor groups attended a one-hour briefing delivered by the study team. The briefing covered the lesson content, reviewed all CO-CPRAED materials, included repeated demonstrations and practice on manikins to reinforce BLS points, and discussed typical student questions and suitable responses.

Students' BLS intervention

The 2-hour CO-CPRAED course structure, equipment, and teaching plan have been detailed previously [7]. The curriculum followed the AHA CPR in School Training Kit™ model. In short, students first participated in a discussion on recognizing cardiac arrest and the immediate actions required (10 minutes), watched a video illustrating compression-only CPR and safe AED operation (10 minutes), and then engaged in hands-only CPR and AED skills practice using a "practice-while-watching" method (75 minutes). Both instructor types offered individualized feedback on hand placement, compression depth, and compression rate as students practised CO-CPR on a Laerdal Mini Anne manikin for 15 minutes. Instructors also demonstrated AED pad placement, delivery of the initial shock, and emphasized continuing CO-CPR after defibrillation using a Laerdal Little Anne manikin in small groups.

Every student carried out the steps of a simulated cardiac arrest scenario with real-time prompting and corrections from the group instructor. Each session trained up to 40 participants, maintaining a maximum student-to-instructor ratio of 10:1. For chest-compression practice, the manikin-to-student ratio was 1:1; for simulated cardiac arrest

scenarios, the manikin-plus-AED-to-student ratio was 1:10. These ratios were consistent with AHA recommendations for the CPR in School Training Kit™ program.

Outcomes and measures

The primary endpoint was the proportion of students who passed the BLS skills assessment at the 6-month follow-up, applying a noninferiority margin of 20%. Secondary endpoints included changes in students' and teachers' knowledge and attitudes, as well as the proportion of trained teachers who subsequently served as CO-CPRAED instructors (%).

School teachers study instruments

Before attending the BLS provider course, participating teachers completed a questionnaire. It contained five multiple-choice items (each with four options) aligned with the 2015 AHA BLS recommendations, one question addressing whether CPR instruction should be compulsory in secondary schools, and five attitude statements rated on a Likert scale [8]. The same instrument was re-administered after teachers completed the BLS provider course to evaluate changes in knowledge and views regarding CPR instruction.

Student study instruments

• *(a) Objective structured clinical examination (OSCE)*

Students underwent an assessment in which they were required to respond to a simulated cardiac arrest, carry out CO-CPR, and apply an AED correctly on a manikin (LittleAnne; Laerdal). Each student was examined separately in a different room without observing peers. The evaluation concluded that once the student continued CO-CPR for one minute after delivering the first simulated shock. Scoring criteria were adapted from the AHA Heartsaver Course, and an OSCE pass required fulfilling all nine checklist criteria [7].

• *(b) Knowledge and attitudes questionnaire*

Both groups completed a survey prior to training, immediately after the session, and again at the 6-month mark. Questionnaire items were based on materials from the CPR in School Training Kit™ and from a previously validated local instrument measuring attitudes toward CPR [15]. The survey included five multiple-choice items on CO-CPR and AED knowledge, ten Likert-scale statements reflecting attitudes toward bystander CPR/AED, five Likert-scale items (1 = very unimportant, 5 = very important) on factors that might deter CPR performance, and three enabling-factor questions. A ≥20% improvement in knowledge score was regarded as clinically meaningful [7]. Attitude scores summed to 30, with higher totals indicating more positive perspectives.

Sample size

A sample of 152 students in each arm (trained-teacher instructors vs. healthcare instructors) provided 90% power to detect a 20% noninferiority margin, based on prior findings at 4-month follow-up [16]. A one-sided pooled Z test at $\alpha = 0.025$ (equivalent to a two-sided 95% CI) was applied. With an expected 10% attrition rate, the total required sample size increased to 335. Calculations were generated using PASS 14 (NCSS, LLC, Kaysville, Utah, USA).

Data analysis

Because no crossover between groups occurred, the modified intention-to-treat analysis [17] and the per-protocol analysis produced identical primary-outcome results. Missing values for knowledge or attitude items were not imputed. Diverging stacked bar charts were created to visualize temporal changes in Likert-scale responses concerning CPR attitudes and barriers [18]. Knowledge and attitude changes for teachers and students were examined using McNemar's tests and generalized estimating equations (GEE) [19] with school-level adjustment. GEE was selected due to its flexibility in modeling varying outcome types, correlations, and occasional missing data [19]. A sensitivity check comparing baseline characteristics of students with complete 6-month data across instructor groups was performed to evaluate potential attrition bias [20].

Differences in overall BLS skill pass rates between instructor groups were estimated using modified Poisson regression while adjusting for school effects [21]. Noninferiority was concluded when the lower bound of the one-sided 97.5% CI (equivalent to a two-sided 95% CI) lay within the predetermined noninferiority region [22]. Analyses were carried out using Stata 18.0 (StataCorp, College Station, TX) and SPSS 27.0 (IBM, Armonk, NY). A two-sided significance threshold of $P < 0.05$ was applied.

Results

Among the 33 trained teachers from five schools (four single-sex schools and one international coeducational school), 16 were unable to teach the CO-CPRAED classes due to school closures caused by social unrest (2019/2020) and COVID-19. Twenty-six teachers (78.8%) were younger than 45, and 19 (57.6%) were male. Two

teachers (6.1%) had witnessed a cardiac arrest. While 78.8% had prior CPR training, most (60.6%) had not received AED instruction before the AHA BLS course. Key motivators for participating in BLS training were school-based delivery (100%), free access (87.1%), and timing after exams (76.7%). Although 23 teachers (69.7%) expressed willingness to teach the CO-CPRAED course, 13 (39.4%) ultimately volunteered as instructors. The average (SD) time between AHA BLS training and CO-CPRAED teaching was 80 (62) days.

Of 329 eligible students across four schools, 311 (94.5%) were randomized—161 to the teacher-led group and 150 to the healthcare-led group—between November 2021 and December 2022 **(Figure 1)**. Baseline characteristics were comparable between groups **(Table 1)**, which was confirmed in the sensitivity analysis . The average (SD) time from CO-CPRAED training to follow-up assessment was 174 (48) days.

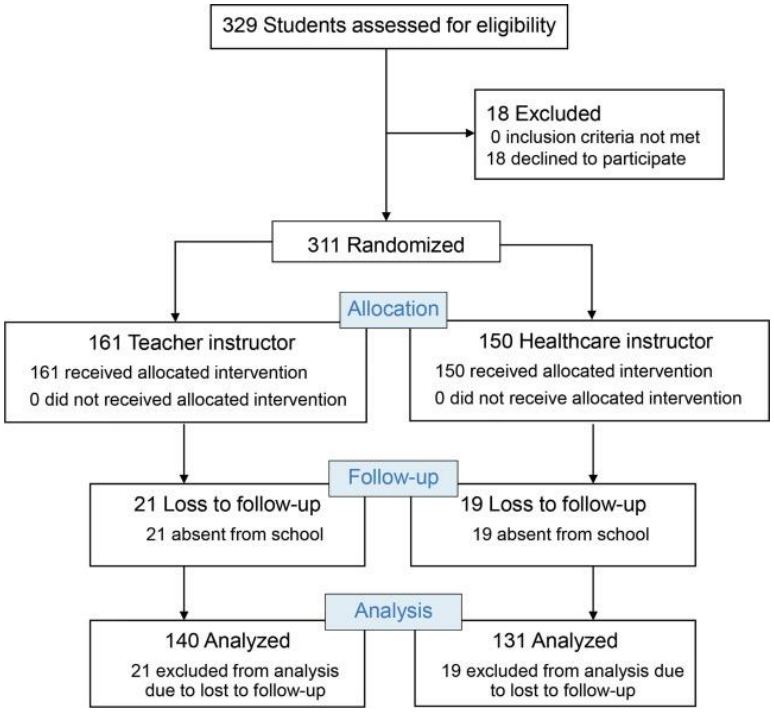

Figure 1. Diagram outlining participant progression from enrollment through the 6-month assessment

Table 1. Baseline features of the intention-to-treat cohort of students

Characteristic	Teacher instructor group (n = 161)	Healthcare instructor group (n = 150)
School, n (%)		
School 1	35 (21.7)	35 (23.3)
School 2	27 (16.8)	25 (16.7)
School 3	65 (40.4)	61 (40.7)
School 4	34 (21.1)	29 (19.3)
Sex, n (%)		
Male	108 (67.1)	101 (67.3)
Female	53 (32.9)	49 (32.7)
Age, years, median (IQR)	15 (15–16)	15 (15–16)
Body weight, kg, median (IQR)	56.0 (50.0–63.5)	56.0 (50.0–64.0)
Previous CPR/AED training, n (%)	4 (2.5)	10 (6.7)

Abbreviations: AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; IQR, interquartile range.

Teachers' knowledge and attitudes

Two teachers (6.1%) left the knowledge section incomplete. Pre- and post-training knowledge results for those who received instruction appear in **Table 2**. Total knowledge accuracy increased from 57% (95% CI: 48–65%) to 95% (95% CI: 91–99%), yielding a mean rise of 38% (95% CI: 29–47%) **(Table 2)**.

Table 2. Percentage of correct responses to knowledge items among teachers and students over time

Assessment Item	Group	Baseline	Immediately After Training	6-Month Follow-Up	p-value*
BLS Provider (Teacher) Knowledge Assessment					

Correct order of steps to save a cardiac arrest victim, n/N (%)	BLS Providers	26/31 (83.9)	31/31 (100)	—	0.025
Effect of untreated cardiac arrest on survival chances, n/N (%)	BLS Providers	24/31 (77.4)	27/31 (87.1)	—	0.257
Desired chest compression rate, n/N (%)	BLS Providers	15/31 (48.4)	31/31 (100)	—	<0.001
Desired chest compression depth, n/N (%)	BLS Providers	12/30 (40.0)	29/30 (96.7)	—	<0.001
Recommended compression-to-ventilation ratio, n/N (%)	BLS Providers	10/31 (32.3)	29/31 (93.5)	—	<0.001
Overall knowledge score, mean % (95% CI)	BLS Providers	57 (48–65)	95 (91–99)	—	<0.001
Student Knowledge Assessment					
Compression rate during 1 minute of hands-only CPR, n/N (%)	Teacher group	78/161 (48.4)	159/161 (98.8)	124/140 (88.6)	0.817
	Healthcare group	79/150 (52.7)	150/150 (100)	118/131 (90.1)	
When to stop chest compressions during hands-only CPR, n/N (%)	Teacher group	106/161 (65.8)	157/161 (97.5)	131/140 (93.6)	0.233
	Healthcare group	102/150 (68.0)	147/150 (98.0)	129/131 (98.5)	
Required compression depth in adults during hands-only CPR, n/N (%)	Teacher group	97/161 (60.2)	152/161 (94.4)	121/140 (86.4)	0.650
	Healthcare group	90/150 (60.0)	146/150 (97.3)	111/131 (84.7)	
Function of an automated external defibrillator (AED), n/N (%)	Teacher group	125/161 (77.6)	157/161 (97.5)	133/140 (95.0)	0.961
	Healthcare group	115/150 (78.7)	147/150 (98.0)	125/131 (95.4)	
Correct steps for hands-only CPR, n/N (%)	Teacher group	119/161 (73.9)	157/161 (97.5)	134/140 (95.7)	0.454
	Healthcare group	102/150 (68.0)	147/150 (98.0)	127/131 (96.9)	
Overall knowledge score, mean % (95% CI)	Teacher group	65 (61–69)	97 (96–98)	92 (90–94)	0.909
	Healthcare group	65 (61–69)	98 (97–99)	93 (91–95)	

a McNemar's test applied to teachers with complete paired data.
b Generalized estimating equation for teachers accounting for school clustering.
c Generalized estimating equation for students with school-level adjustment; group × time interaction P value.

Fifteen of the 32 teachers (45.5%) agreed that CPR instruction ought to be compulsory for students. Their answers to the five attitude and readiness-to-teach statements prior to and immediately after AHA BLS training are summarized in **Figure 2**. Roughly half (51.6%) expressed concern about potential legal consequences connected to student CPR training **(Figure 2)**. Mean scores reflecting attitudes and willingness to teach CPR (maximum 25) changed significantly after adjusting for school differences: from 13.9 (95% CI: 12.9–14.9) pre-training to 16.3 (95% CI: 15.5–17.2) after training, representing a mean increase of 2.4 (95% CI: 1.4–3.3) (P = 0.002).

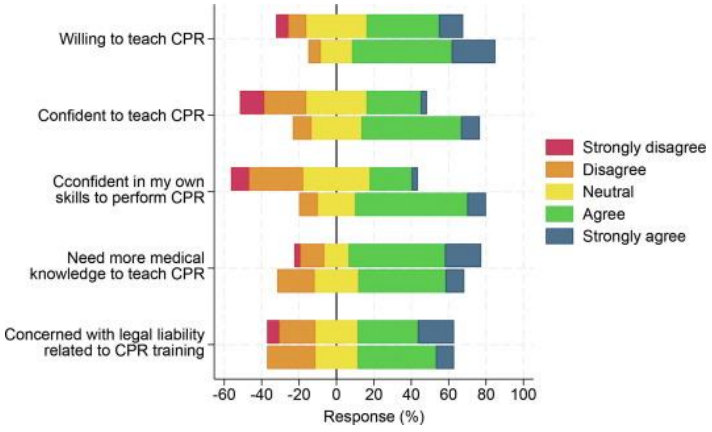

Figure 2. Diverging stacked bar chart illustrating teachers' Likert-scale responses before (top row) and immediately after (bottom row) the training session

Students' OSCE skill performance

OSCE pass rates at 6-month follow-up differed by school, ranging from 83% to 98% (P = 0.002). The unadjusted passing proportions did not differ meaningfully between instructor types: students taught by trained teachers passed at 88%, while those taught by healthcare professionals passed at 91% (mean difference −3.1%, 95% CI: −10.4% to 4.3%; **Table 3**). When school effects were incorporated into the model, the adjusted difference was −3.2% (95% CI: −11.3% to 4.9%), satisfying noninferiority criteria (P = 0.221). Excluding students with previous CPR/AED exposure produced comparable findings.

Table 3. OSCE skill outcomes at 6-month follow-up

Skill Item	Teacher-led group (n = 140)	Healthcare-led group (n = 131)	Mean difference (%, 95% CI)	p-value
1. Checks responsiveness, n (%)	138 (98.6)	128 (97.7)	0.9 (−2.4 to 4.1)	0.598
2. Calls for help / activates emergency response and requests AED, n (%)	140 (100)	130 (99.2)	0.8 (−0.7 to 2.3)	0.300
3. Performs high-quality chest compressions (correct rate and depth), n (%)	129 (92.8)*	122 (93.1)	−0.3 (−6.4 to 5.8)	0.917
4. Powers on the AED, n (%)	140 (100)	131 (100)	0.0 (0–0)	NA
5. Correctly places AED pads, n (%)	138 (98.6)	130 (99.2)	−0.7 (−3.1 to 1.8)	0.601
6. Clears for rhythm analysis, n (%)	137 (97.9)	130 (99.2)	−1.4 (−4.2 to 1.4)	0.347
7. Clears for safe shock delivery, n (%)	133 (95.0)	128 (97.7)	−2.7 (−7.1 to 1.7)	0.237
8. Presses shock button, n (%)	139 (99.3)	130 (99.2)	0.0 (−2.0 to 2.1)	0.962
9. Immediately resumes chest compressions after shock, n (%)	139 (99.3)	130 (99.2)	0.0 (−2.0 to 2.1)	0.962
10. Time to first shock, seconds, median (IQR)	60 (54–69)	60 (53–67)	0 (−3.0 to 3.0)†	1.000†
Overall pass rate (unadjusted), n (%)	122 (87.8)*	119 (90.8)	−3.1 (−10.4 to 4.3)	0.208
Overall pass rate (adjusted), % (95% CI)	87.9 (82.5–93.2)*	90.7 (85.8–95.6)	−3.2 (−11.3 to 4.9)‡	0.221

Abbreviations: AED, automated external defibrillator; IQR, interquartile range; NA, not applicable; OSCE, objective structured clinical examination.
a One missing value.
b Quantile regression.
c One-sided noninferiority comparison of proportions.
d Modified Poisson regression adjusted for school clustering; one-sided noninferiority P value.

Students' knowledge and attitudes

Student knowledge over time is detailed in **Table 2**. From baseline to 6 months, knowledge gains in the teacher-instructor group rose from 65% to 92% (change 27%, 95% CI: 22–31%), while the healthcare-instructor group increased from 65% to 93% (change 28%, 95% CI: 23–33%). The difference in change between groups was not significant (P = 0.431).

After adjusting for school effects (P = 0.040), no meaningful difference emerged between instructor groups in the evolution of attitude scores (P = 0.399). Mean attitude scores were comparable: 28.1 (95% CI: 27.8–28.3) for the teacher-instructor cohort vs. 28.4 (95% CI: 28.1–28.6) for the healthcare-instructor group (P = 0.093).

A notable proportion of students (45.1%) indicated reluctance to perform CPR due to legal concerns, and 57.6% feared causing harm if CPR was performed incorrectly (**Figure 3**). At follow-up, the factors most frequently motivating willingness to perform CPR included awareness that early CPR improves survival (82.2%), valuing life regardless of formal training (75.6%), and receiving CPR instruction in school (75.2%).

Regarding whether the victim's identity would influence their decision, 41 students (29.7%) in the teacher-instructor group and 26 (19.8%) in the healthcare-instructor group said it would (P = 0.062). Willingness to assist family members was reported by 106 students (76.8%) taught by teachers and 87 (66.4%) taught by healthcare professionals (P = 0.058). The proportion expressing readiness to help any person in need did not differ between groups (79.6% vs. 84.0%; P = 0.351).

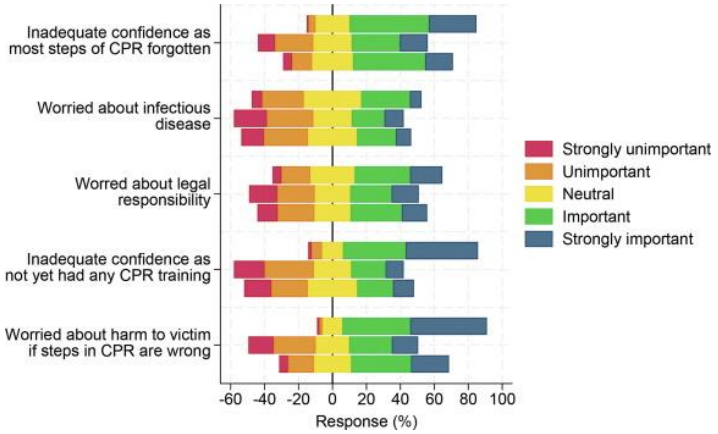

Figure 3.

Discussion

In this multi-school noninferiority RCT, assessment of students' BLS skills roughly six months after a short CO-CPR-AED program showed that teachers who had undergone AHA BLS provider training performed on par with healthcare professionals as course instructors. Of every ten teachers who completed the AHA provider course, four progressed to serve as CO-CPR-AED trainers. Both the BLS course for teachers and the student CO-CPR-AED sessions produced notable gains in CPR knowledge. At the 6-month mark, knowledge outcomes did not differ between the two instructor groups. Teachers generally held moderately positive perceptions and willingness to teach CPR, even though many expressed a preference for having complimentary BLS provider courses offered at their workplace. In contrast, students from both groups demonstrated consistently strong enthusiasm toward learning and carrying out BLS, with the only noticeable variation being their reported satisfaction with their ability to perform CPR.

To date, this appears to be the first randomized controlled comparison of instructor categories paired with a teaching video for a brief school-based BLS program. The results mirror those from our prior pre–post research on CO-CPR-AED performance, knowledge, and attitudes [7]. Our findings also align with two longitudinal investigations comparing trained teachers and healthcare instructors [13, 14], both of which reported no meaningful differences between groups regarding compression rate and depth [14]. A recent systematic review analyzing 17 RCTs (n = 5578) concluded that technology-supported, instructor-supervised CPR instruction with hands-on practice and real-time feedback was noninferior to standard instructor-led demonstration and practice for adolescent CPR knowledge and skills [23]. Collectively, this body of work underscores trained teachers as a viable, scalable option for BLS education.

Although positive attitudes toward CPR are generally linked to a higher likelihood of intervening in emergencies [15], nearly half of the students in this trial remained concerned about legal consequences, consistent with earlier observations from our group [7]. Similarly, around half of the trained teachers expressed apprehension about legal accountability, likely influenced by the absence of a Good Samaritan Law in Hong Kong. A local survey indicated that, if such legislation were enacted, 57% of first aid course participants would be more inclined to provide bystander CPR [24]. Introducing this legal protection might therefore increase teachers' openness to serving as BLS instructors and could raise survival rates for OHCA, which currently suffer from low community CPR and AED usage [2].

Limitations

Pandemic-related school closures reduced the pace at which schools and students could be enrolled. At one site, trained teachers were unable to recruit students because no curricular time was available for running the CO-CPR-AED course. While the teachers effectively delivered the training, they lacked preparation in conducting BLS skill assessments. To address this, a future project will measure agreement between trained teachers and healthcare assessors in evaluating students' performance. To support broader implementation in local secondary schools, we have developed a Cantonese instructional video, reflecting the primary language used in teaching. During the RCT, instructors conducted manikin practice sessions in students' preferred language (English or Cantonese). Evidence from a recent study in multicultural settings emphasized that offering BLS training in participants' preferred language enhances uptake [25].

Conclusions

Teacher instructors were shown to be noninferior to healthcare instructors in conducting CO-CPR-AED sessions. The approach fostered highly positive student attitudes toward CPR, along with sustained retention of BLS knowledge and skills for up to six months. These results reinforce the suitability of trained teachers as credible and effective CO-CPR-AED instructors within the local school setting.

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Conflict of interest: The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 'CYY is a lecturer at the Hong Kong Red Cross. All other authors declare no conflicts of interest'.

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Ethics statement: None.

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