BMJ Open Brief compression-only cardiopulmonary resuscitation and automated external defibrillator course for secondary school students: a multischool feasibility study

Kit Ying So,¹ Hiu Fai Ko,^{1,2} Cindy Sin Yui Tsui,³ Chi Yeung Yeung,¹ Yee Ching Chu,¹ Veronica Ka Wai Lai ,^{2,4} Anna Lee ²

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ABSTRACT

Objectives This study assessed the feasibility and preliminary efficacy of a 2-hour compression-only cardiopulmonary resuscitation and automated external defibrillator (CO-CPRAED) course in secondary school students.

Design Prospective pre-post feasibility study.

Setting and participants 128 students (12–15 years old) without prior basic life support (BLS) training at four secondary schools in Hong Kong. All students were followed up at 3 months after training.

Interventions Emergency medicine-trained nurse and physicians taught the 2-hour CO-CPRAED course using the American Heart Association 'CPR in School Training Kit' programme. Students were trained in groups up to 40 students/session, with an instructor to student ratio not exceeding 1:10. To practise hands-on compressions, the manikin to student ratio was 1:1. For a simulated cardiac arrest, the manikin and AED to student ratio was 1:10.

Primary and secondary outcomes CPR and AED knowledge, attitude statements towards bystander CPR and AED, quality of BLS performance skills during training and at 3 months.

Results Some students (46%) knew how deep to push on an adult chest when doing CO-CPR before training. The course was associated with an increase in knowledge score (pretraining 55%, post-training 93%; adjusted mean difference (MD) 38%, 95% CI 33% to 43%; $p < 0.001$). Most students (68%) thought that CPR education in senior secondary school was essential before training. The students had a very positive attitude towards CPR; no change in the mean (SD) attitude score out of 30 over time (pretraining 27.2 (2.5), post-training 27.6 (2.7); adjusted MD 0.5, 95% CI -0.1 to 1.0; $p = 0.132$). Most students were competent in performing BLS immediately after training (77%) and at 3 months (83%) (adjusted MD 6%, 95% CI -4% to 15%; $p = 0.268$).

Conclusions The results demonstrate the feasibility of scaling up the number of secondary schools trained in a brief CO-CPRAED course within the local school curriculum.

Strengths and limitations of this study

- As this is a multischool feasibility observational study, causal relationships between the course and students' measures must be made with caution.
- Valid and reliable course materials, objective structured clinical examinations and knowledge and attitude questionnaires were used throughout this study.
- The recruited schools were not randomly selected but were chosen by the authors who had established collaborations with the senior school management teams.
- The study does not present long-term follow-up beyond 3 months of students' competency in basic life support skills.
- Limited to secondary school students in Hong Kong, China.

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is an important global public health issue, with a 10-fold global variation in incidences and outcome.¹ The 30-day survival rate or hospital discharge rate associated with OHCA in Hong Kong is low (2.3%) and is probably due to low rates of bystander cardiopulmonary resuscitation (CPR) and use of automated external defibrillator (AED) (28.8% and 1.4%, respectively).² The Hong Kong general public knowledge of CPR showed that over half of adult respondents (57%) knew very little about how to perform CPR and highlighted the need for CPR training in secondary school and college curricula.³

School-based first aid interventions can significantly contribute to the number of adults trained in first aid and basic life support (BLS) in the community over time.^{4,5} Students are more likely to perform CPR to a

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For numbered affiliations see end of article.

Correspondence to

Dr Anna Lee;
annalee@cuhk.edu.hk

victim promptly if they have been trained in BLS.^{4 5} Teenagers are competent in learning and performing BLS skills after a brief training intervention.^{6–11} However, the effectiveness of these BLS programmes varies according to trainer type, content and duration of training, assessment methods and students' age, gender and body weight.^{6 12 13}

Currently, there is no consensus on the optimal content and duration of training for use of AEDs. A layman older than 16 years old can enrol in St John's Ambulance or Red Cross First Aid courses covering CPR and use of AEDs in Hong Kong. AED training often occurs in a stand-alone course after obtaining a valid First Aid certificate or a CPR certificate. The course duration is 4 hours and the syllabus includes the topics of physiology of heart and cardiac rhythm, principle of defibrillation, operations and protocol of AEDs, safety and maintenance. When combined with adult CPR training, the course takes 6 hours resulting in essential comprehensive knowledge and skills for AED owners and facility staff. However, for general public use of AED in an OHCA scenario, the only life-saving knowledge likely to be important is just the AED operation and its safety.

To address the limited availability of time in the school curriculum, we developed a 2-hour 'Compression-only CPR and AED (CO-CPRAED)' course for secondary school students delivered by healthcare professionals. The first objective of the feasibility study was to determine the recruitment and 3-month retention rates of secondary school students interested in participating in the CO-CPRAED course. The second objective of the study was to assess the preliminary efficacy of the CO-CPRAED course on student's knowledge, attitudes and quality of simulated resuscitation (CO-CPR and AED use) to inform the design of larger multischool randomised non-inferiority controlled trial.

METHODS

Study design and participants

This prospective pre-post feasibility study was conducted during the academic year 2018/2019 (September 2018 to March 2019) at three public (single-sex) schools and one private coeducational international secondary school. We invited students aged 12–15 years without prior BLS or AED training to participate in the study. We obtained written informed consent for the study from the school principal and parents before training. The Resuscitation Council of Hong Kong accredited the course.

Patient and public involvement

There were no funds or time allocated for secondary school students, teachers or school principals to be involved in the design, methodology and analysis of the study.

Content of training course

We recruited five instructors for the course in four secondary schools. They were a volunteer emergency

medicine nurse and physicians with varying BLS teaching experiences. We obtained approval from the American Heart Association (AHA) to use the lesson plan, knowledge tests, teaching video and training materials of the CPR in School Training Kit. We used an AED trainer 3 for simulating the HeartStart FR3 model during the course.

First, an instructor led a discussion with students on how to identify a cardiac arrest victim and what initial steps to take when encountering a cardiac arrest victim (10 min). This was followed by showing the teaching video demonstrating CO-CPR and use of an AED (10 min). Students then practised hands-only CPR and AED skills on manikins (75 min).

We adopted a skill practice while watching strategy; compression-only CPR without mouth-to-mouth ventilation was taught, together with an alignment to the AHA AED protocol. First, the instructors gave specific feedback to individual students on the correct hand positioning, appropriate rate and depth of compression while practising CO-CPR on a Laerdal Mini Anne manikin (15 min). Second, the instructors demonstrated the correct positioning of AED pads, how to deliver the first shock safely and emphasised the need for CO-CPR continuation after the first defibrillation on a Laerdal Little Anne manikin in small groups. Each student then practised the steps involved in a simulated cardiac arrest scenario, with individual feedback and prompts from their small group instructor.

The students were trained in groups up to 40 students/session, with a student to instructor ratio that did not exceed 10:1. To practise hands-on compressions, the manikin to student ratio was 1:1. For a simulated cardiac arrest, the manikin and AED to student ratio was 1:10.

Objective structured clinical examination

In the last 30 min of the training session, students were individually assessed on their ability to act in a cardiac arrest scenario. The same training instructors acted as examiners, but were allocated to another small group to assess the student's performance and to give feedback to the class after the completion of the resuscitation test. For the objective structured clinical examination (OSCE), students were prompted by an examiner with the following statement: *'This patient is found collapsed on the ground. There is another person nearby who might help but they do not know any first aid. This person might help you to get an AED if you need.'* Each student was assessed individually and was blinded to the performance of other students. The examiner provided an AED 30 s after the student had initiated CPR and the assessment ended 1 min after the first defibrillation.

The marking scheme for assessing the student's performance was based on the AHA Heartsaver course. The assessment criteria included the following nine checklist items:

1. Checks response of patient.
2. Shouts for help and sends someone to call the ambulance and to get an AED.

3. Performs high-quality compressions (correct hand position, correct rate and depth of compression and complete recoil after each compression). The manikin was installed with a sensor and was connected to an app on an electronic device. The sensor detected the compression rate, depth and whether there was complete recoil. A score was generated after 2 min of chest compressions. High-quality compression was regarded as a score higher than 75%.
4. Powers on AED.
5. Attaches AED pads correctly.
6. Clears for analysis.
7. Clears to safely deliver a shock.
8. Presses button to deliver a shock.
9. Immediately resumes compression after shock.

Each checklist item was evaluated with 'yes' or 'no'. Students passed the OSCE if all nine items were marked 'yes'. The OSCE passing rate was calculated as the proportion of students meeting all nine checklist items. We also measured the 'time to first shock' in seconds. The same OSCE was given to students at 3 months after training to assess their BLS skills retention.

At the end of the training session, we introduced the 'Lifesaver' game⁸ to the students by showing the weblink and a screen capture of it. We did not demonstrate how to play the game but did encourage the students to check it out as an extra educational resource for reference. During the 3-month period, students could freely access 'Lifesaver'⁸ through personal choice. Students were asked if they had used 'Lifesaver' and to rate the statement about how helpful the game was to enhance their knowledge and skills to perform CPR and AED on a five-item Likert scale on the follow-up questionnaire.

Knowledge and attitudes questionnaire

Students completed an identical, validated, 25-item knowledge and attitudes questionnaire before and at 3 months after BLS training. The bilingual questionnaire consisted of 5 multiple-choice questions on CO-CPR and AED knowledge taken from the CPR in School Training Kit, 10 attitude statements towards bystander CPR and AED with 5-item Likert scale responses from 1 (strongly disagree) to 5 (strongly agree) and 10 questions on barriers and enablers to performing CPR.¹⁴ We considered a passing mark of 50% and a 20% increase in knowledge score to be a noticeable and valuable change¹⁵ associated with the training course a priori. The responses to the 10 attitude statements were summated to give an overall attitude score, ranging from 10 to 30, with higher scores representing a more positive attitude towards CPR.¹⁴

At the 3 months of follow-up, students were asked to rate how well the course learning outcomes were met using a 5-item Likert response from 1 (strongly disagree) to 5 (strongly agree). The learning outcomes included: (1) recognise that performing CPR saves lives, (2) recall the two easy steps of hands-only CPR: call 999, and push hard and fast in the centre of the chest, (3) perform hands-only CPR at a rate of 100–120 compressions per

minute, pushing down at least 5 cm on the chest, and (4) demonstrate how to use an AED.

Statistical analysis

This is a feasibility study. When the sample size is 97, a two-sided 95% CI for a single proportion using the large sample normal approximation will extend 10% from the observed proportion for an expected proportion of 50% of students passing the 3-month knowledge and CO-CPRAED skills test (nQuery Advisor V.7.0, Statistical Solutions, Cork, Ireland). To adjust for possible lost to follow-up at 3 months, we expected to recruit a total of 120 students (30 students per school).

Individual knowledge, barriers and enablers to performing CPR, and skill performance items are reported as frequency counts (%). Wilcoxon rank-sum test and McNemar's test were used to compare the individual knowledge and skill items over time respectively. No imputation was carried out for missing responses to individual attitude statements but missing data for estimating the overall attitude score were imputed by sample median. To visually compare the Likert scale responses to the attitude towards CPR statements and barriers to performing CPR over time, diverging stacked bar charts were drawn.¹⁶

The overall students' knowledge of CPR score, overall attitude towards CPR score and time to first shock are reported as means and SDs or median and IQR as appropriate after checking for normality by visual inspections and using the Shapiro-Wilk tests. Mixed-effects models were used to estimate the change over time for knowledge score, attitude score and OSCE passing rate after adjusting for school effect, age and gender.^{17 18} The McNemar's test was used in a post hoc analysis of the OSCE passing rate over time in students who played the 'Lifesaver' game.⁸ The school intraclass correlation was estimated after performing a mixed-effects logistic regression for OSCE skills. SPSS V.24.0 (IBM) software and Stata V.16.0 (StataCorp, College Station, TX) were used for data analyses. The level of significance was set at $p < 0.05$.

RESULTS

One hundred and twenty-eight students attended a CO-CPRAED training session. At one school, the recruitment was undersubscribed (20/27 students attended) due to the training session being held after normal school hours. In two other schools, the course was held during school hours and was oversubscribed (78/60 students attended). The remaining school recruited 30 students. There was no loss to follow-up at 3 months after training. The numbers of students participating in each age group in the study were 18 (12–13 years old), 97 (13–14 years old) and 13 (14–15 years old). Most were females (72.7%). Few (11.7%) students had played the 'Lifesaver'⁸ game before the 3-month follow-up; most (66.7%) strongly agreed with the statement that the game helped them to

Table 1 Success rate (%) of correct responses to knowledge questions before and after BLS training

Questions	Before (%) (n=128)	After (%) (n=128)	P value
1. When performing hands-only CPR, how many times should you push in the centre of the chest during a 1 min period?	67 (52.3)	124 (96.9)	<0.001
2. When do you stop pushing on the victim's chest during hands-only CPR?	63 (49.2)	122 (95.3)	<0.001
3. How deep should you push on the chest of an adult when doing hands-only CPR?	59 (46.1)	117 (91.4)	<0.001
4. What does an automated external defibrillator (AED) do?	96 (75.0)	117 (91.4)	0.001
5. What are the correct steps for providing hands-only CPR?	68 (53.1)	116 (90.6)	<0.001
Unadjusted overall mean (SD) knowledge score (%)	55.2 (24.2)	93.1 (11.9)	<0.001

BLS, basic life support; CPR, cardiopulmonary resuscitation.;

enhance their knowledge and skills to perform CPR and AED.

CPR and AED knowledge

The proportion of correct responses to individual multiple-choice questions before and after training is shown in [table 1](#). Less than half (46.1%) of the students knew how deep to push on the chest of an adult when doing CO-CPR before training. The pre-post passing rates were 60.2% and 98.4%, respectively. The difference in paired proportions of students passing the knowledge test over time was 38.3% (49/128 improvement and 0/128 decrement; $p<0.001$). The course was associated with an increase in knowledge score (pretraining 55%, post-training 93%; adjusted mean difference 38%, 95% CI 33% to 43%; $p<0.001$).

Attitudes towards performing CPR

Over 90% of students agreed or strongly agreed with the need to learn CPR knowledge and over two-thirds (68%) of students thought that CPR education in senior secondary school was essential before training ([figure 1](#)). As there was a marked shift in participant satisfaction with the level of knowledge to perform CPR before and after training ([figure 1](#)), we modified the scoring of this item in calculating the total attitude score at the 3-month follow-up by considering it as a positive statement. The students had a very positive attitude towards CPR; no change in the mean (SD) attitude score out of 30 over time after adjusting for school effect, age and gender (pretraining 27.2 (2.5), post-training 27.6 (2.7); adjusted mean difference 0.5, 95% CI -0.1 to 1.0; $p=0.132$).

Factors considered when performing CPR

In deciding when to perform CPR, the most common factor considered by students was about the relationship between starting CPR early and victim's increased survival rate (pretraining 82% vs post-training 92%). Having received CPR training in school was also associated with more willingness to perform CPR (pretraining 44% vs post-training 81%; $p<0.001$). The identity of the victim was unlikely to affect the decision to perform CPR (pretraining 69% vs post-training 72%). Of the 334 responses at follow-up, students indicated that they

would perform CPR on family members (25.1%), friends (24.3%), passers-by (18.0%) and any person in need (32.6%). The students were most worried about harming a victim if steps in performing CPR were wrong before training as the main factor for not performing CPR ([figure 2](#)). The least important factor considered when deciding not to perform CPR was being worried about contracting an infectious disease ([figure 2](#)).

OSCE skills performance

Students maintained a high level of BLS skills competency at follow-up ([table 2](#)). The median time to first shock was shorter at follow-up ([table 2](#)). The passing rate did not change over time (77% vs 83%, adjusted mean difference 6%, 95% CI -4% to 15%; $p=0.268$). In a post hoc analysis of 15 'Lifesaver' users, eight passed both OSCE assessments and two failed both OSCE assessments; five students who failed the first OSCE later passed the second OSCE at the 3-month follow-up ($p=0.063$). The school intraclass correlation was 0.02 (95% CI 0 to 0.33).

Course learning outcomes

All students gave feedback on how well learning outcomes were met by the course. The majority of students strongly agreed or agreed that the course enables them to recognise that performing CPR can save lives (96%), recall the two easy steps of hands-on CPR (97%) and be able to perform high-quality hands-only CPR (94%). Most students (94%) strongly agreed or agreed that they could demonstrate how to use an AED.

DISCUSSION

This multischool feasibility study demonstrated that it was feasible to recruit secondary school students to participate in a 2-hour CO-CPRAED course. The course was widely accepted by the students, particularly when it was conducted within normal school hours. A valuable and noticeable increase in knowledge score was associated with the course, with correct responses of more than 90% to each question observed after the 3-month follow-up. Students had a very positive attitude towards CPR, with no change in the mean attitude score over time. More

Figure 1 Diverging stacked bar charts for Likert responses to attitude towards CPR statements before (first row) and after (second row) training. CPR, cardiopulmonary resuscitation.

than 75% of students were competent in performing BLS at both assessment times. Almost all students were able to operate an AED correctly, with only a few attaching the pads inappropriately and not safely delivering a shock. The learning outcomes of the CO-CPRAED course were met for the majority of students.

Improving secondary school student's knowledge and attitudes towards performing CPR and using an AED is just as important as teaching the physical skills associated with the delivery of life-saving CPR and AED interventions.¹⁹ The large gain in BLS knowledge (38%, 95% CI 33% to 43%) in this study appeared to be greater than the results comparing a baseline control group and three postinstructional methods (computer training, computer

training plus practice, video plus demonstration and practice) for teaching CPR and AED.²⁰ Knowledge deficits in rate and depth of CPR compression were apparent before training in this study, but substantially improved and were retained at the 3-month follow-up. These results were also comparable to knowledge gains immediately after a training video and hands-on practice intervention delivered to five Singaporean junior secondary schools.¹⁹

A positive attitude towards CPR is likely to be a good predictor of a person willing to perform CPR in a real situation.¹⁴ Most students in this study were self-selected and motivated to learn CO-CPRAED skills to increase the victim's chance of survival. Our study showed that CO-CPRAED training in school was associated with

Figure 2 Diverging stacked bar charts for Likert responses to decision not to perform CPR statements before (first row) and after (second row) training. CPR, cardiopulmonary resuscitation.

a favourable change in confidence levels towards performing CPR and intentions to perform CPR. However, as with previous studies,^{14 19} the main barrier affecting CPR and AED practice was anxiety with harming the victim if steps in performing CPR were wrong. BLS instructors reassuring students, for example, about the trade-off of a victim with CPR-related broken ribs having a higher chance of survival versus poorer outcomes without CPR could partly address this common misconception.¹⁹ Nearly half of our students were worried about the legal responsibility in performing CPR as a Good Samaritan Law is not in place. A local survey showed that if the Good Samaritan Law was enacted, 57% of first aid course participants indicated they would be more willing to perform bystander CPR.²¹ Enacting the Good Samaritan Law

locally has the potential to improve survival rates from current low rates of bystander OHCA and use of AED.²

The quality of chest compression is affected by physical characteristics and age of students, with lower competency associated with females and those weighing less than 50 kg.¹² Nevertheless, we targeted secondary school students aged 12–15 years for this study rather than older students because the junior curriculum was more flexible in allowing CO-CPRAED training to occur. Of the many OSCE skills examined, being able to perform the correct rate and depth of compressions was most difficult in only a small proportion of students in this study. The low failure rate in attaching pads correctly and clearing surroundings to deliver a shock safely was likely related to the ease in performing these steps following English

Table 2 Skills performance in OSCE immediately and at follow-up (3 months) after training

Skills	Immediate (n=128)	Follow-up (n=128)	P value
1. Checks response (n, %)	123 (96.1)	125 (97.7)	0.727
2. Shouts for help, sends someone to phone 999 and get an AED (n, %)	128 (100)	128 (100)	NA
3. Performs high-quality (correct rate and depth) compressions (n, %)	106 (82.8)	113 (88.3)	0.265
4. Powers on AED (n, %)	128 (100)	128 (100)	NA
5. Correctly attaches pads (n, %)	126 (98.4)	127 (99.2)	1.000
6. Clears for analysis (n, %)	128 (100)	128 (100)	NA
7. Clears to safely deliver a shock (n, %)	127 (99.2)	125 (97.7)	0.500
8. Presses button to deliver a shock (n, %)	128 (100)	128 (100)	NA
9. Immediately resumes compressions (n, %)	128 (100)	128 (100)	NA
10. Median (IQR) time to first shock (sec)	65 (58–76)	60 (55–75)	0.046
Unadjusted overall pass (n, %)	99 (77.3)	106 (82.8)	0.337

AED, automated external defibrillator; NA, not applicable; OSCE, objective structured clinical examination.

or Cantonese (a Chinese dialect) vocal prompts of the AEDs. At the 3-month follow-up, our students maintained a high level of BLS skills with shorter median time to first shock. A possible explanation is that students refreshed their training before the follow-up, with some playing the 'Lifesaver' game⁸ and others remembering the examiner's feedback for improvements after the first OSCE performance.

Our knowledge and skill results are also consistent with the findings in a systematic review of a wide range of BLS programmes in schoolchildren.⁶ The implication of our results is that the majority of secondary students aged 12–15 years are physically fit to perform high-quality CPR and use AED correctly up to several months after a brief CO-CPRAED training session. These findings are supportive of including CO-CPRAED in the local secondary school curriculum and would be consistent with mandatory first aid and BLS training to occur within the UK school curriculum from 2020.²²

The main strengths of this study were that we used CPR knowledge questions from the CPR in School Training Kit and attitude statements from a local validated questionnaire in high school students that had sound content validity properties.¹⁴ Our BLS instructors marked students' competencies according to a standardised OSCE using the AHA adult CPR and AED skills testing checklist. However, there were several limitations. First, the recruited schools were selected by the authors who had already established a close collaborative relationship with the senior school management teams. These schools were very receptive to and supportive of the CO-CPRAED intervention. Second, the teaching adopted from the CPR in School Training Kit was in English, but most students' native language was Cantonese. Nonetheless, we used bilingual written questionnaires. Instructors taught in either English or Chinese in the language students were more fluent in during small group manikin practice. The low uptake of the 'Lifesaver' game⁸ may be related to students' English language competency and highlights the need for local adaptations of similar game-based e-learning interventions to facilitate BLS skill retention.¹¹ Finally, the instructor to student ratio of 1:10 for small group manikin practice might pose difficulties in recruiting enough healthcare professionals to teach the CO-CPRAED course on a long-term basis. However, results of this study will inform the design of a larger cluster-randomised non-inferiority controlled trial of instructors (healthcare professionals vs trained secondary school teachers) delivering a brief CO-CPRAED training course for secondary school students that we plan to conduct in the future.

CONCLUSION

A brief 2-hour CO-CPRAED intervention by healthcare professionals was associated with a noticeable increase in BLS knowledge, very positive attitudes towards CPR and retention of BLS skills up to 3 months in students at four

different secondary schools. These results demonstrate the feasibility of scaling up the numbers of schools trained in CO-CPRAED within the local school curriculum.

Author affiliations

¹Accident and Emergency Medicine, Queen Elizabeth Hospital, Kowloon, Hong Kong SAR, China

²Anaesthesia and Intensive Care, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, China

³Anaesthesia and Intensive Care, Prince of Wales Hospital, Shatin, Hong Kong SAR, China

⁴Felizberta Lo Padilla Tong School of Social Sciences, Caritas Institute of Higher Education, Tseung Kwan O, Hong Kong SAR, China

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Contributors HFK, CSYT and AL conceived the study. KYS, HFK and AL designed the study protocol, with input from CSYT, CYY, YCC and VKWL. The data were collected by all authors. KYS and AL analysed the data, with input from HFK and CYY. KYS and AL drafted the manuscript and made revisions following critical review by all authors. All authors approved the final version of the manuscript.

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Competing interests CYY is a lecturer at the Hong Kong Red Cross.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Approval for the study was obtained from The Chinese University of Hong Kong Survey and Behavioural Research Ethics Committee, Shatin, Hong Kong (SBRE-071-18).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data sets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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ORCID iDs

Veronica Ka Wai Lai <http://orcid.org/0000-0003-3593-9141>

Anna Lee <http://orcid.org/0000-0003-2864-0045>

REFERENCES

- 1 Berdowski J, Berg RA, Tijssen JGP, *et al.* Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. *Resuscitation* 2010;81:1479–87.
- 2 Fan KL, Leung LP, Siu YC. Out-of-hospital cardiac arrest in Hong Kong: a territory-wide study. *Hong Kong Med J* 2017;23:48–53.
- 3 Chair SY, Hung MSY, Lui JCZ, *et al.* Public knowledge and attitudes towards cardiopulmonary resuscitation in Hong Kong: telephone survey. *Hong Kong Med J* 2014;20:126–33.
- 4 Cave DM, Aufderheide TP, Beeson J, *et al.* Importance and implementation of training in cardiopulmonary resuscitation and automated external defibrillation in schools: a science advisory from the American Heart Association. *Circulation* 2011;123:691–706.
- 5 Wilks J, Pendergast D. Skills for life: first aid and cardiopulmonary resuscitation in schools. *Health Educ J* 2017;76:1009–23.
- 6 Plant N, Taylor K. How best to teach CPR to schoolchildren: a systematic review. *Resuscitation* 2013;84:415–21.

- 7 Vetter VL, Haley DM, Dugan NP, *et al.* Innovative cardiopulmonary resuscitation and automated external defibrillator programs in schools: results from the Student Program for Olympic Resuscitation Training in Schools (SPORTS) study. *Resuscitation* 2016;104:46–52.
- 8 Yeung J, Kovic I, Vidacic M, *et al.* The school Lifesavers study-A randomised controlled trial comparing the impact of Lifesaver only, face-to-face training only, and Lifesaver with face-to-face training on CPR knowledge, skills and attitudes in UK school children. *Resuscitation* 2017;120:138–45.
- 9 Watanabe K, Lopez-Colon D, Shuster JJ, *et al.* Efficacy and retention of basic life support education including automated external defibrillator usage during a physical education period. *Prev Med Rep* 2017;5:263–7.
- 10 Beskind DL, Stolz U, Thiede R, *et al.* Viewing a brief chest-compression-only CPR video improves bystander CPR performance and responsiveness in high school students: a cluster randomized trial. *Resuscitation* 2016;104:28–33.
- 11 Semeraro F, Frisoli A, Loconsole C, *et al.* Kids (learn how to) save lives in the school with the serious game Relive. *Resuscitation* 2017;116:27–32.
- 12 Mpotos N, Iserbyt P. Children saving lives: training towards CPR excellence levels in chest compression based on age and physical characteristics. *Resuscitation* 2017;121:135–40.
- 13 Lee JH, Cho Y, Kang KH, *et al.* The effect of the duration of basic life support training on the learners' cardiopulmonary and automated external defibrillator skills. *Biomed Res Int* 2016;2016:2420568
- 14 Ada M, Wong K, Tou A, *et al.* CPR knowledge and attitudes among high school students aged 15–16 in Hong Kong. *Hong Kong J Emerg Med* 2015;22:3–13.
- 15 Weinfurt KP. Clarifying the meaning of clinically meaningful benefit in clinical research: noticeable change vs valuable change. *JAMA* 2019. doi:10.1001/jama.2019.18496. [Epub ahead of print: 02 Dec 2019].
- 16 Robbins NB, Heiberger RM. Plotting Likert and other rating scales. *Sec Survey Res Method* 2011;1058–66.
- 17 Chu R, Thabane L, Ma J, *et al.* Comparing methods to estimate treatment effects on a continuous outcome in multicentre randomized controlled trials: a simulation study. *BMC Med Res Methodol* 2011;11:21.
- 18 Kahan BC. Accounting for centre-effects in multicentre trials with a binary outcome - when, why, and how? *BMC Med Res Methodol* 2014;14:20.
- 19 Kua PHJ, White AE, WY Ng, *et al.* Knowledge and attitudes of Singapore schoolchildren learning cardiopulmonary resuscitation and automated external defibrillator skills. *Singapore Med J* 2018;59:487–99.
- 20 Reder S, Cummings P, Quan L. Comparison of three instructional methods for teaching cardiopulmonary resuscitation and use of an automatic external defibrillator to high school students. *Resuscitation* 2006;69:443–53.
- 21 Hung KKC, Leung CY, Siu A, *et al.* Good Samaritan law and bystander cardiopulmonary resuscitation: cross-sectional study of 1223 first-aid learners in Hong Kong. *Hong Kong J Emerg Med* 2005;23:102490791987092.
- 22 Education Secretary Damian Hinds. Learning life-saving skills in school is crucial. Available: <https://www.gov.uk/government/news/damian-hinds-learning-life-saving-skills-in-school-is-crucial> [Accessed 29 Mar 2020].