Knowledge and attitudes of Vietnamese high school students towards cardiopulmonary resuscitation: Results from a pilot student-led cross-country bystander training workshop

Marcus Wei Xuan Yeow¹, Julia Yu Xin Ng¹, Van Hinh Nguyen², Anh Dung Quan², Huyen Trang Le², Thi Nga Nguyen³, Anh Tuan Le⁴⁵, Zisheng Li⁶, Jonathan Zhe Ying Tang⁶, Dow Rhoon Koh⁷ and Jeff Yi-Fu Hwang⁸

Abstract

Objectives: This is a first-of-its-kind cross-country collaboration between medical students from Singapore and Vietnam in conducting a cardiopulmonary resuscitation (CPR) workshop for Vietnamese high school students. Our objective was to assess the effectiveness of CPR training in improving students’ knowledge and attitudes towards CPR.

Methods: The CPR workshop was conducted using active learning methods, including interactive lecture session, games, small group demonstration and hands-on practice on the mannequin. Knowledge and attitudes towards CPR were studied using a standardised questionnaire administered at three time points: before the workshop (TP1), immediately after the workshop (TP2) and three months after the workshop (TP3).

Results: There was an improvement in the median knowledge score from 6.5/14 at TP1 to 13/14 at TP2 (p<0.001) which was sustained at TP3 (10/14). Willingness and confidence in performing CPR on strangers increased from TP1 to TP2. From TP2 to TP3, however, there was a decrease in willingness to perform CPR on all groups, though confidence in performing CPR remained high at TP3. The most-cited concern about performing CPR was a lack of skills and knowledge. Most participants picked formal training courses to increase confidence in performing CPR.

Conclusions: The CPR training was effective in improving the knowledge and attitudes of high school students towards CPR. Our study supports expanding this workshop to train more students in basic cardiac life support in the community and further collaboration internationally between medical schools in order to increase the number of students in the community competent in performing CPR.

Keywords
Cardiopulmonary resuscitation, knowledge, attitudes, Vietnamese, high school students

¹Yong Loo Lin School of Medicine, National University of Singapore, Singapore
²Faculty of Medicine, Vietnam Military Medical University, Vietnam
³Faculty of Pharmacy, Vietnam Military Medical University, Vietnam
⁴Department of Nursing, Vietnam Military Medical University, Vietnam
⁵Department of Urology Surgery, Military Hospital 103, Vietnam Military Medical University, Vietnam
⁶Emergency Medicine Department, National University Hospital, National University Health System, Singapore

Corresponding author: Marcus Wei Xuan Yeow, Yong Loo Lin School of Medicine, National University of Singapore, Singapore.
Email: E0032486@nus.edu.sg
Introduction

Out-of-hospital cardiac arrest (OHCA) is a global health concern, and current emergency cardiovascular care (ECC) emphasises a strong 'chain of survival', starting with prompt bystander responses. However, in lower-middle income countries, including Vietnam, the rate of bystander cardiopulmonary resuscitation (CPR) remains low. Hoang et al. reported that the community's lack of knowledge and fear of causing inadvertent harm while performing CPR were the main factors for this. Increased awareness and proficiency in CPR among the general population will lead to improved bystander CPR rates and in turn OHCA survival, as seen in countries with established community CPR programmes. In particular, students are well placed to receive CPR training, with the World Health Organization (WHO) endorsing the 'kids save lives' initiative in 2015. Studies have suggested that training students creates a multiplier effect, with 2.5 additional students getting training with every trained student, and early training lays the foundation for a sense of civic duty to reinforce CPR knowledge and respond in emergency situations. Since then, school bystander CPR programmes have been introduced in schools all around the world, with five countries in Europe legislating CPR education in schools. Since Vietnam currently has no formal community CPR training programme, a first-of-its-kind cross-country collaboration between National University of Singapore (NUS) and Vietnam Military Medical University (VMMU) was inspired to introduce such CPR programmes. This study hopes to implement a bystander CPR training course for Vietnamese high school students with the aim of investigating the long-term effectiveness of bystander CPR training course in improving the knowledge and attitudes of students towards CPR.

Methods

Study population

The study was conducted in a high school located in Hanoi, Vietnam. This high school chosen is a public school for gifted students within a metropolitan area. All high school students were 16-year-old ethnic Vietnamese. They were recruited from a convenience sample of 14 grade 11 classes with a total of 150 students. Invitation leaflets to participate in this study were sent out once to the 14 classes, and an invitational presentation was given once to all 14 classes.

Study design

This was an interventional study of pre–post design. As part of the study, students completed the same questionnaire at three time points – before the workshop (TP1), immediately after the workshop (TP2) and three months after the workshop (TP3) – to assess their awareness, knowledge and attitudes towards CPR. The three-month assessment was made to assess the long-term impact on the outcomes. Before administering the questionnaire to the students, it was translated from English into Vietnamese. The instructors consisted of medical students from the National University of Singapore (NUS) and Vietnam Military Medical University (VMMU) under the mentorship of professors and doctors from the two institutions. All instructors received a training manual and attended a one-day training course before running the workshop.

The CPR training course was a four-hour-long workshop comprising theoretical CPR education and practical bystander CPR components. On top of guided practice sessions, each student had a practical assessment under the direct observation of the instructors. The course was designed based on the 2016 Singapore basic cardiac life support (BCLS) guidelines and aligned with the 2015 American Heart Association guidelines used in Vietnam. The objective of the training course was to educate and change attitudes of Vietnamese high school students to CPR.

Theoretical CPR education was conducted by the instructors using videos and presentations. Its content emphasised mainly recognising symptoms of cardiac arrest, initiating early CPR and key facts relating to the conduct of CPR and cardiac arrest. The practical bystander CPR section was conducted after the theoretical education in a 1:5 instructor-to-student ratio with demonstrations of CPR followed by hands-on practice on mannequins. The demonstration was performed once without explanation and then repeated with running commentary of the key elements. The students were also given a training course book after the CPR training course to reinforce the knowledge gained during the CPR training course.

Questionnaire design

The questionnaire used at the three time points was designed based on the intended learning outcomes of the workshop and the teaching and learning activities in the workshop, with the aim of achieving constructive alignment. Demographic questions such as sex and prior CPR experience were collected, as they may be potential confounders. Given the key outcomes of the workshop were knowledge and attitude, the majority of the questionnaire consisted of questions related to these outcomes. The knowledge section comprised 14 questions, with a mix of one yes/no question, four true/false questions and nine multiple-choice questions. The attitude section assessed the participant's willingness and confidence to perform CPR and also to undergo further training. Participants were asked to rate their confidence and willingness on a Likert scale of 1–5, with 1 being the least confident/willing and 5 being the most confident/willing. The questions on knowledge and attitudes were set by the study team with the instructors based on the course content, given that there was no previously validated questionnaire on knowledge or attitudes for CPR.

Statistical analysis

The knowledge score for each participant was computed based on the number of correct knowledge questions answered out of a total of 14, and comparison of the knowledge score over time was done using median knowledge score at each time point. The Wilcoxon signed-rank test was used to look for statistical differences in knowledge score.
over time and differences in knowledge score at TP2 according to sex and according to whether participants have seen CPR. The chi-square test was used for any association between categorical data. McNemar’s test was used to compare between two matched categorical samples. A p-value of <0.05 was taken to be significant. Statistical analysis was performed using IBM SPSS Statistics for Windows v23.0 (IBM Corp., Armonk, NY).

Results

A total of 118 (78.7%) Vietnamese high school students participated in the study out of a total population of 150 students. There were 118 responses at TP1, 111 responses at TP2 (seven students did not submit the completed questionnaire) and 118 responses at TP3.

Baseline characteristics

Just over half (n=68; 57.6%) of the students were male. While the majority of participants (77.1%) had heard of CPR prior to the training, only a small percentage had attended a prior formal CPR training course (0.8%), knew how to perform CPR (8.5%) or had first-hand experience performing CPR (1.7%).

Baseline knowledge

Prior to the training, the median knowledge score was 6.5 (out of a total of 14). Detailed recording of the knowledge questions answered correctly were recorded in Table 1.

At TP1, questions with the fewest correct responses by participants were related to the technical aspects of performing CPR such as hand positioning, number of hand compressions per CPR cycle and depth of compressions. Other questions that were answered correctly by less than half of the participants included time from cardiac arrest to brain death and the conditions which warranted the need for CPR.

Nearly two-thirds (62.7%) of participants answered incorrectly that there is a significant risk of human immunodeficiency virus (HIV) transmission through mouth-to-mouth breathing.

Baseline attitude

At TP1, 93.2% of participants expressed they were open to undergo formal CPR training. Most highlighted reasons for willingness to participate in a formal CPR training course included preparedness in case of emergency (57.8%) and having vulnerable members of the community at home, namely children (10.0%) and elderly relatives (11.7%). In terms of time, the majority (94.9%) were willing to spend at least one hour on a formal CPR training course.

Eight (6.8%) students did not wish to participate in a formal CPR training course, of whom seven indicated that they had no time to learn and one indicated no interest.

At TP1, the majority of participants were willing to perform CPR on both strangers and people they know (family members and friends; Table 2). While participants were more willing to perform CPR on family members and friends compared to strangers, close to 80% of participants were willing to perform CPR on a stranger who was a child or elderly. More participants were willing to perform CPR on strangers of the same sex (75%) compared to strangers of the opposite sex (60%).

Having seen CPR previously and sex were not associated with a difference in willingness to perform CPR on any subjects (p-values ranging from 0.127 to 0.66; Table 3). The majority of participants would perform chest compressions if there was a need (56%) compared to mouth-to-mouth breathing (26%). The main concern highlighted was the fear of performing CPR wrongly due to a lack of skills or knowledge (37.5%; Table 6). Other common concerns included fear of causing harm and a lack of confidence. In particular, a small proportion of participants (7%) highlighted fear of disease transmission as a concern.

Post-workshop changes in knowledge

After the workshop, there was a significant increase in median knowledge score from 6.5 at TP1 to 13 at TP2 (p<0.001). While this was subsequently followed by a decrease to a median score of 10 at TP3, the knowledge score at TP3 remained significantly higher compared to TP1 (p<0.001). Sex and having seen CPR before this workshop were not associated with a difference in knowledge score at TP2 (Table 4).

At TP2, the majority of the participants (>87%) were able to answer questions on the technical aspects of CPR correctly. However, for the question on the risk of HIV transmission through mouth-to-mouth breathing, the proportion of participants who answered correctly remained similar from TP1 (62.7%) to TP2 (67.6%) and TP3 (67.8%).

At TP3, the question that had the largest decrease in the proportion of participants who answered correctly was the order of steps to perform CPR.

Post-workshop changes in attitudes

People on whom participants are willing to perform CPR. There was an increase in willingness to perform CPR on all groups of people from TP1 to TP2 (Table 2). However, the increase was only statistically significant for performing CPR on strangers who were children (p=0.019). There was a decrease in willingness to perform CPR on all groups from TP2 to TP3. The level of willingness, however, remained similar comparing TP3 and TP1. In addition, there was a statistically significant increase in willingness to perform CPR on strangers of the opposite sex between TP1 and TP3 (p=0.024).

Willingness to perform chest compressions and mouth-to-mouth ventilations. Referring to Table 5, there was a statistically significant increase in willingness to perform chest compressions (p<0.001) and mouth-to-mouth ventilation (p<0.001) from TP1 to TP2, and from TP1 to TP3 (p=0.003 and p<0.001 for chest compressions and mouth-to-mouth, ventilations respectively). From TP2 to TP3, while there was a statistically significant decrease in willingness to perform chest compressions, the level of willingness remained higher compared to TP1. Willingness to perform mouth-to-mouth breathing did...
not decrease from TP2 to TP3. At TP2, having correct knowledge on the risk of HIV transmission through mouth-to-mouth breathing was associated with an increase in the odds of willingness to perform mouth-to-mouth breathing, though it did not reach statistical significance (odds ratio = 2.16 (95% confidence interval 0.93–4.99), p = 0.070).

Confidence in performing CPR. There was a significant increase in confidence in performing CPR from TP1 to TP2 (p < 0.001) which remained high at TP3 compared to TP1 (p < 0.001; Table 5). At TP2 and TP3, common concerns about performing CPR remained similar: fear of performing CPR wrongly due to a lack of skills or knowledge and fear of causing more harm than benefit (Table 6). At TP2, those who were confident in performing CPR had a higher median knowledge score compared to those who were not confident (p = 0.033). At all time points, formal CPR training courses remained the most cited method to increase confidence in performing CPR, followed by educational CPR workshops and being certified for CPR (Table 7).

Willingness to encourage others to learn CPR. There was an increase in willingness to encourage others to learn CPR from TP1 to TP2 (p < 0.001) and between TP3 (89.0%) and TP1 (70.3%; p < 0.001).

Discussion

This is a novel inter-Southeast Asian collaboration between two medical schools in conducting a targeted CPR training session and is the first study to assess Vietnamese students’ knowledge and attitudes towards CPR. We aimed to identify and thereafter lower barriers to bystander CPR among Vietnamese high school students.

Our findings revealed that the high school students had low pre-training knowledge of CPR, which improved with a four-hour CPR training course. We were unable to compare their knowledge with the general population due to the lack of previous studies. Improvements in the knowledge of many aspects of CPR were also found to be sustained three months after the workshop. We thus believe that such a course would be effective in promoting greater CPR awareness, as well as additional efforts in improving CPR knowledge and skills in Vietnam.

There was also an improvement in the attitudes towards CPR, as evidenced by an increase in the willingness to perform CPR after the workshop. The level of willingness varied with the subject to perform CPR on, with participants less willing to perform CPR on strangers of the opposite sex. This could be due to cultural reasons and fear of harming others, even at baseline, the majority of the participants were willing to perform CPR on strangers, which may mean that formal CPR workshops would be of interest to the students.

Given the observed drop in knowledge score from the time of the workshop to three months later, it is important to look into the possible reasons for specific knowledge gaps after the workshop. One key knowledge gap three months following the workshop is regarding the steps in performing CPR. This is in line with the top concern regarding the fear of performing CPR wrongly due to a lack of skills or knowledge, which remained after the workshop. This could be attributed

| Table 1. Knowledge questions answered correctly at the respective time points |
|---------------------------------|-----------------|-----------------|-----------------|
| Early CPR can save a life. (True/False) | 94 (79.7%) | 107 (94.4%) | 109 (92.4%) |
| Only CPR done by health-care professionals can save lives. (True/False) | 84 (71.2%) | 101 (91.0%) | 101 (85.6%) |
| CPR should be performed on people with the following condition. (Choose appropriate options) | 58 (49.2%) | 93 (83.8%) | 70 (59.3%) |
| There is a significant risk of HIV transmission through mouth-to-mouth breathing. (True/False) | 74 (62.7%) | 75 (67.6%) | 80 (67.8%) |
| In the process of doing CPR, we may accidentally cause rib fractures. Is this dangerous? (Yes/No) | 62 (52.5%) | 90 (81.1%) | 92 (78.0%) |
| We should do CPR on a person’s bare chest rather than with clothing. (True/False) | 70 (59.3%) | 106 (95.5%) | 104 (88.1%) |
| How long is the time from cardiac arrest to the death of the brain (irreversible brain damage)? (Choose the most appropriate option) | 42 (35.6%) | 106 (95.5%) | 70 (59.3%) |
| What does CPR consist of? (Choose the most appropriate option) | 114 (96.6%) | 110 (99.1%) | 112 (94.9%) |
| Where is the correct position to place the hands during compressions? (Choose the most appropriate option) | 51 (43.2%) | 104 (93.7%) | 85 (72.0%) |
| How many compressions do you think should be done in one minute? (Choose the most appropriate option) | 39 (33.1%) | 100 (90.1%) | 83 (69.5%) |
| How many compressions do you think should be done in one cycle of CPR? (Choose the most appropriate option) | 44 (37.3%) | 107 (96.4%) | 82 (69.5%) |
| How deep do you think should be done in compression? (Choose the most appropriate option) | 20 (16.9%) | 100 (90.1%) | 60 (50.8%) |
| What is the ratio of times of chest compressions and times of breathing in one cycle of CPR? (Choose the most appropriate option) | 31 (26.3%) | 108 (97.3%) | 83 (70.3%) |
| What is the order of steps to perform CPR? (Choose the most appropriate option) | 33 (28.0%) | 97 (87.4%) | 30 (25.4%) |

CPR: cardiopulmonary resuscitation; HIV: human immunodeficiency virus.
to our workshop focusing more on improving the knowledge and attitudes towards CPR, and teaching the practical steps of performing CPR would require a more formal CPR skills training workshop. There could also be slight discrepancies between Singapore’s BCLS guidelines and what was taught during the lecture, possibly as a result of different interpretations and translation from English to Vietnamese. Such an observation is important and should be considered and accounted for in future international collaborations.

Another potential knowledge gap is the correct knowledge of HIV transmission risk during mouth-to-mouth breathing. Even after our workshop, >30% of the participants still stated that there is a significant HIV transmission risk. Given that willingness to perform mouth-to-mouth breathing may be associated with correct knowledge of this risk, future CPR training programmes would need to address this knowledge gap.

Early CPR training within the community is essential. Basic life support training has been recommended to be part of the school curriculum, which some countries have done successfully. Studies have shown that the high school population is ideal to start teaching CPR. Surveys conducted have shown that students are eager to share their gained knowledge with family and friends, thereby increasing awareness of CPR within the wider community beyond the school setting. This attitude of sharing is also supported by findings in our study where the majority of students said that they would encourage others to learn CPR. The positive results in our study as well as previous studies conducted have shown that students are eager to share their gained knowledge with family and friends, thereby increasing awareness of CPR within the wider community beyond the school setting.

Table 2. Willingness to perform CPR on different groups of people (P-values comparing the percentage at different time-points for each group of people are show below. McNemar test was used in the analysis.)

| Willing to perform CPR on: | N | TP1 (n=118) (%) | TP2 (n=111) (%) | TP3 (n=118) (%) |
|---------------------------|---|----------------|----------------|----------------|
| Family member, n (%)      | 112 (94.9) | 110 (99.1) | 107 (90.7) |
| Friend, n (%)             | 110 (93.2) | 110 (99.1) | 114 (96.6) |
| Stranger who is a child, n (%) | 94 (79.7) | 102 (91.9) | 97 (82.2) |
| Stranger who is an elderly, n (%) | 88 (74.6) | 88 (79.3) | 89 (75.4) |
| Stranger of the same sex, n (%) | 88 (74.6) | 88 (79.3) | 91 (77.1) |
| Stranger of the opposite sex, n (%) | 71 (60.2) | 81 (73.0) | 87 (73.7) |
| p-Value (p)               | TP1 | 0.625 | 0.070 |
| TP2 | – | – | 0.021 |
| TP1 | – | 0.125 | 0.375 |
| TP2 | – | – | 1.000 |
| Stranger who is a child (p-value) | TP1 | 0.019 | 1.000 |
| TP2 | – | – | 0.115 |
| Stranger who is an elderly (p-value) | TP1 | 0.678 | 0.851 |
| TP2 | – | – | 0.720 |
| Stranger of the same sex (p-value) | TP1 | 1.000 | 1.000 |
| TP2 | – | – | 1.000 |
| Stranger of the opposite sex (p-value) | TP1 | 0.122 | 0.024 |
| TP2 | – | – | 0.585 |

Table 3. Having seen CPR and Gender effect on willingness to perform CPR at TP1. (Chi-Square test was used in the analysis.)

| Willing to perform CPR on: | Seen CPR before (N=53) (%) | Have not seen CPR before (N=61) (%) | p-Value |
|---------------------------|-----------------------------|-------------------------------------|---------|
| Family member             | 51 (96.2%)                  | 60 (98.4%)                          | 0.597   |
| Friend                    | 50 (99.3%)                  | 59 (96.7%)                          | 0.662   |
| Stranger who is a child    | 46 (86.8%)                  | 47 (77.0%)                          | 0.181   |
| Stranger who is an elderly | 43 (81.1%)                  | 45 (73.8%)                          | 0.350   |
| Stranger of the same sex   | 43 (81.1%)                  | 44 (72.1%)                          | 0.260   |
| Stranger of the opposite sex | 36 (69.2%)                | 35 (57.4%)                          | 0.194   |

Table 4. Difference in knowledge score at TP2 according to gender and according to whether participants have seen CPR (Wilcoxon Sign Rank test was used in the analysis.)

| Knowledge score, median (IQR) | Male (N=51) | Female (N=59) | p-Value |
|-------------------------------|-------------|---------------|---------|
| Seen CPR                     | 13.0 (12.0–13.0) | 13.0 (12.0–14.0) | 0.209   |
| Have not seen CPR             | 13.0 (12.0–14.0) | 13.0 (12.0–14.0) | 0.481   |

IQR: Interquartile range.
Table 5. Confidence to perform CPR, willingness to perform chest compressions and mouth to mouth breathing (P-values comparing the percentage at different time-points for each group of people are shown below. McNemar test was used in the analysis.)

|                          | TP1 (N=118) | TP2 (N=111) | TP3 (N=118) |
|--------------------------|-------------|-------------|-------------|
| I have the confidence to perform CPR, n (%) | 11 (9.3) | 67 (60.4) | 64 (54.2) |
| I will perform chest compressions, n (%) | 66 (55.9) | 102 (91.9) | 89 (75.4) |
| I will perform mouth-to-mouth breathing, n (%) | 31 (26.3) | 52 (46.8) | 56 (47.4) |
| I have the confidence to perform CPR (p-value) | - | <0.001 | <0.001 |
| TP1                      | -           | -           | 0.597       |
| TP2                      | -           | -           | 0.001       |
| I will perform chest compressions (p-value) | - | <0.001 | 0.003 |
| TP1                      | -           | -           | 0.001       |
| TP2                      | -           | -           | 0.001       |
| I will perform mouth-to-mouth breathing (p-value) | - | <0.001 | <0.001 |
| TP1                      | -           | -           | 1.000       |
| TP2                      | -           | -           | 0.001       |

Table 6. Concerns about performing CPR

| Concern                        | TP1 (%) | TP2 (%) | TP3 (%) |
|--------------------------------|---------|---------|---------|
| Fear of performing it wrongly due to lack of skills/knowledge | 101 (37.5) | 67 (32.2) | 74 (30.8) |
| Lack of confidence            | 54 (20.1) | 35 (16.8) | 41 (17.1) |
| Fear of disease transmission  | 18 (6.7)  | 24 (11.5) | 26 (10.8) |
| Fear of causing more harm than benefits for person | 61 (22.7) | 46 (22.1) | 53 (22.1) |
| Phobia of medical circumstances | 13 (4.8)  | 17 (8.2)  | 23 (9.9)  |
| Fear of legal implications    | 22 (8.2)  | 19 (9.1)  | 23 (9.9)  |

Table 7. Methods to increase confidence in performing CPR

| Method                          | TP1 (%) | TP2 (%) | TP3 (%) |
|--------------------------------|---------|---------|---------|
| Self-learning materials         | 11 (6.1) | 15 (7.1) | 26 (12.0) |
| Educational workshops           | 47 (26.2) | 56 (26.4) | 52 (24.1) |
| Formal training courses         | 78 (43.6) | 94 (44.3) | 91 (42.1) |
| Being certified                 | 43 (24.0) | 47 (22.2) | 47 (21.8) |

and skills in addition to successfully educating non-medical students in the community. On top of the didactic lecture, the workshop employed active learning methods which have shown to increase knowledge retention and transfer. In turn, students are more likely to perform good-quality CPR in real-life scenarios. This study proves that it is feasible to have student-led training programmes with a positive impact on knowledge acquisition in the community.

In establishing a CPR training course in developing countries, it is important for the development of expertise and infrastructure from within the local system. In our study, the main role of the Singaporean CPR instructors was to share technical expertise with the Vietnamese team, while the execution of the CPR training course was mainly directed by the Vietnamese medical students. This ensured that the CPR training course was culturally relevant, as the course was tailored to the local audience, and sustainable in the long run, as the Vietnamese team is able to reproduce the CPR training course independently. At the same time, the Vietnamese team was more aware of the local cultural norms, including the methods of engaging the students and the choice of teaching materials. It would have been difficult for a Singaporean team to conduct the workshop alone without the contributions of the local counterparts.

Limitations

There are several limitations in our study. First, certain demographic data such as weight, height, religion and household income were not collected. Thus, how these demographics influence the knowledge and attitudes of Vietnamese high school students cannot be evaluated. Second, the population in this study may not be representative of all Vietnamese high school students, given that we recruited gifted students living in a city area, who may have different attitudes and learning capabilities from other students towards CPR training. Having said that, the findings in relation to the knowledge, willingness and concerns would still be useful in planning a formal CPR training programme in Vietnam. Third, we acknowledge that a four-hour workshop is insufficient to teach students CPR skills properly and that retaining CPR skills requires constant retraining. Hence, we have focused on improving knowledge and attitudes of the students towards CPR, and suggest that Vietnamese schools formally implement practical CPR courses for as many high school students as possible, which will provide students with a structured training programme. This effectively addresses concerns of causing harm due to lack of CPR-related skills or knowledge, as found in our study. Lastly, the questionnaire used has not been validated in the local context. While this may affect the internal validity of the results, we believe that the observed changes in the outcomes over time as well as the knowledge gaps noted reflect the population of study accurately.

Conclusion

A CPR training course that is designed specifically for Vietnamese high school students can improve their knowledge and attitude towards CPR and encourage their willingness to participate in CPR training courses. It is our hope that such a model can be replicated on a wider scale across the country and eventually encourage more participation in formal BCLS courses. More emphasis should be put on practical skills training to ensure that students are equipped with both theoretical knowledge and practical skills to be sufficiently
competent in performing CPR. CPR training should also be done more frequently to help improve knowledge retention and the confidence of the students. Given the successful implementation of our CPR training course, it is possible that future international collaborations between countries can be carried out in other nations which currently lack community bystander CPR courses in order to improve their students’ knowledge and attitude towards CPR.

Acknowledgements
Special thanks to mentors and members of Operation CPR project, teachers and students of Nguyen Hue high school for the gifted, Hanoi and professors from the National University of Singapore, School of Medicine and Vietnam Military Medical University for their support. We would also like to acknowledge Laerdal for supporting our project by loaning mannequins for our CPR training.

Authors’ contributions
All authors were involved in the conception or design of the work. M.W.X.Y., J.Y.X.N., V.H.N., A.D.Q., H.T.L. and T.N.N. were involved in the data collection. M.W.X.Y. and J.Y.F.H. were involved in the data analysis and interpretation. M.W.X.Y., J.Y.X.N. and J.Y.F.H. were involved in drafting the article. All authors were involved in the critical revision of the article and gave final approval of the version to be published.

Availability of data and materials
The data sets generated and/or analysed during the current study are available from the corresponding author.

Conflict of interest
The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical approval
Ethics approval was granted by the National University of Singapore (NUS) under NUS-IRB Ref. No.: S-19-296.

Funding
The authors disclosed receipt of the following financial support for the research, authorship and/or publication of this article: This study was co-funded by National University of Singapore, School of Medicine and Vietnam Military Medical University.

Informed consent
Parental consent was sought from the high school before students were enrolled in the study.

ORCID iD
Marcus Wei Xuan Yeow https://orcid.org/0000-0002-1023-7402

References
1. Cheng A, Nadkarni VM, Mancini MB, et al. Resuscitation education science: educational strategies to improve outcomes from cardiac arrest: a scientific statement from the American Heart Association. Circulation. 2018; 138: e82–e122.
2. Hoang BH, Dao XD, Nakahara S, et al. The need for improving access to emergency care through community involvement in low- and middle-income countries: a case study of cardiac arrest in Hanoi, Vietnam. Emerg Med Australas. 2018; 30: 867–869.
3. Lai H, Choong C V, Fook-Chong S, et al. Interventional strategies associated with improvements in survival for out-of-hospital cardiac arrests in Singapore over 10 years. Resuscitation 2015; 89: 155–161.
4. Böttiger BW and Van Aken H. Kids save lives – training school children in cardiopulmonary resuscitation worldwide is now endorsed by the World Health Organization (WHO). Resuscitation 2015; 94: AS–A7.
5. Isbye DL, Rasmussen LS, Ringsted C, et al. Disseminating cardiopulmonary resuscitation training by distributing 35,000 personal manikins among school children. Circulation 2007; 116: 1380–1385.
6. Roppolo LP and Pepe PE. Retention, retention, retention: targeting the young in CPR skills training! Crit Care 2009; 13: 185.
7. Böttiger BW, Semeraro F, Altermeyer KH, et al. Kids save lives. Eur J Anaesthesiol 2017; 34: 792–796.
8. Hoang BH, Nakahara S and Nguyen HT. Training of potential trainers on lay-people CPR in Vietnam. Resuscitation 2019; 136: 149–150.
9. Lim SH, Wee FC and Chee TS. Basic cardiac life support; 2016 Singapore guidelines. Singapore Med J 2017; 58: 347–353.
10. Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: adult basic life support and cardiopulmonary resuscitation quality; 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2015; 132: S414–S435.
11. Huang EP-C, Chiang W-C, Hsieh M-J, et al. Public knowledge, attitudes and willingness regarding bystander cardiopulmonary resuscitation: a nationwide survey in Taiwan. J Formos Med Assoc 2019; 118: 572–581.
12. Holmberg S, Halsdroy A, Bahr J, et al. Guidelines for basic life support. BMJ 1993; 306: 1587–1589.
13. Hoyme DB and Atkins DL. Implementing cardiopulmonary resuscitation training programs in high schools: Iowa’s experience. J Pediatr 2017; 181: 172–176.e3.
14. Reder S and Quan L. Cardiopulmonary resuscitation training in Washington state public high schools. Resuscitation 2003; 56: 283–288.
15. Watanabe K, Lopez-Colon D, Shuster J, 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: 263–267.
16. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013; 310: 1377–1384.
17. Kavelak HL, Hollands JM and Bingham AL. Student-led cardiopulmonary resuscitation education to lay providers results in successful knowledge acquisition and skill performance. J Allied Health 2019; 48: 18–21.
18. Wolff M, Wagner MJ, Poznanski S, et al. Not another boring lecture: engaging learners with active learning techniques. J Emerg Med 2015; 48: 85–93.
19. Berger C, Brinkoff P, Ertlmer C, et al. Combination of problem-based learning with high-fidelity simulation in CPR training improves short and long-term CPR skills; a randomised single blinded trial. BMC Med Educ 2019; 19: 1–10.
20. López-Herce J, Urbano J, Carrillo A, et al. Resuscitation training in developing countries; importance of a stable program of formation of instructors. Resuscitation 2011; 82: 780.