

Original Article

A pilot study of Practice While Watch based 50 min school quality cardiopulmonary resuscitation classroom training: a cluster randomized control trial

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Aim: Cardiopulmonary resuscitation (CPR) training in schools can increase the rate of bystander CPR. We assessed whether a “Quality CPR (Q CPR) Classroom” can support CPR performance by students trained by a teacher who is not a CPR instructor.

Methods: A cluster randomized trial was undertaken to assess the effectiveness of a 50-min Practice While Watch CPR training program enhanced by Q CPR Classroom, which used 42 manikins connected by Bluetooth to real-time feedback monitoring. Fifty-seven students were divided into Group 1, taught by a non-CPR-instructor, and Group 2, taught by a CPR instructor. Psychomotor and cognitive tests were administered before and after training. Primary outcomes were post-training compression depth and rate and percent of improvement in adequate depth, recoil, and overall score. The secondary outcome was risk improvement.

Results: Post-training, Group 1 achieved 62.1 ± 7.7 mm and 118.0 ± 3.6 compressions/min whereas Group 2 achieved 57.4 ± 9.8 mm and 119.8 ± 5.4 compressions/min. The overall score improvement in percentage points was $36.4 \pm 25.9\%$ and $27.0 \pm 27.7\%$, respectively ($P \leq 0.001$ for both). The adequate depth improvement in percentage points was $22.4 \pm 35.4\%$ and $32.5 \pm 40.0\%$, respectively ($P = 0.33$). Teaching by a non-CPR instructor improved student cognitive knowledge.

Conclusions: Using a Q CPR Classroom to enhance CPR teaching by a non-CPR-instructor results in similar or better outcomes compared to using a CPR instructor. Use of a Practice While Watch Q CPR Classroom will provide adequate quality in preparing students for CPR.

Key words: Cardiopulmonary resuscitation, emergency medicine, medical education

BACKGROUND

THE NECESSITY OF bystander cardiopulmonary resuscitation (CPR) has been emphasized in the last decade.¹ Performing bystander CPR increases the out-of-hospital cardiac arrest (OHCA) survival rate.^{2–7} After cardiac arrest, a person is two to four times more likely to survive when bystander CPR is provided.⁸ To improve the rate of bystander CPR, CPR training is key, and various types of CPR training have been implemented, including in-school CPR, community CPR, and mass CPR training.⁹

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In 2011, the American Heart Association published a recommendation that school CPR training be made mandatory.¹⁰ Greater resuscitation rates by laypersons have been seen in regions where school CPR training is mandatory.^{3,11} This meets the goal of conducting school CPR training, which increases the bystander CPR rate and survival rate after OHCA.¹² School CPR training has been led by people of various occupations: physicians, fire fighters, medical students, and paramedics.¹³ However, the most appropriate personnel to deliver this information has yet to be determined.¹² In a Japanese study, Tanaka *et al.*¹³ suggested that school teachers lead CPR training primarily because they know their students' characteristics, learning habits, and environment, but they do so in only approximately 20% of the schools. Lukas *et al.*¹⁴ reported that teachers are as effective as physicians in teaching CPR to school children. Over 90% of school teachers who led the training had confidence in teaching their students.¹⁵ However, studies indicate

that 50% of teachers were not willing to teach CPR because they lacked the knowledge¹⁶ and lacked CPR teaching skills.¹³ The Japan Resuscitation Council (JRC) recommends using a feedback device during CPR training because it gives objective skill assessments.¹⁷ To ensure quality CPR training, the ultimate goal is that school teachers use feedback devices throughout training. The “Quality CPR (QCPR) Classroom,” a CPR feedback solution for classroom training, together with Practice While Watch (PWW)-based videos, could enable teachers who are not CPR instructors to deliver good-quality training that will eventually increase survival rates. Kanstad *et al.*¹⁸ indicated that the first chain of survival will be stronger when school CPR training is of high quality.

We hypothesized that CPR training by experienced and inexperienced school teachers, both supported by a QCPR Classroom and PWW videos, will be equally effective. We aimed to compare the two based on improvements in the differences in psychomotor skills and knowledge between pre-training tests and post-training tests.

METHODS

A CLUSTER RANDOMIZED trial was used to assess the effects of using the QCPR Classroom when training was delivered by a teacher who was not a CPR instructor. The Institutional Review Board at Kokushikan University (Tokyo, Japan) approved this study. Written informed consent was obtained from parents, and verbal informed consent was obtained from participants prior to CPR training and study enrollment.

Participants

Two high school classes were recruited, and students were assigned by class: 30 in Group 1 and 27 in Group 2 (Fig. 1). Two teachers from the same high school were selected to participate in this study as CPR instructors. Group 1 was led by a physical education teacher with no background as a health-care professional and no experience teaching CPR. Group 2 was led by a physical education teacher with a paramedic license and more than 10 years of experience teaching CPR.

Measurements

Psychomotor and cognitive tests were undertaken. Primary outcomes were post-training compression depth (in mm) and rate (in compressions/min [cpm]) and percent improvements in adequate depth, recoil, and overall score. Adequate depth is the percentage of all compressions exceeding 5 cm. Overall compression score was calculated based on

compression depth, rate, and recoil. Knowledge level was evaluated using a cognitive test. The secondary outcome was risk difference based on the cognitive test.

Psychomotor and cognitive tests were administered before and after training. The pretraining tests were administered before the class. The post-training psychomotor test was administered immediately after the class, and the post-training cognitive test was administered 2 weeks later. Both psychomotor tests were administered without real-time feedback.

Procedure

Fifty minutes of PWW-based QCPR-Classroom-enhanced training was given to both groups. Training flow is shown in Figure 1. The PWW session consisted of a 17.5-min basic life support training video followed by skills practice for the remainder of the session (Fig. 2). To promote hands-on practice,^{19,20} this QCPR training intended to allow each student 1,000 compressions. Teachers were instructed to provide feedback based on the feedback icon displayed on an iPad (China), if necessary. The QCPR Classroom monitor was positioned at the front of the classroom so that all students could visualize the feedback. Before beginning training, each student identified the specific icon representing their own feedback. Throughout the training, a metronome set at 110 b.p.m. was audible.

Instrumentation

The QCPR Classroom concept was launched by Laerdal Medical (Stavanger, Norway) to provide real-time feedback on CPR performance to instructors. A maximum of 42 manikins is used.

The QCPR Classroom uses Laerdal “Little Anne” QCPR manikins (Laerdal Medical) that collect chest compression data for the psychomotor tests throughout the training. An optical compression sensor and microcontroller within each manikin communicate to the instructor’s iPad by Bluetooth, allowing visualization of the real-time CPR performances from all manikins simultaneously. The Reflector 2 application (North Canton, Squirrels, OH, USA) allows the iPad screen to also be displayed at the front of the classroom.

Using the compression sensor, the microcontroller calculates compression rate and depth, incomplete release, and number of compressions. This “instrumented” Little Anne is calibrated to the 2015 guidelines, and when a student deviates from those guidelines, a yellow icon appears, indicating that compressions are too fast, too slow, too shallow, or incompletely released (Fig. 2). A green icon indicates that compressions meet guidelines.

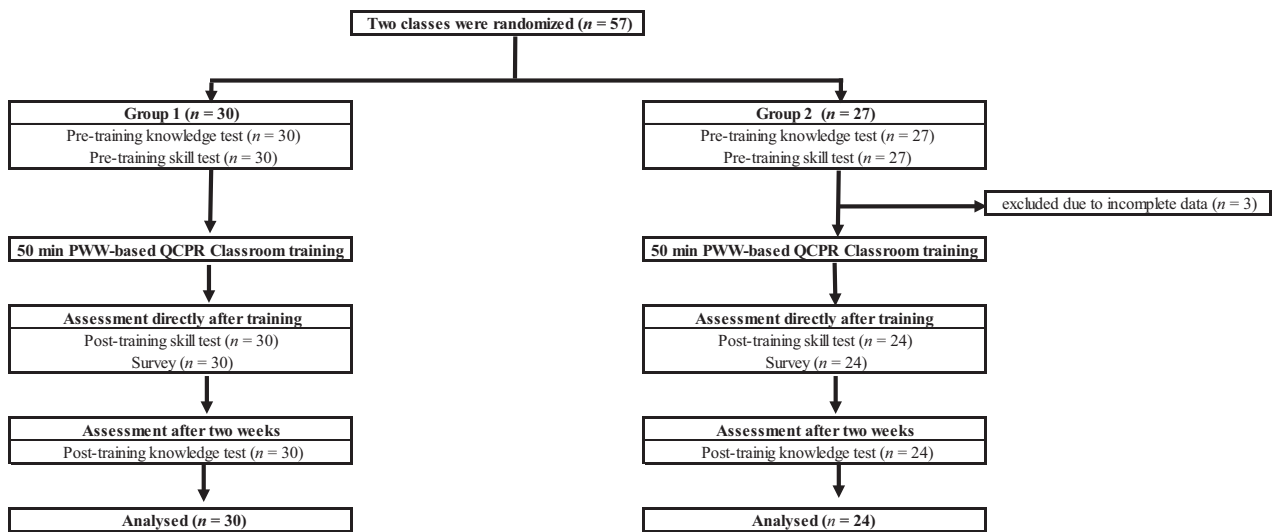


Fig. 1. Flow chart on randomization and inclusion of students who participated in school-based cardiopulmonary resuscitation (CPR) training. PWW, Practice While Watch; QCPR, Quality CPR



Fig. 2. Photograph of a class participating in school-based cardiopulmonary resuscitation (CPR) training and Quality CPR icons

Statistical analysis

Mean and standard deviation were used to describe continuous data. The χ^2 -test and a non-paired *t*-test were used to examine background and psychomotor skills. The χ^2 -test and McNemar's test were used to assess the amount of knowledge acquired based on the pre- and post-training written exams. Ordinal data are described using median and interquartile range. When $P < 0.05$, significance was recognized. Data analyses were carried out using JMP software version 11.0.3 (SAS Institute, Cary, NC, USA).

RESULTS

Demographic characteristics

THREE STUDENTS WERE excluded because incomplete data were obtained; therefore, 30 students comprised Group 1, and 24 students comprised Group 2 in the analysis (Fig. 1). As shown in Table 1, significant differences were not seen in background characteristics. However, 63.3% of Group 1 had CPR training experience compared to 37.5% of Group 2 (Table 1; $P = 0.06$).

Primary outcomes

The psychomotor test is shown in Table 2. After training, Group 1 achieved a compression depth of 62.1 ± 7.7 mm and a rate of 118.0 ± 3.6 cpm. Group 2 achieved 57.4 ± 9.8 mm and 119.8 ± 5.4 cpm, respectively. Overall scores significantly improved between pre- and post-training tests in both groups. In Group 1, the overall scores improvement in percentage points was $36.4 \pm 25.9\%$ (from $57.9 \pm 27.2\%$ to $94.3 \pm 12.8\%$, $P \leq 0.001$). In Group 2, the overall scores improvement in percentage points was

$27.0 \pm 27.7\%$ (from $54.6 \pm 31.1\%$ to $81.5 \pm 22.5\%$, $P \leq 0.001$; Table 2). These values were not different between the groups ($P = 0.21$). In adequate depth, the improvement in percentage points was $22.4 \pm 35.4\%$ in Group 1 and $32.5 \pm 40.0\%$ in Group 2 ($P = 0.33$). Improvement in percentage points in recoil was similar ($21.1 \pm 38.5\%$ and $13.1 \pm 28.9\%$, respectively; $P = 0.40$).

Secondary outcome

Based on the cognitive tests, both groups improved in CRP knowledge (Table 3). Frequencies of correct answers in the pre- and post-training tests are shown in Table 3. For example, Group 1 correctly answered the question, "What would you do next immediately after you deliver shock through automated external defibrillator" 90.0% of the time after training as opposed to 43.3% of the time before training, an improvement of 47% ($P = 0.001$). By comparison, Group 2 answered correctly 79.2% of the time after training, compared to 41.7% before training, an improvement of 38% ($P = 0.013$). Both groups significantly improved their knowledge using the same PWW-based training.

DISCUSSION

THE TWO GROUPS showed similar improvements in CPR skills, suggesting that school teachers who have never taught CPR can provide the same quality of psychomotor skills and cognitive knowledge through CPR training as those with CPR teaching experience.

A 2008 study reported that in Seattle, USA, 79.3% of 1,001 people had CPR training, and 46.5% of them had the training within the previous 5 years,²¹ contributing to high resuscitation and survival rates.²² In 2017, the bystander CPR rate was 70% and the rate for survival to hospital discharge

Table 1. Background characteristics of students who participated in school-based cardiopulmonary resuscitation (CPR) training

	Group 1: School teacher without CPR teaching experience ($n = 30$)	Group 2: School teacher with CPR teaching experience ($n = 24$)	<i>P</i> -value
Male, n (%)	22 (73.3)	18 (75.0)	0.89
Age, years	17.7 ± 0.7	17.5 ± 0.5	0.25
Height, cm	167.0 ± 7.8	167.5 ± 8.2	0.85
Weight, kg	60.1 ± 9.5	59.3 ± 8.5	0.76
CPR training experience, n (%)	19 (63.3)	9 (37.5)	0.06

Data are shown as mean \pm standard deviation; χ^2 -test and non-paired *t*-test. $P > 0.05$.

Table 2. Comparison in cardiopulmonary resuscitation (CPR) psychomotor skills between groups of students who participated in school-based CPR training, and between pre- and post-trainings

	Group 1: School teacher without CPR teaching experience (n = 30)	Group 2: School teacher with CPR teaching experience (n = 24)	P-value (compared between groups)
Depth, mm			
Improvement in percentage points	6.0 ± 9.8	8.6 ± 9.6	0.330
Pretraining	56.1 ± 12.3	48.8 ± 12.8	0.040*
Post-training	62.1 ± 7.7	57.4 ± 9.8	0.050
P-value (pre- versus post-training)	0.002*	<0.001*	
Rate, cpm			
Improvement in percentage points	1.0 ± 20.0	7.3 ± 12.8	0.180
Pretraining	117.0 ± 19.0	112.4 ± 15.5	0.340
Post-training	118.0 ± 3.6	119.8 ± 5.4	0.170
P-value (pre- versus post-training)	0.79	0.01*	
Adequate depth, %			
Improvement in percentage points	22.4 ± 35.4	32.5 ± 40.0	0.330
Pretraining	70.9 ± 39.6	42.3 ± 39.7	0.010*
Post-training	93.3 ± 10.6	74.8 ± 35.0	0.008*
P-value (pre- versus post-training)	0.002*	<0.001*	
Recoil, %			
Improvement in percentage points	21.1 ± 38.5	13.1 ± 28.9	0.400
Pretraining	58.9 ± 6.2	68.9 ± 6.9	0.280
Post-training	79.9 ± 26.9	82.0 ± 23.6	0.770
P-value (pre- versus post-training)	0.006*	0.04*	
Overall, %			
Improvement in percentage points	36.4 ± 25.9	27.0 ± 27.7	0.210
Pretraining	57.9 ± 27.2	54.6 ± 31.1	0.670
Post-training	94.3 ± 12.8	81.5 ± 22.5	0.010*
P-value (pre- versus post-training)	<0.001*	<0.001*	

Data are shown as mean ± standard deviation; χ^2 -test and non-paired *t*-test for comparison in CPR skills between groups. Paired *t*-test for comparison in CPR skills between pre- and post-training.

**P* > 0.05

cpm, compressions/min.

for witnessed ventricular fibrillation (VF) was 56% in Seattle and the surrounding King County.²² Comparatively, the bystander CPR rate was 43.0% and the rate for survival to hospital discharge was 2.2% in Japan in 2015.²³ Increasing the number of people who can provide high-quality CPR can increase the OHCA resuscitation rate; survival rates reportedly increase as bystander rates increase.² Other contributing factors are the use of an automated external defibrillator before ambulance arrival and ambulance response time. However, time to the first chest compression could have a great role in the outcome.⁹ Immediate initiation of bystander CPR is necessary to increase the chance of survival.^{2,3}

According to the Pan-Asian Resuscitation Outcomes Study, OHCA occurs in those aged between 49.7 and 71.7 years and in men 57.9–82.7% of the time,²⁴ primarily

at the home or a private residence.^{13,25–27} A family member should be prepared to perform CPR; therefore, children have potentially important roles in saving the life of a person in cardiac arrest in the home. If a child can initiate high-quality chest compressions, the chance of survival increases. In Denmark, once school CPR training was mandated, the rate of bystander CPR increased.^{3,15,28} Tanigawa *et al.*²⁹ indicated that people with basic life support training tended to perform bystander CPR more often than those not trained. In Japan, CPR training is part of obtaining a driver's license, and school CPR training has begun. School CPR training aims to ensure that students graduate with certain knowledge about recognizing cardiac arrest and the skills to save lives. In other words, school CPR training directly influences the early phase of the chain of survival.

Table 3. Comparison of correct answers between groups of students who participated in school-based cardiopulmonary resuscitation (CPR) training, and between pre- and post-training regarding basic life support knowledge

Written exam	Group 1: School teacher without CPR teaching experience (n = 30)	Group 2: School teacher with CPR teaching experience (n = 24)	Risk difference (95% CI)	P-value (compared between groups)
1. What is the correct number you would dial to activate an ambulance?				
Pretraining, n (%)	25 (83.3)	20 (83.3)	0% (−20 to 21%)	0.99
Post-training, n (%)	27 (90.0)	22 (91.7)	−2% (−18 to 16%)	0.83
Risk difference (95% CI)	7% (−11 to 24%)	8% (−10 to 27%)		
P-value (pre- versus post-training)	0.32	0.32		
2. What would you do first when you find someone who has collapsed?				
Pretraining, n (%)	22 (73.3)	12 (50.0)	23% (−3 to 47%)	0.78
Post-training, n (%)	25 (83.3)	14 (58.3)	25% (0.2 to 47%)	0.04
Risk difference (95% CI)	10% (−11 to 31%)	8% (−20 to 36%)		
P-value (pre- versus post-training)	0.18	0.48		
3. What would you do next after you confirm no movement of chest or stomach?				
Pretraining, n (%)	4 (13.3)	5 (20.8)	−8% (−28 to 13%)	0.46
Post-training, n (%)	10 (33.3)	9 (37.5)	−4% (−29 to 21%)	0.75
Risk difference (95% CI)	20% (−1 to 41%)	17% (−9 to 42%)		
P-value (pre- versus post-training)	0.03*	0.21		
4. Where would you place your hands when you perform chest compressions?				
Pretraining, n (%)	5 (16.7)	8 (33.3)	−17% (−39 to 7%)	0.15
Post-training, n (%)	14 (46.7)	6 (25.0)	22% (−4 to 44%)	0.10
Risk difference (95% CI)	30% (8 to 52%)	−8% (−34 to 17%)		
P-value (pre- versus post-training)	0.003*	0.530		
5. What is the correct rate for chest compressions on an adult patient?				
Pretraining, n (%)	12 (40.0)	9 (37.5)	3% (−23 to 27%)	0.85
Post-training, n (%)	24 (80.0)	15 (62.5)	18% (−7 to 40%)	0.15
Risk difference (95% CI)	40% (17 to 63%)	25% (−3 to 52%)		
P-value (pre- versus post-training)	0.001*	0.060		
6. What is the correct depth for chest compressions on an adult patient?				
Pretraining, n (%)	2 (6.7)	3 (12.5)	−6% (−23 to 11%)	0.46
Post-training, n (%)	6 (20.0)	8 (33.3)	−13% (−36 to 10%)	0.27
Risk difference (95% CI)	13% (−4 to 30%)	21% (−2 to 44%)		
P-value (pre- versus post-training)	0.046*	0.100		
7. What is the correct method for adequate recoil?				
Pretraining, n (%)	17 (56.7)	11 (45.8)	11% (−16 to 36%)	0.43
Post-training, n (%)	25 (83.3)	16 (66.7)	17% (−7 to 39%)	0.15
Risk difference (95% CI)	27% (5 to 49%)	21% (−7 to 48%)		
P-value (pre- versus post-training)	0.011*	0.130		
8. What would you do immediately after you deliver shock through an AED?				
Pretraining, n (%)	13 (43.3)	10 (41.7)	2% (−24 to 27%)	0.90
Post-training, n (%)	27 (90.0)	19 (79.2)	11% (−9 to 30%)	0.27
Risk difference (95% CI)	47% (26 to 67%)	38% (12 to 63%)		
P-value (pre- versus post-training)	0.001*	0.013*		

The table presents the number of students who answered correctly on pre-tests and post-tests. McNemar's test for comparison between pre- and post-training. χ^2 -Test for comparison between groups.

* $P > 0.05$.

AED, automated external defibrillator; CI, confidence interval.

Implementing school CPR training is a key factor in increasing bystander intervention.^{9,10,30–33} This has been accomplished in many ways. In most schools around the world, students are gathered on a specific date to participate in CPR training. A short CPR training course is introduced in the chapter “EIT: Education, Implementation, and Teams” in the 2015 JRC Guidelines.¹⁷ One manikin per student is preferable. However, many manikins are needed, and this becomes a challenge as the number of students increases. Approximately 40 manikins are needed per classroom. The ratio of manikins and students should be 1:1 and a maximum of 42 manikins can be used due to the upper limit of the QCPR Classroom system. At present, either the Mini Anne or the Little Anne (Laerdal Medical) is used for CPR training. A CPR instructor who is also a school teacher teaches with their subjective perspective when feedback devices are unavailable. Without feedback devices to measure the quality of chest compressions, quality assurance is questionable. In fact, the number of feedback devices available for use during CPR training is limited. Thus far, training has been accomplished by trial and error, but the recent launch of the QCPR Classroom concept by Laerdal Medical effectively achieves training a great number of students. In our opinion, school teachers are professionals in teaching school-aged children and know their students better than CPR instructors from outside of the school environment. However, they do not perform resuscitation skills in daily life. School teachers are concerned about teaching CPR because they lack the knowledge and performance skills. However, high school teachers, even without CPR training experience, can teach CPR well with “QCPR Classroom” method and their routine teaching method at school.

In this study, we introduced this new school CPR training model wherein school teachers without CPR teaching experience can deliver the same quality of training when videos are used to increase knowledge, and feedback devices are used to assess skills. The QCPR Classroom training improves the quality of CPR performance during training. Teachers who have been educated on this can teach CPR, and they can do so as well as, and as effectively as, health-care professionals. As long as students obtain a certain level of knowledge and skills, the method used for CPR training does not matter, for example, they can be trained by the standard, PWW-based, or e-learning adapted methods. Recently, a self-learning style has been adopted and proven effective;³⁴ students watched a video before class, and they focus only on practicing skills during class time. The lack of hands-on practice presents challenges; therefore, spending hands-on practice during most of the in-class training time will be very efficient. No other research has reported providing each learner with approximately 1,000 practice

compressions within a 50-min period. We suggest that this model be used for high-quality CPR training.

Limitations

This study has several limitations. The long-term retention of CPR skills was not assessed because of the academic schedule in Japan. Measurements were taken all together in the same classroom, as Figure 2 shows. The rate measurements could have been influenced by neighboring students because the motion of others could have been felt. However, QCPR Classroom training remains advantageous over conventional training. The number of students who answered questions 3, 4, and 6 correctly was low, but these topics were covered in a video. We were unable to specify the reason.

CONCLUSIONS

SCHOOL TEACHERS WITHOUT experience in CPR teaching can deliver high-quality CPR training that is equivalent to that taught by school teachers experienced in teaching CPR. Using the QCPR Classroom device, teachers can provide real-time feedback according to the recommendations of the JRC 2015 Guidelines. This PWW-based, QCPR Classroom-enhanced training will aid school teachers who are not CPR instructors in providing high-quality CPR training in a short amount of time. The QCPR Classroom concept should be incorporated into school CPR training programs.

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DISCLOSURE

Approval of the research protocol: This study was approved by the Institutional Review Board at Kokushikan University.

Informed consent: Verbal informed consent was obtained from students and written informed consent was obtained from their parents.

Registry and the registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: Helge Myklebust and Tonje Søråas Birkenes are employees of Laerdal Medical. They contributed with study design and manuscript revision. They did not have any role in data collection or analyzing the results, nor in the decision for publication. They agreed to submit this manuscript for publication.

Consent for publication: This manuscript does not contain any identifiable individual data.

REFERENCES

- Berdowski J, Berg RA, Tijssen JGP, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. *Resuscitation* 2010; 81: 1479–87.
- Hasselqvist-Ax I, Riva G, Herlitz J *et al.* Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. *N. Engl. J. Med.* 2015; 372: 2307–15.
- 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: 1377–84.
- Hansen CM, Kragholm K, Pearson DA *et al.* Association of bystander and first-responder intervention with survival after out-of-hospital cardiac arrest in North Carolina, 2010–2013. *JAMA* 2015; 314: 255–64.
- Iwami T, Kawamura T, Hiraide A *et al.* Effectiveness of bystander-initiated cardiac-only resuscitation for patients with out-of-hospital cardiac arrest. *Circulation* 2007; 116: 2900–7.
- Takahashi H, Sagisaka R, Natsume Y, Tanaka S, Takyu H, Tanaka H. Does dispatcher-assisted CPR generate the same outcomes as spontaneously delivered bystander CPR in Japan? *Am. J. Emerg. Med.* 2018; 36: 384–91 (in press).
- Nakahara S, Tomio J, Ichikawa M *et al.* Association of bystander interventions with neurologically intact survival among patients with bystander-witnessed out-of-hospital cardiac arrest in Japan. *JAMA* 2015; 314: 247–54.
- Van Hoeyweghen RJ, Bossaert LL, Mullie A *et al.* Quality and efficiency of bystander CPR. *Resuscitation* 1993; 26: 47–52.
- Perkins GD, Lockey AS, de Belder MA, Moore F, Weissberg P, Gray H. National initiatives to improve outcomes from out-of-hospital cardiac arrest in England. *Emerg. Med. J.* 2016; 33: 448–51.
- 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.
- Wnent J, Bohn A, Seewald S *et al.* Bystander resuscitation: the impact of first aid on survival. *Anästhesiol. Intensivmed. Notfallmed. Schmerzther.* 2013; 48: 562–5.
- Plant N, Taylor K. How best to teach CPR to schoolchildren: a systematic review. *Resuscitation* 2013; 84: 415–21.
- Tanaka H, Nakao A, Mizumoto H *et al.* CPR education in Japan—Past present and future. *Nippon Rinsho* 2011; 69: 658–69.
- Lukas R-P, Aken HV, Mölhoff T *et al.* Kids save lives: a six-year longitudinal study of schoolchildren learning cardiopulmonary resuscitation: who should do the teaching and will the effects last? *Resuscitation* 2016; 101: 35–40.
- Isbye DL, Rasmussen LS, Ringsted C, Lippert FK. Disseminating cardiopulmonary resuscitation training by distributing 35,000 personal manikins among school children. *Circulation* 2007; 116: 1380–5.
- Mptos N, Vekeman E, Monsieurs K, Derese A, Valcke M. Knowledge and willingness to teach cardiopulmonary resuscitation: a survey amongst 4273 teachers. *Resuscitation* 2013; 84: 496–500.
- Japan Resuscitation Council. Guideline 2015 Online. Chapter 8, EIT: Education, Implementation, and Teams [cited 26 Nov 2017]. Available from: <http://www.japanresuscitationcouncil.org/wp-content/uploads/2016/04/b7b5b647189bc07f38f6fecf014cf5d9.pdf>.
- Kanstad BK, Nilsen SA, Fredriksen K. CPR knowledge and attitude to performing bystander CPR among secondary school students in Norway. *Resuscitation* 2011; 82: 1053–9.
- Kaye W, Rallis SF, Mancini ME *et al.* The problem of poor retention of cardiopulmonary resuscitation skills may lie with the instructor, not the learner or the curriculum. *Resuscitation* 1991; 21: 67–87.
- Parnell MM, Larsen PD. Poor quality teaching in lay person CPR courses. *Resuscitation* 2007; 73: 271–8.
- Sipsma K, Stubbs BA, Plorde M. Training rates and willingness to perform CPR in King County, Washington: a community survey. *Resuscitation* 2011; 82: 564–7.
- Public Health Seattle & King County. Division of Emergency Medical Services 2018 annual report to the King County Council. [cited 11 Jun 2019]. Available from: [https://www.kingcounty.gov/depts/health/emergency-medical-services/~media/depts/health/emergency-medical-services/documents/reports/2018-Annual-Report.ashx](https://www.kingcounty.gov/depts/health/emergency-medical-services/~/media/depts/health/emergency-medical-services/documents/reports/2018-Annual-Report.ashx).
- Kitamura T, Iwami T, Atsumi T *et al.* The profile of Japanese association for acute medicine – out-of-hospital cardiac arrest registry in 2014–2015. *Acute Med. Surg.* 2018; 5: 249–58.
- Ong ME, Shin SD, De Souza NN *et al.* Outcomes for out-of-hospital cardiac arrests across 7 countries in Asia: The Pan Asian Resuscitation Outcomes Study (PAROS). *Resuscitation* 2015; 96: 100–8.
- Swor R, Khan I, Domeier R, Honeycutt L, Chu K, Compton S. CPR training and CPR performance: do CPR-trained bystanders perform CPR? *Acad. Emerg. Med.* 2006; 13: 596–601.
- Weisfeldt ML, Everson-Stewart S, Sitlani C *et al.* Ventricular tachyarrhythmias after cardiac arrest in public versus at home. *N. Engl. J. Med.* 2011; 36: 313–21.

- 27 Haff SR, Rea TD, Culley LL, Kerry F, Becker L, Eisenberg MS. Factors impeding dispatcher-assisted telephone cardiopulmonary resuscitation. *Ann. Emerg. Med.* 2003; 42: 731–7.
- 28 Hansen CM, Lippert FK, Wissenberg M *et al.* Temporal trends in coverage of historical cardiac arrests using a volunteer-based network of automated external defibrillators accessible to laypersons and emergency dispatch centers. *Circulation* 2014; 130: 1859–67.
- 29 Tanigawa K, Iwami T, Nishiyama C, Nonogi H, Kawamura T. Are trained individuals more likely to perform bystander CPR? An observational study *Resuscitation* 2011; 81: 523–8.
- 30 National Academy of Sciences. Strategies to improve cardiac arrest survival: a time to act; 2015. [cited 29 Jan 2017]. Available from: <http://www.nationalacademies.org/hmd/Reports/2015/Strategies-to-Improve-Cardiac-Arrest-Survival.aspx>.
- 31 Bhanji F, Donoghue AJ, Wolff MS *et al.* Part 14: education: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2015; 132: S561–73.
- 32 Greif R, Lockey AS, Conaghan P *et al.* European Resuscitation Council Guidelines for Resuscitation 2015: section 10. Education and implementation of resuscitation. *Resuscitation* 2015; 95: 288–301.
- 33 Bottiger BW, Bossaert LL, Castren M *et al.* Kids Save Lives —ERC position statement on school children education in CPR.: “Hands that help - Training children is training for life”. *Resuscitation* 2016; 105: 1–3.
- 34 Nishiyama C, Iwami T, Kawamura T *et al.* Effectiveness of simplified chest compression-only CPR training program with or without preparatory self-learning video: a randomized controlled trial. *Resuscitation* 2009; 80: 1164–8.