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Hands-only cardiopulmonary resuscitation training for schoolchildren: A comparison study among different class groups

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Abstract:

BACKGROUND AND AIM: Up to 70% of out-of-hospital cardiac arrests are witnessed by family members, friends, and other bystanders. These bystanders can play a vital role in delivering help, before professional help arrives. Mandatory nationwide training of schoolchildren has shown the highest impact in improving the bystander cardiopulmonary resuscitation (CPR) rate. In our study, we compared the competency of different classes of schoolchildren from middle school onward in learning hands-only CPR.

MATERIALS AND METHODS: This study was conducted in four schools. Schoolchildren were divided into three groups as middle school (6th to 8th standard) (MS), secondary school (9th and 10th standard) (SC), and senior secondary school (11th and 12th standard) (SN). Training module consisted of slide presentation on "hands-only CPR" of 1 h, video demonstration of 30 min, and hands-on session of 2.5 h. Students were then individually assessed for the skills.

RESULTS: A total of 810 children were enrolled and trained. Initial approach was performed correctly by 68% of MS, 79.3% of SC, and 82.4% of SN school children, whereas 49.4% of MS, 61.3% of SC, and 72.5% of SN correctly performed chest compression in terms of rate, depth, and duration. Median compression depth and maximum duration of CPR achieved were significantly different across class groups ($P < 0.001$) Compression depth and duration of chest compression were positively correlated with children's age, height, weight, and body mass index ($P < 0.001$).

CONCLUSION: Theoretical training on hands-only CPR can be started at the middle school level, and practical training can be incorporated in school curricula from secondary school.

Keywords:

Cardiopulmonary resuscitation, children, bystander, school

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Introduction

Globally, the incidence of out-of-hospital cardiac arrest (OHCA) varies significantly with very poor outcomes.[1,2] In developing countries, the outcome of OHCA is poor, which can be attributed to its inadequate prehospital emergency medical services.[3,4] This problem is further compounded by the lack of knowledge and skills in cardiopulmonary resuscitation (CPR) among bystanders in the community. Up to 70% of OHCAs are witnessed by family members, friends, and other bystanders. These bystanders can play a vital role in delivering help, before professional help arrives, and training them

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Box-ED

What is already known on the study topic?

Bystander cardiopulmonary resuscitation (CPR) helps in improving the outcomes for out-of-hospital cardiac arrest. The WHO recommends training of children in basic resuscitation skills.

Has it importance for readers?

Training of schoolchildren in CPR skills improves their knowledge and attitude toward responding to an unresponsive patient. This, in turn, can improve bystander CPR rates and outcomes of out-of-hospital cardiac arrests.

How is this study structured?

This is a prospective interventional study done in four schools.

What does this study tell us?

Training schoolchildren in hands-only CPR has a significant impact on schoolchildren's knowledge, attitude, and practices toward bystander response to an unresponsive person and recommendation on different skill sets which should be taught at different levels of classes.

with necessary skills is a way to improve this initial response by laypeople.[5]

Mandatory nationwide training of schoolchildren has shown the highest impact in improving the bystander CPR rate.[6] The WHO has endorsed mandatory training for schoolchildren under the statement "Kids save lives" in 2015.[7] Training of schoolchildren is challenging, as their ability to perform a successful CPR depends on various factors such as age, weight, height, and the aptitude to learn new skills.[8] Hence, it is important to identify specific skills that can be taught at each school level and can be incorporated into their curriculum.

A complete CPR skill includes verifying scene safety, calling for help, performing chest compressions, giving rescue breaths, and using automated external defibrillator (AED) once available. There may be an aversion to mouth-to-mouth ventilation, as even resuscitation trainers are reluctant to carry out mouth-to-mouth ventilation in patients due to the fear of disease transmission.[9] Therefore, in our study, we focused on teaching the students' hands-only CPR. Community-level programs have been conducted for training adult bystanders,[10] but there is a paucity of literature regarding the performance of Indian students in CPR skills. In this study, we assessed the competency of schoolchildren from middle school onward in learning hands-only CPR, so that we could ascertain the variability in excellence among each class and provide a recommendation for the same.

Materials and Methods

Study design, participants, and settings

This study was designed as a prospective, interventional study conducted in convenient sample of four schools. We recruited schoolchildren from 6th to 12th standard, which were divided into three groups as middle school (6th to 8th standard) (MS), secondary school (9th and 10th standard) (SC), and senior secondary school (11th and 12th standard) (SN) according to commonly acceptable Indian norms. The training program on "hands-only CPR" was conducted in the respective school premises. The study was explained, and written consent was taken from to the head of the school. Children's weight, height, age, and gender were recorded. Ethical clearance was taken from the institutional ethics committee (IEC/284/3/2019).

Training program

Training module on hands-only CPR for schoolchildren was decided from consensus in the scientific advisory committee consisting of three faculty members from the department of emergency medicine. It was based on the European Resuscitation Council 2017 and American Heart Association 2015 guidelines. Trainers were emergency physicians who were given a precourse standardized training by the faculties for maintaining the intervention fidelity. They were blinded to the data collection and analysis plan of the study. The training module included slide presentation on different theoretical aspects of hands-only CPR of 1 h, video demonstration of 30 min, and hands-on session of 2 h and 30 min on the Laerdal Resusci Anne SkillReporter manikins. Lecture was comprising (1) scene safety, (2) checking responsiveness by shouting and tapping, (3) checking respiration, (4) calling for help, (5) conveying of correct message, and (6) chest compression. All the lectures including slides and communication were in local language.

Assessment

Before starting the training session, each of the children was given pro forma consisting of six questions with respect to their attitude toward CPR [Supplementary Material 1]. This pro forma had a question "Can you do something if someone collapses in front of you?" whose response was again recorded after the course. Pretraining knowledge assessment was done with a 10-statement questionnaire (1 mark each) recording three aspects – basic knowledge, theoretical aspects, and algorithm of hands-only CPR [Supplementary Material 1]. Posttraining assessment was done with the same pretraining 10-statement questionnaire and practical evaluation by the trainer. Practical assessment was categorized as "correct initial approach" consisting of checking scene safety and responsiveness by shouting and tapping; "conveying complete message" in terms of all details such as calling emergency contact

number (108), introducing oneself, specific address, situation, starting CPR, and requesting for early arrival with AED; and "performing correct chest compressions" comprising correct hand position, correct rate (100–120/min), and correct depth (5–6 cm). A trained assistant collected the details of chest compression performance with the help of Laerdal SkillReporter (PC) software, version 3.2.0.1.

Study outcomes

The primary outcome of this study was to investigate the impact of training on practical aspect of hands-only CPR of students in each class group. The secondary outcome was to investigate the impact of training on change in knowledge and attitude of children as compared to untrained status, the relationship of demographic data of children with compression quality, and forming a recommendation for hands-only CPR training in different class groups.

Statistical analysis

Statistical analysis and graphs were made with SPSS (Version 23; IBM, Armonk, NY) and Microsoft Excel (2018). Normality of continuous data was checked with Shapiro–Wilk test. Age, height, weight, body mass index (BMI), compression rate, compression depth, maximum compression duration, and pre- and posttraining questionnaire scores were found to be nonnormal and hence expressed as median and interquartile range (IQR). Kruskal–Wallis H-test was used to compare median compression quality data, and *post hoc* analysis with Bonferroni correction was undertaken to find the pairwise difference. Wilcoxon signed-rank test was used to compare median pre- and posttraining questionnaire scores. Categorical variables (proportion of children who achieved correct compression rate and depth and could do compression for more than 2 min) were reported in frequency (percentage) and compared using Chi-square test. For investigating correlation between demographics (age, weight, height, and body mass index) with compression quality, Pearson's correlation was used and reported as Pearson's coefficient (*r*-value with its *P* value). Linear regression was used to find the contribution of each variable on compression quality. Two-sided $P < 0.05$ was considered statistically significant.

Results

Demographic characteristics

A total of 810 children from 4 schools (15 classes) were enrolled in the study. Out of 810, a proportion of MS and SC children were higher than that of SN children. Demographic characteristics were significantly different among class groups (Kruskal–Wallis H $P < 0.01$). The demographic characteristics of students who participated in this study are presented in Table 1.

Impact of training on hands-only cardiopulmonary resuscitation quality

Overall practical assessment

Practical assessment was assessed in terms of correct initial approach, conveying complete message, and performing correct chest compressions [Figure 1]. Initial approach was performed correctly by 68% of MS, 79.3% of SC, and 82.4% of SN school children. Every detail of the message was correctly conveyed to the emergency contact number by 52% of MS, 51.8% of SC, and 74.6% of SN school children, whereas only 49.4% of MS, 61.3% of SC, and 72.5% of SN correctly performed chest compression in terms of rate, depth, and duration.

Assessment of chest compression quality according to class category

Median compression rate, depth, and maximum duration of CPR achieved were significantly different across class groups (Kruskal–Wallis H $P < 0.001$) [Figure 2]. A proportion of children who achieved correct compression depth of 5–6 cm were 61.7%, 79.3%, and 83% in MS, SC, and SN schools, respectively. A proportion of children who did the compression at rate of 100–120/min were 63.4%, 75.7%, and 82.9% in MS, SC, and SN schools, respectively, whereas only 1.9% of MS, 15.1% of SC, and 52.8% of SN school children could do CPR for more than 2 min.

Impact of training on knowledge assessment

The median score of questionnaires increased significantly from pretraining value of 4 (IQR: 3–4) to that of posttraining value of 7 (IQR: 6–8), with a Wilcoxon signed-rank test's $P < 0.001$. Although 57% of MS could correctly answer more than or equal to 7 out of 10 questions, 80% of SC and 89% of SN school children secured the same.

Attitude of children toward training

Majority of the students were interested in learning CPR. 76.4% and 13.8% of schoolchildren were "very excited" and "excited" to be a part of this training program,

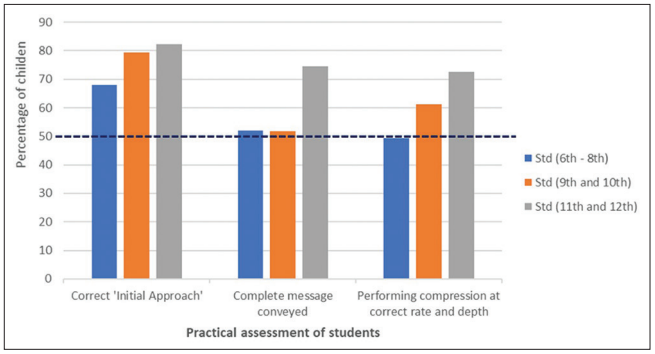

Figure 1: Practical assessment of schoolchildren for various steps of hands-only cardiopulmonary resuscitation (blue dotted line suggests the 50% of students in that class category)

Table 1: Demographic characteristics of study population, cardiopulmonary resuscitation acquaintance prior to the training, and chest compression performance according to the class categories

	Middle School (6th to 8th standard)	Secondary School (9th and 10th standard)	Senior Secondary School (11th and 12th standard)
Student population (%)	45.2	40	23.8
Number of children (male, female)	366 (214, 152)	251 (137, 114)	193 (80, 113)
Schoolchildren' demographics-mean (IQR)*			
Age in years	13 (12–13)	14 (14–15)	16 (16–17)
Weight in kg	37 (31.9–41.8)	43.2 (39.4–48.5)	45.5 (40.6–51.3)
Height in cm	148 (142–155)	155 (147.5–161)	155 (149–163.5)
BMI in kg per square meter	16.4 (15.2–18.2)	18.2 (16.6–19.5)	18.9 (17.7–20.4)
CPR acquaintance (yes %)			
Any previous CPR training	3.3	15.1	17.1
Any family member trained in CPR	3.3	6.4	6.7
Any encounter with unresponsive person	44.8	55.8	57.5
Chest compression performance (%)			
Children achieving rate of 100-120/min	63.4	75.7	82.9
Children achieving depth of 5-6 cm	61.7	79.3	82.9
Children performing CPR for 2 min or more	1.9	15.1	52.8

*Suggests *P* value for Kruskal-Wallis H test $P<0.001$. *Post hoc* analysis with Bonferroni correction showed all pairwise comparison to be significantly different ($P<0.05$), except for height (secondary school and senior secondary school children were not different in terms of their height), ^Suggests *P* value for Chi-square test <0.001. CPR=Cardiopulmonary resuscitation, BMI=Body mass index, IQR=Interquartile range

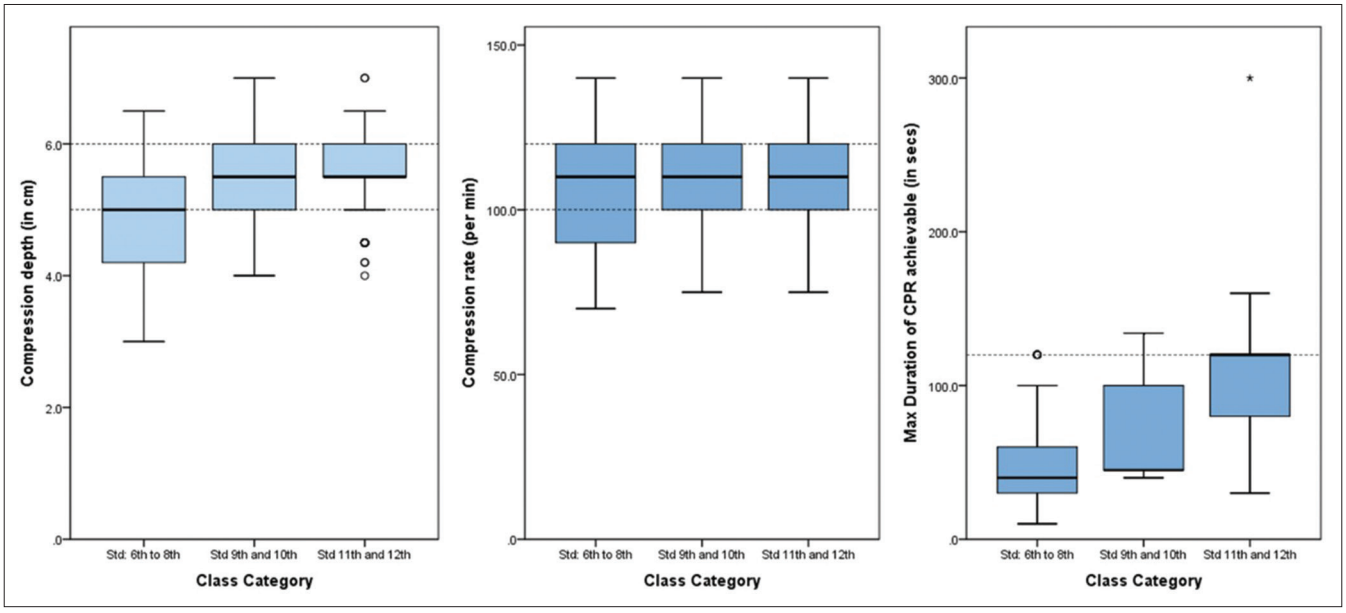

Figure 2: Comparison of chest compression depth, rate, and duration with different class categories (Kruskal–Wallis H-test showed that compression depth, rate, and duration were significantly different across class categories, $P < 0.001$) (*post hoc* analysis with Bonferroni correction showed all pairwise comparison to be significantly different from each other with $P < 0.05$, except for compression rate. Compression rate achieved by middle school and secondary school children was not statistically different from each other)

whereas only 2.1% of students were "disinterested" in training. When they were asked about the integration of CPR training in their study curriculum, 61.1% and 22.1% of children were "strongly agreeing" and "agreeing." Pre- and posttraining, a single question was asked on their confidence of providing CPR (*Can you do something if someone collapses in front of you?*). Pretraining, 4.8%, 34.1%, and 61.1% of children had marked "yes," "may be," and "not sure," respectively. However, this scenario changed after training. Posttraining, 82.3%, 11.4%, and 6.3% had marked "yes," "may be," and "not sure," respectively.

Relationship of demographic characteristics with cardiopulmonary resuscitation quality

Compression depth and duration of chest compression were positively correlated with children's age, height, weight, and BMI ($P < 0.001$) [Table 2]. A positive correlation of compression rate with age and height was statistically significant ($P < 0.001$) but not with that of weight ($P = 0.58$), whereas compression rate was negatively correlated with BMI although statistically insignificant ($P = 0.076$). To further investigate the contribution of age and BMI to

Table 2: Pearson's correlation statistics-correlation between compression quality items and demographic characteristics

CPR performance characteristics	Age	Height	Weight	BMI
Compression depth	0.399	0.275	0.536	0.529
Compression rate	0.137	0.104	0.019*	−0.062**
Duration of CPR	0.581	0.281	0.352	0.253

All correlation coefficients are statistically significant (P<0.05) except *Where P=0.58 and **Where P=0.076. CPR=Cardiopulmonary resuscitation, BMI=Body mass index

CPR quality, linear regression was performed. It showed that change in BMI (beta: 0.446, $P < 0.05$) was attributing more to the change in compression depth than that of age (beta: 0.253, $P < 0.05$), whereas change in age (beta: 0.558, $P < 0.05$) was attributing more to the change in duration of CPR than that of BMI (beta: 0.071, $P < 0.05$). It was found that the compression rate was somewhat differently related to demographic characteristics. Change in BMI was actually significantly decreasing the efficacy of compression rate (beta: −0.12, $P < 0.05$), but change in age was contributing to increase in compression rate (beta: 0.176, $P < 0.05$).

Discussion

Training schoolchildren in school CPR has the highest impact on improving bystander CPR rates as young children are not only enthusiastic to learn and perform but also eager to teach those around them.[6,11] We focused on teaching the students' hands-only CPR as it is easier for students to learn and also removes aversion associated with mouth to mouth ventilation. Our study revealed that majority of the students could identify unresponsive patients, ensure scene safety, and call for help correctly. However, in terms of performing CPR, MS students lagged behind their SC and SN counterparts.

Impact of training on practical skills

After practical demonstration, all the three class groups were able to perform initial approach correctly, along with conveyance of proper message to the emergency contact. Children of MS were somewhat poor in providing correct chest compression when compared to that of SC and SN. Median compression rate, depth, and maximum duration of CPR achieved were significantly different across class groups ($P < 0.001$). Jones *et al*. in a similar study found that compression rate was not varying across year-5 (mean age – 9.7 years), year-7 (mean age – 11.6 years), and year-9 (mean age – 13.6 years) schoolchildren, whereas compression depth achieved was different across these class groups.[12] Our study revealed a difference in compression rate too.

Impact of training on attitude of children toward hands-only cardiopulmonary resuscitation and theoretical knowledge

Prior to CPR training, majority of the schoolchildren (90.2%) had strong desire and were excited to learn CPR. Even most of them wanted it to be integrated into their school curriculum (83.2%). To the question "Can you do something if someone collapses in front of you?," the proportion of children who confidently responded "yes" in the precourse was 4.8% which when compared to studies from neighboring Asian countries was significantly less.[13,14] Although posttraining, there was a significant improvement in the response to around 82.3%. This highlights the lack of awareness on how to respond in emergency situations among the study population and the importance of such training programs at school level which could have a significant impact in improving their attitude toward CPR and confidence in providing bystander CPR. This training also had a significant impact on schoolchildren's knowledge of CPR, as posttraining scores of 7 (IQR: 6–8), improved from pretraining score of 4 (IQR: 3–4) ($P < 0.001$). These observations were similar to that of other studies, showing that training program can increase basic life skills' knowledge of primary school children regarding CPR.[15-17]

Determinant of cardiopulmonary resuscitation quality

We found that the compression depth and duration were positively correlated with age, height, weight, and BMI of schoolchildren. Fleischhackl *et al*. conducted a similar study in Austrian schoolchildren and found that depth of chest compression was dependent on height, weight, and BMI but not on age.[18] In our study, the compression rate had a significant association with age and height but not with that of weight and BMI. This was in contrast with previous observations by Jones *et al*., where they had found no association of compression rate and pupil's demographic characteristics.[12] We also found that hardly 2% of middle school and 15% of secondary children could sustain CPR for more than 2 min. These findings reinforce the fact that children's physical characteristics play a role in the quality of chest compressions.[12,18-20]

Training module at each level of school

Even though physical strength may limit effective CPR, our study shows that cognitive skills are not dependent on age. In our study, almost all children were excited to learn CPR, and on knowledge assessment, posttraining, majority could achieve a 70% score. We recommend that basic theoretical knowledge of CPR can be taught from 6th standard itself. With regard to practical training, the authors believe that secondary school would be an ideal level at which hands-on training can be initiated. Although the SC students could not sustain

Table 3: Recommendations of main focus areas of hands-only cardiopulmonary resuscitation training in each level of school

	Theory	Practical
Standard 6th to 8th	Basic knowledge	Identification, scene safety
	Theory of CPR	Call for help and convey correct message
Standard 9th and 10th	Basic knowledge	Identification, scene safety
Standard 11th and 12th	Theory of CPR	Call for help and convey correct message
	Algorithm of CPR	Performing chest compression

CPR=Cardiopulmonary resuscitation

CPR for more than 2 min, they performed fairly in the initial approach, conveying the message and correctly performing the chest compression in terms of rate and depth. With repeated training and periodic refresher courses, the child's ability to perform CPR is likely to improve.[17,21] At least these children can help each other in emergency situations and call the emergency services, which is an important link in the chain of survival. The need to incorporate mandatory training in school curriculum is the way forward. Based on our findings, we formulated the recommendations of the main focus areas for each level of school [Table 3], which is similar to the recommendations made by De Buck *et al*.[21]

Limitation

This was a study done in few schools of a province, which would not be a fair representative of a large country like ours. Training on the use of AED was not done. Refresher course and assessment were not undertaken; hence, recommendations regarding the frequency of training could not be made.

Conclusion

Training schoolchildren in hands-only CPR has a significant impact on schoolchildren' knowledge, attitude, and practices toward bystander response to an unresponsive person. The recommendations proposed should be tested in a larger cohort and may help policy-makers to integrate "hands-only" CPR training in school curriculum.

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Author contribution statement

RM, AK, and SB conceived the study and designed the trial. RM, AKS, AK, and NT undertook recruitment of participating centers and patients and managed the data, including quality control. AKS and RM provided statistical advice on study design and analyzed the data; PA chaired the data oversight committee. RM drafted the manuscript, and all the authors contributed substantially to its revision. RM takes responsibility for the study as a whole.

Conflicts of interest

None Declared.

Ethical approval

Ethical Board or Institutional Review Board Approval was taken from the All India Institute of Medical Sciences Ethics Committee on March 2019 (IEC/284/3/2019).

Consent to participate

Since it was a training project for schoolchildren, the consent for the same was taken by the principal of the participating schools on behalf of all the students.

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Supplementary Material 1

Contents

1. Pro forma – Attitude of schoolchildren toward learning hands-only CPR (prior to the initiation of training)

Name: .....
Age: ..... Gender: M/F
Class: .....

Questions	You answer (*tick the appropriate*)				
Do you have any previous training on basic first aid and/or cardiopulmonary resuscitation (CPR)?			Yes/No		
Does anyone from your family know how to perform CPR?			Yes/No		
Do you feel that CPR training should be a part of your study curriculum in the school?	1	2	3	4	5
1: Strongly agree					
2: Agree					
3: Neither					
4: Disagree					
5: Strongly disagree					
Have you ever encountered an unresponsive person in your locality?			Yes/No		
How excited are you to learn "hands-only CPR" today?	1	2	3	4	5
1: Very excited					
2: Excited					
3: Don't know					
4: Not really interested					
5: Completely disinterested					
Can you do something if someone collapses in front of you?	1	2	3	4	5
Yes, I can do					
May be, I can try					
Not sure					

2. Pretraining questionnaire

1. CPR stands for
   a. Cardiopulmonary resuscitation
   b. Cardiac pulse rate
   c. Central pulse rate
   d. Cardiopreventive resuscitation

2. Which number is the correct one for an emergency phone call if you need an ambulance in India?
   a. 108
   b. 101
   c. 911
   d. 100

3. What is the usual heart rate of an adult at rest?
   a. 10–20 beats per min
   b. 120–160 beats per min
   c. 100–120 beats per min
   d. 60–80 beats per min

4. Which is the best way to assess responsiveness in a patient?
   a. Shake and shout
   b. Touch and talk
   c. Pressure and pain
   d. Order and observe

5. If you witness a person collapsing before you, what will you do first?
   a. Call the ambulance and then start CPR
   b. Start CPR and then call ambulance
   c. Do not attempt any CPR
   d. Call the police

6. What is the recommended depth of compression of chest in an adult during CPR?
   a. 3–4 cm
   b. 4–5 cm
   c. 5–6 cm
   d. 6–7 cm

7. What is the recommended rate of compression in an adult during CPR?
   a. 80–100 per min
   b. 100–120 per min
   c. Any rate is acceptable
   d. None of the above

8. Correct hand position for CPR is
   a. Between two nipples
   b. Upper chest
   c. Left side of chest
   d. Upper part of stomach (abdomen)

9. If someone does not respond, I will do the following in this order (first, second, third, final):
   a. Look for scene safety – I call for help – I start chest compressions
   b. I call for help – Look for scene safety – I start chest compressions
   c. I start chest compressions – I call for help – Look for scene safety
   d. I will run away from the scene

10. Till what time will you perform chest compressions?
    a. Till the time you get tired
    b. Till the ambulance arrives
    c. Till the victim reaches hospital
    d. All of the above

3. Posttraining questionnaire

1. CPR stands for
   a. Cardio-pulmonary resuscitation
   b. Cardiac- pulse rate
   c. Central pulse rate
   d. Cardio-preventive resuscitation

2. Which number is the correct one for an emergency phone-call if you need an ambulance in India?
   a. 108
   b. 101
   c. 911
   d. 100

3. What is the usual heart rate of an adult at rest?
   a. 10–20 beats per min
   b. 120–160 beats per min
   c. 100–120 beats per min
   d. 60–80 beats per min

4. Which is the best way to assess responsiveness in a patient?
   a. Shake and shout
   b. Touch and talk
   c. Pressure and pain
   d. Order and observe

5. If you witness a person collapsing before you, what will you do first?
   a. Call the ambulance and then start CPR
   b. Start CPR and then call ambulance
   c. Do not attempt any CPR
   d. Call the police

6. What is the recommended depth of compression of chest in an adult during CPR?
   a. 3–4 cm
   b. 4–5 cm
   c. 5–6 cm
   d. 6–7 cm

7. What is the recommended rate of compression in an adult during CPR?
   a. 80–100 per min
   b. 100–120 per min
   c. Any rate is acceptable
   d. None of the above

8. Correct hand position for CPR is
   a. Between two nipples
   b. Upper chest
   c. Left side of chest
   d. Upper part of stomach (abdomen)

9. If someone does not respond, I will do the following in this order (first, second, third, final):
   a. Look for scene safety – I call for help – I start chest compressions
   b. I call for help – Look for scene safety – I start chest compressions
   c. I start chest compressions – I call for help – Look for scene safety
   d. I will run away from the scene

10. Till what time will you perform chest compressions?
    a. Till the time you get tired
    b. Till the ambulance arrives
    c. Till the victim reaches hospital
    d. All of the above

Can you do something if someone collapses in front of you?	1	2	3	4	5
Yes, I can do					
May be, I can try					
Not sure					

4. Categorization of pre- and posttraining questions

A. Basic knowledge
   1. Question number 2

B. Theoretical aspects of "hands-only CPR"
   1. Question number 1
   2. Question number 3
   3. Question number 6
   4. Question number 7
   5. Question number 8

C. Algorithm of "hands-only CPR"
   1. Question number 4
   2. Question number 5
   3. Question number 9
   4. Question number 10