‘The year of first aid’: effectiveness of a 3-day first aid programme for 7-14-year-old primary school children

Balint Banfai,1 Emese Pek,1 Attila Pandur,1 Henrietta Csonka,2 Jozsef Betlehem1

ABSTRACT
Aim of the study Bystanders can play an important role in the event of sudden injury or illness. Our aim was to evaluate the effects of a 3-day first aid course for all primary school age groups (7–14 years old).
Methods 582 school children were involved in the study. Training consisted of three sessions with transfer of theoretical knowledge and practical skills about first aid. The following most urgent situations were addressed in our study: adult basic life support (BLS), using an automated external defibrillator (AED), handling an unconscious patient, managing bleeding and calling the ambulance. Data collection was made with a questionnaire developed for the study and observation.
Results Prior to training there was a low level of knowledge and skills on BLS, management of the unconscious patient, use of an AED and management of bleeding. Knowledge and skills improved significantly in all of these categories (p<0.01) and remained significantly higher than the pre-test level at 4 months after training (p<0.01). Younger children overall performed less well than older children, but significantly improved over the pre-test level both immediately and 4 months after training (p<0.01). Prior first aid training was associated with knowledge of the correct ambulance number (p=0.015) and management of bleeding (p=0.041). Prior to training, age was associated with pre-test knowledge and skills of all topics (p<0.01); after training, it was only associated with AED use (p<0.001). There was a significant correlation between the depth of chest compression and children’s age, weight, height and body mass index (p<0.001). Ventilation depended on the same factors (p<0.001).
Conclusion Children aged 7–14 years are able to perform basic life-saving skills. Knowledge retention after 4 months is good for skills, but thinking in algorithms is difficult for these children.

INTRODUCTION
Bystanders can play an important role in the event of sudden injury or illness before professional help arrives. The willingness, frequency and quality of first aid provision is low worldwide but can be increased with effective training.1–3 After being alerted to a situation where first aid is required, the emergency call dispatcher can encourage bystanders to act on their prior knowledge.4

Sometimes children are the first people to the scene of an emergency situation. According to a statement by the American Heart Association, cardiopulmonary resuscitation (CPR) training for school children is mandatory in the USA.5 Cardiopulmonary resuscitation training for school children was endorsed in 2015 by the World Health Organization.6 A published systematic review in 2013 collated the most effective methods for teaching CPR to children.7

According to De Buck et al, first aid education is broader than CPR training alone.8 First aid training in early childhood can improve an individual’s knowledge, skills and willingness to perform first aid in an emergency situation.9 Eisenburger and Safar recommended that everybody, including children, should learn life-supporting first aid.10 Children are able to call for help and give basic first aid after training.11 12 However, it is unclear at what age students can learn the different aspects of first aid (including resuscitation).13 14

Commencing first aid education in early childhood can be beneficial even if intellectual and physical abilities usually present as a barrier to learning. Early training provides the basis for future training opportunities. The aim of the current study was to evaluate the effects of a 3-day first aid course for all primary school age groups (7–14 years). Our aim was to measure the children’s first aid knowledge and skills before, immediately after and 4 months after training.
METHODS
In this longitudinal cohort study we investigated the effectiveness of our first aid teaching programme.

Participants
The first aid programme was delivered within the framework of ‘The year of first aid’. All students (first to eighth grades) were required to participate in a 3-day training programme which was held between September 2015 and June 2016. After training, the children received a poster which summarised the tasks learnt. Children in this study were from an inner-city primary school located in Pécs, Hungary. Children who had not attended all three lessons or did not pass any of the tests were excluded from the study.

Training programme
Training consisted of three sessions (45 min each) on three consecutive weeks (one per week) with transfer of theoretical knowledge and practical skills about first aid. The following most urgent situations were addressed in the study: adult basic life support (BLS), using an automated external defibrillator (AED), handling an unconscious patient, managing severe bleeding and calling the ambulance. For this latter point, we measured children’s ability to recall the correct telephone number of the local ambulance service (104 or 112 in Hungary) and to give necessary relevant information (location, nature of the emergency, number of victims, own telephone number). To test this as part of practical skills we described emergency situations and for each of these situations, the children had to decide whether it was necessary to call the ambulance service (eg, mild nose bleeding vs unconscious patient). The teaching programme was adapted to the needs and abilities of all age groups. All of the instructors were paramedics. The training programme contained theoretical and ‘hands-on training’ components. The curriculum and the checklists are shown in online supplementary appendix A.

Measurements
We administered a questionnaire to the students before, immediately after and 4 months after the training course. The questionnaire used open-ended questions because we believe the answers to open questions better reveal actual knowledge than the results of multiple-choice tests (see online supplementary appendix B). Questionnaires in earlier studies contained only multiple-choice items and thus we developed the questionnaire ourselves. Children with lower levels of cognitive status (first and second graders) could receive questions aurally and give answers orally. In addition, children were tested in first aid scenarios before and immediately after teaching, and then re-tested 4 months later. We therefore measured both knowledge and practical skills. Completion of the questionnaire and practical measurements were performed on the same days.

The sex, age, body height and weight of all children were recorded and their body mass index (BMI) calculated. Children used a ‘code word’ when they were measured so we could follow them anonymously for the entire programme duration (pre- and post-test). Based on the questionnaire, we documented whether participants had experienced previous first aid training.

To evaluate the CPR performance we used an AMBU Man W model with AMBU CPR Software (AMBU A/S, Baltorpbakken 13, DK 2750 Ballerup, Denmark). The programme recorded chest compression depth, frequency and rate, hand position, chest compression-ventilation rate, ventilation volumes and frequency, compression-relaxation rate and pause between each compression round during a continuous CPR scenario of 2 min duration. To teach and practice handling of the AED, we used a Lifepak1000 AED Trainer. ‘Self-made wounds’ (artificial wounds made using materials such as makeup and syrup) were made to simulate severe bleeding. The victims were other children or adult imitators in the scenarios.

Measurements were conducted in a private classroom. Other participants waited in another room. First aid skills were scored by an instructor using checklists that were developed according to European Resuscitation Council (ERC) guidelines.15 16

Statistical analysis
Statistical analysis was conducted using SPSS 22.0 (Statistics Package for Social Sciences, Chicago, IL, USA) statistical software. Descriptive statistics were performed (percentages, mean, SD). Categorical variables were presented as number (%) and were compared using the χ² test or Fisher’s exact test as appropriate. One-way ANOVA and t-test was applied to test the association between knowledge, skills (pre-test, post-test and after 4 months) and demographic characteristics (age, body weight and height, BMI, previous first aid experience). Pearson correlation analysis was applied to test CPR quality (chest compression depth and ventilation volume vs age, BMI, body weight and height). A p value of <0.05 was considered to be statistically significant.

Ethical considerations
Since this survey evaluated a first aid teaching programme, it did not lie within the mandate of the research ethics committees in Hungary and therefore no approval was needed according to Hungarian law and regulations. The participants, their parents and teachers received written and oral information prior to study commencement. They were informed of their right to withdraw at any time with no personal consequences. The children’s parents gave written informed consent before their child entered the study.

RESULTS
We recruited 607 children. Of these, 25 were excluded from the study because they did not attended all three lessons (13 children) or they did not pass at least one of the tests (12 children). There were therefore 582 study participants, between 7 and 14 years old, comprising 317 girls (54.5%) and 265 boys (45.5%); 75 (12.9%) of these students had previously attended first aid training. Demographic data are displayed in table 1.

THEORETICAL KNOWLEDGE
In almost all of the children the theoretical knowledge after training and at 4 months was significantly higher than pre-test (table 2).

Our results showed that some children without previous first aid training had preliminary first aid knowledge from different sources (eg, media, parents).

The majority of children were able to give the correct ambulance phone number and location and type of emergency prior to training; the proportion improved immediately after the course and remained high at 4 months. The ability to perform the steps of BLS was very low (<20%) prior to the course and improved significantly after the course. After 4 months this knowledge declined somewhat but remained significantly higher than the pre-test level. Theoretical knowledge about AED was low overall (14%) but improved post-test and remained significantly better at 4 months compared with
the pre-test level. The proportion of children who knew how to approach an unconscious patient was 12% and rose after training (77%) and remained significantly higher at 4 months (66%). Management of bleeding also rose significantly after training and some aspects improved further at 4 months.

**PRACTICAL SKILLS**

In almost all of the practical skills the ability immediately after training and at 4 months was significantly higher than pre-test (table 3).

In the facilitated situation game, the number of participants who could decide whether it was necessary to call the ambulance before training, immediately after training and 4 months after training were 285 (49%), 530 (91%) and 512 (88%), respectively. Correct use of an AED was not difficult for most of the children. Only a little more than 10% of the participants knew the function of an AED before training. However, approximately one-third of the participants knew the correct electrode position, followed the instructions correctly and could deliver a safety shock before training. AED ability rose from 35% pre-test to >90% for the tested aspects after instruction and remained significantly higher than pre-test at 4 months.

Management of the unconscious patient rose substantially. Prior to training only 2% of participants could identify if a patient was breathing correctly; after training and at 4 months 83% and 74%, respectively, of the children could determine whether the patient did or did not have normal breathing. Children assessed the breathing of an unconscious patient more often than they did in the BLS scenario immediately after and 4 months after training. The reason for the greater willingness to assess breathing could be that the patient in the BLS scenario was a manikin whereas another child played the victim in the situation with the unconscious patient.

Management of bleeding also significantly improved after training and remained significantly higher than the pre-test level at 4 months.

Table 4 shows the main results of practical skills in different age groups.

Only a few children from the 13–14-year-old age group could assess breathing correctly before training but approximately one-half and one-third of all age groups could assess breathing correctly immediately after and 4 months after training, respectively.

Only a few children from the 13–14-year old age group were able to place the patient in the recovery position before training. Approximately three-quarters of the children were able to establish the correct recovery position immediately after training and 4 months after training (more than half of the 7-year-old children). Only children >10 years of age could place the adult patient in the recovery position alone after the test and 4 months later (because of their better physical abilities). Other children solved the problem by working in groups.

**EFFECT OF AGE, SEX AND PRIOR TRAINING**

The effect of predictor variables are displayed in table 5.

The children’s sex was not associated with any of the pre-test results. However, age was associated with knowledge of correct

### Table 1 Demographic data of the children (n=582)

| Class in school | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Participants (n)| 84  | 81  | 82  | 73  | 80  | 69  | 55  | 58  |
| Previous first aid course (n)| 6   | 5   | 14  | 10  | 12  | 20  | 2   | 6   |
| Mean age (years)| 7 (7–8) | 8 (8–9) | 9 (9–10) | 10 (10–11) | 11 (11–12) | 12 (12–13) | 13 (13–14) | 14 (14–15) |
| Mean body weight (kg)| 27 (17–45) | 31 (19–47) | 30 (20–47) | 36 (25–46) | 42 (26–60) | 45 (30–45) | 50 (33–70) | 59 (35–76) |
| Mean body height (cm)| 128 (120–156) | 135 (122–155) | 139 (124–156) | 145 (140–159) | 153 (140–165) | 157 (140–178) | 163 (145–179) | 169 (144–184) |
| Mean body mass index| 16 (11–19.2) | 17 (11–19) | 16 (11.8–23) | 17 (12–19.7) | 18 (12–23.6) | 18 (13.3–23) | 19 (15–23.1) | 21 (15.7–25) |

Range given in parentheses. Data are normally distributed.

### Table 2 Success rate (%) of correct answers of the theoretical measurements (based on the result of the questionnaire) (n=582)

| Topic | Activity | Pre-test (% success rate) | Post-test (% success rate) | After 4 months (% success rate) |
|-------|----------|---------------------------|----------------------------|---------------------------------|
| Call the ambulance | Correct telephone number | 79 | 98* | 87 |
| | Give the location | 75 | 99* | 94* |
| | Nature of the emergency | 73 | 98* | 94* |
| | Give the number of victims | 5 | 42* | 11 |
| | Give their own phone number | 3 | 99* | 22* |
| Basic life support (BLS) | Correct examination time of breathing (10 s) | 17 | 66* | 40* |
| | Correct chest compression frequency | 17 | 97* | 74* |
| | Correct chest compression rate | 7 | 73* | 46* |
| | Correct chest compression depth | 7 | 73* | 54* |
| | Correct ventilation frequency | 12 | 97* | 61* |
| Automated external defibrillator (AED) | What is function of an AED? | 14 | 97* | 75* |
| Unconscious patient | Why necessary to examine unconscious patient before recovery position? | 12 | 77* | 66* |
| Manage bleeding | Lay the patient | 1 | 51* | 86* |
| | Direct pressure to the wound | 1 | 52* | 85* |
| | Raise the injured extremity | 29 | 98* | 84* |
| | Call the ambulance service | 30 | 98* | 47* |

*p<0.01 compared with the pre-test (χ² test).
emergency number, correct assessment of breathing, correct recovery position, correct use of the AED and managing severe bleeding, and previous training was associated with knowledge of the correct emergency number and bleeding management (raising the injured extremity, applying direct pressure to the wound) in the pre-test. Immediately after and 4 months after training none of these variables remained associated, except the knowledge about AED (13–14 years vs younger children; p<0.001) and the correct practical use of the AED (7–8 years vs older children; p<0.001).

**Effectiveness of CPR**

The effectiveness of CPR (chest compression and ventilation) in different age groups with AMBU CPR Software was only detected once, immediately after training (table 6).

There was a significant correlation between chest compression depth and children’s age (r=0.604; p<0.001), body weight (r=0.645; p<0.001), body height (r=0.605; p<0.001) and BMI (r=0.373; p<0.001). Children in the 12–14-year-old age group performed significantly better chest compressions than younger children (p<0.001). Ventilation volume correlated significantly with children’s age (r=0.395; p<0.001), body weight (r=0.374; p<0.001), body height (r=0.372; p<0.001) and BMI (r=0.18; p=0.002). There was no significant correlation between chest compression depth (p=0.1), ventilation volume (p=0.618) and children’s sex. Correct hand position was not dependent on BMI (p=0.368), age (p=0.213) and sex (p=0.17). The compression-ventilation ratio was also not dependent on BMI (p=0.923), age (p=0.06) and sex (p=0.584). Children who previously learnt first aid compressed the chest significantly deeper (p=0.018) but ventilated the manikin to a similar volume as the group without previous first aid training (p=0.308).

The applied compression-ventilation ratio was independent of previous first aid training (p=0.619).

**DISCUSSION**

The main result of our study is that children as young as 7 years are able to learn basic first aid activities including calling the ambulance service, starting CPR, using an AED, handling an unconscious patient and managing severe bleeding. After the 3-day first aid programme and 4 months after training, most of the skills were significantly better than before training in all age groups.

In our study, children aged 7 years performed worse than older children, but their scores increased significantly immediately after and 4 months after training compared with the pre-test. Overall, more than half of the 7-year-old children correctly performed all of the topics (except correct assessment of breathing) immediately after training.

Only children >10 years of age could place the adult patient in the recovery position alone because of their better physical abilities. Only a few children in the 13–14-year-old age group were able to assess breathing correctly and place the patient in the recovery position before training. These scores were significantly better immediately after and 4 months after training.

We measured both CPR knowledge and CPR practical skills of all participants. A significant correlation was found between chest compression depth and children’s age, weight, height and BMI. Only one-tenth of participants were able to effectively ventilate the patient. The quality of ventilation correlated significantly with the children’s age, weight, height and BMI. Children aged <10 years could not perform effective CPR because of their physical abilities but were able to learn the cognitive parts of BLS as well as older children. BMI and other physical factors

| Topic | Activity | Pre-test (% success rate) | Post-test (% success rate) | After 4 months (% success rate) |
|-------|----------|---------------------------|---------------------------|-------------------------------|
| Call the ambulance | Correct telephone number | 79 | 98* | 88 |
| | Give the location | 75 | 98* | 94* |
| | Nature of the emergency | 73 | 98* | 93* |
| | Give the number of victims | 5 | 42* | 11 |
| | Give their own phone number | 3 | 99* | 22* |
| Basic life support (BLS) | Correct assessment of responsiveness | 2 | 59* | 36* |
| | Shout for help | 0 | 46* | 23* |
| | Correct assessment of breathing | 1 | 52* | 38* |
| | Call the ambulance | 6 | 71* | 53* |
| | Correct hand position | 2 | 90* | 72* |
| | Correct compression-ventilation rate (30:2) | 0 | 86* | 68* |
| | Correct ventilation technique | 0 | 50* | 34* |
| Automated external defibrillator (AED) | Correct electrode position | 35 | 92* | 75* |
| | Follow the instructions | 34 | 98* | 70* |
| Unconscious patient | Deliver safety shock | 36 | 92* | 76* |
| | Correct assessment of consciousness | 3 | 55* | 43* |
| | Correct assessment of breathing | 2 | 68* | 68* |
| | Correct recovery position | 1 | 74* | 75* |
| | Examination before recovery position | 0 | 57* | 40* |
| | Call the ambulance | 9 | 82* | 60* |
| Manage bleeding | Lay the patient | 1 | 59* | 32* |
| | Direct pressure to the wound | 3 | 74* | 46* |
| | Raise the injured extremity | 0 | 66* | 36* |
| | Call the ambulance | 15 | 77* | 58* |

*p<0.01 compared with the pre-test (χ² test).
Table 4  Success rate (%) of practical skills in different age groups of children in the pre-test, post-test and 4 months later (n=582)

| Children’s age (years) | Pre-test | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|------------------------|----------|---|---|----|----|----|----|----|
| Knowledge of emergency number | Pre-test | 46 | 58 | 88 | 88 | 92 | 92 | 81 |
|                         | Post-test | 92* | 98* | 100* | 100* | 100* | 100* | 100* |
|                         | 4 months after | 85* | 89* | 81* | 89 | 80* | 92 | 98* |
| Call the ambulance scenario (necessary or not) | Pre-test | 81 | 75 | 91 | 93 | 95 | 94 | 98 |
|                         | Post-test | 81 | 79 | 94 | 96 | 95 | 96 | 100 |
|                         | 4 months after | 81 | 78 | 90 | 86 | 92 | 89 | 100 |
| Correct assessment of breathing | Pre-test | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
|                         | Post-test | 43* | 49* | 49* | 58* | 53* | 58* | 60* |
|                         | 4 months after | 37* | 49* | 32* | 27* | 31* | 41* | 44* |
| Assessment of breathing scenario (recognise normal, abnormal or no breathing) | Pre-test | 41 | 46 | 43 | 62 | 74 | 74 | 81 |
|                         | Post-test | 73* | 77* | 84* | 82* | 85* | 88* | 89* |
|                         | 4 months after | 60* | 70* | 66* | 73 | 80 | 89* | 90 |
| Correct recovery position | Pre-test | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
|                         | Post-test | 56* | 70* | 77* | 80* | 72* | 85* | 83* |
|                         | 4 months after | 55* | 67* | 72* | 64* | 87* | 90* | 85* |
| Correct AED electrode position | Pre-test | 18 | 16 | 19 | 27 | 31 | 51 | 53 |
|                         | Post-test | 74* | 86* | 96* | 99* | 97* | 99* | 98* |
|                         | 4 months after | 62* | 67* | 71* | 77* | 81* | 83* | 90* |
| Follow the instructions of the AED | Pre-test | 15 | 19 | 17 | 29 | 35 | 53 | 53 |
|                         | Post-test | 94* | 93* | 100* | 100* | 100* | 100* | 98* |
|                         | 4 months after | 61* | 52* | 61* | 76* | 76* | 79* | 81 |
| Deliver safety shock with the AED | Pre-test | 18 | 19 | 17 | 29 | 35 | 53 | 53 |
|                         | Post-test | 86* | 88* | 92* | 96* | 93* | 93* | 96* |
|                         | 4 months after | 64* | 67* | 77* | 71* | 77* | 85* | 93* |
| Direct pressure to the wound to manage severe bleeding | Pre-test | 0 | 0 | 1 | 3 | 3 | 7 | 5 |
|                         | Post-test | 100* | 100* | 100* | 100* | 99* | 100* | 100* |
|                         | 4 months after | 80* | 82* | 77* | 71* | 66* | 61* | 77* |

* ´p<0.01 compared with pre-test within age groups (χ² test).

Table 5  Effect of age, sex and prior training

| Topic | Test | Age (p values) | Sex (p values) | Prior training (p values) |
|-------|------|---------------|---------------|--------------------------|
|       |      | Theoretical knowledge | Practical skills | Theoretical knowledge | Practical skills |
| Call the correct ambulance number | Pre-test | <0.001* | <0.001* | 0.555 | 0.852 | 0.015* | 0.023† |
|       | Post-test | 0.092 | 0.075 | 0.459 | 0.947 | 0.873 | 0.476 |
|       | 4 months after | 0.123 | 0.224 | 0.416 | 0.803 | 0.203 | 0.171 |
| Correct assessment of breathing | Pre-test | <0.001* | <0.001† | 0.918 | 0.413 | 0.488 | 0.582 |
|       | Post-test | 0.163 | 0.392 | 0.746 | 0.252 | 0.899 | 0.863 |
|       | 4 months after | 0.421 | 0.376 | 0.095 | 0.733 | 0.120 | 0.773 |
| Correct recovery position | Pre-test | 0.03* | <0.001† | 0.122 | 0.478 | 0.927 | 0.384 |
|       | Post-test | 0.206 | 0.374 | 0.062 | 0.692 | 0.482 | 0.402 |
|       | 4 months after | 0.708 | 0.289 | 0.991 | 0.127 | 0.644 | 0.902 |
| Automated external defibrillator (AED) | Pre-test | <0.001† | <0.001* | 0.067 | 0.567 | 0.122 | 0.915 |
|       | Post-test | <0.001† | 0.432 | 0.107 | 0.786 | 0.382 | 0.634 |
|       | 4 months after | <0.001† | <0.001* | 0.997 | 0.385 | 0.292 | 0.701 |
| Manage severe bleeding | Pre-test | <0.001* | <0.001* | 0.466 | 0.312 | 0.041† | 0.121 |
|       | Post-test | 0.211 | 0.444 | 0.947 | 0.274 | 0.245 | 0.700 |
|       | 4 months after | 0.158 | 0.137 | 0.205 | 0.285 | 0.312 | 0.302 |

* Statistically significant difference between 7–8-year-olds and older children (ANOVA and t-test).
† Statistically significant difference between 13–14-year-olds and younger children (ANOVA and t-test).
‡ Statistically significant difference between children with and without prior training (χ² test).

Prehospital care

The main benefit of this study was that all age groups of primary school children (7–14 years) were tested before, immediately after and 4 months after training. Some previous studies
The ERC resuscitation guidelines suggest most important part of CPR is continuous chest compression. If bystanders are untrained or unable to perform rescue breathing, they should perform effective CPR but they can learn some aspects of resuscitation and ventilation were similar to those of previous studies. Teaching ventilation to children is difficult. However, the most important part of CPR is continuous chest compression. The ERC resuscitation guidelines suggest that, if bystanders are untrained or unable to perform rescue breathing, they should give chest compression only. According to previous studies, CPR training should start at the age of 10 years. Based on our results, we believe that teaching BLS under the age of 10 years can be useful. The majority of these children cannot perform effective CPR but they can learn some aspects of resuscitation (eg, assessment of breathing, correct hand position).

**LIMITATIONS**

Our study might not be representative of the whole population of primary school children in Hungary. Children were re-tested after 4 months of training, but we do not know the longer-lasting effects of training. A follow-up study in the future could help to measure long-term knowledge and skill retention. The actual reaction of these children in a possible real emergency situation remains unknown. Despite these limitations, the results from our study are promising.

**CONCLUSIONS**

Many people requiring medical aid in emergency situations die because first aid is not performed. The main reason given by people for 'doing nothing' is the preconceived notion that they will make mistakes if trying to help in such situations.

Beginning first aid education in the first grade of primary school (7 years of age) should be mandatory. These children can learn the basic aspects of first aid. The first aid teaching programme should include the transfer of knowledge and should also motivate children to perform first aid and develop their helping aptitude.

**REFERENCES**

1. Tannvik TD, Bakke HK, Wisborg T. A systematic literature review on first aid provided by laypeople to trauma victims. Acta Anaesthesiol Scand 2012;56:1222–7.

**Table 6**

| Children’s age (years) | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|-----------------------|---|---|---|----|----|----|----|----|
| Participants (n)      | 84| 81| 82| 73 | 80 | 69 | 55 | 58 |
| Mean depth of chest compression (mm) | 22 (12–56) | 26 (12–56) | 36 (12–68) | 44 (30–59) | 41 (25–52) | 51 (29–71) | 55 (35–71) | 58 (38–75) |
| Correct depth of chest compression (%) | 7 | 11 | 15 | 42 | 39 | 68 | 68 | 74 |
| Mean frequency of chest compression/min | 122 (59–158) | 121 (59–158) | 121 (58–158) | 132 (96–155) | 127 (110–153) | 128 (97–163) | 139 (98–159) | 123 (99–151) |
| Correct frequency of chest compression (%) | 28 | 27 | 29 | 10 | 33 | 28 | 35 | 42 |
| Correct compression-relaxation rate (%) | 9 | 17 | 17 | 20 | 22 | 37 | 58 | 68 |
| Correct hand position of chest compression (%) | 62 | 65 | 69.3 | 90 | 78 | 79 | 71 | 86 |
| Compression pause (s) | 11 (0–12) | 9 (0–13) | 4 (0–30) | 10 (0–20) | 8 (0–26) | 9 (0–22) | 11 (7–21) | 8 (7–19) |
| Correct compression-ventilation rate (%) | 23 | 25 | 37 | 55 | 54 | 62 | 76 | 81 |
| Mean ventilation volume (L) | 0 | 0 | 0.05 (0–1) | 0.23 (0–0.8) | 0.02 (0–0.3) | 0.3 (0–1.2) | 0.3 (0–1) | 0.4 (0–1.5) |
| Correct ventilation volume (%) | 0 | 0 | 1.7 | 30 | 0 | 21 | 26 | 34 |

Range given in parentheses. Data are normally distributed.
2 Urban J, Thode H, Stapleton E, et al. Current knowledge of and willingness to perform hands-only CPR in laypersons. Resuscitation 2013;84:1574–8.
3 Oliver E, Cooper J, McKinney D. Can first aid training encourage individuals’ propensity to act in an emergency situation? A pilot study. Emerg Med J 2014;31:518–20.
4 Eisenberg Chavez D, Meischke H, Painter J, et al. Should dispatchers instruct lay bystanders to undress patients before performing CPR? A randomized simulation study. Resuscitation 2013;84:979–81.
5 Cave DM, Aufderheide TP, Beeson J, et al; American Heart Association Emergency Cardiovascular Care Committee; Council on Cardiopulmonary Care, Critical Care, Perioperative and Resuscitation Council on Cardiovascular Diseases in the Young Council on Cardiovascular Nursing Council on Clinical Cardiology, and Advocacy Coordinating Committee. 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.
6 Böttiger BW, Van Aken H. Kids save lives — training school children in cardiopulmonary resuscitation worldwide is now endorsed by the World Health Organization (WHO). Resuscitation 2015;94:45–57. http://dx.doi.org/10.1016/j.resuscitation.2015.07.005
7 Plant N, Taylor K. How best to teach CPR to schoolchildren: a systematic review. Resuscitation 2013;84:415–21.
8 De Buck E, Van Remoortel H, Drielsjens T, et al. Evidence-based educational pathway for the integration of first aid training in school curricula. Resuscitation 2015;94:8–22.
9 Bohn A, Lukas RP, Breckwoldt J, et al. ‘Kids save lives’: why schoolchildren should train in cardiopulmonary resuscitation. Curr Opin Crit Care 2015;21:220–5.
10 Eisenberger P, Safar P. Life supporting first aid training of the public – review and recommendations. Resuscitation 1999;41:3–18.
11 Bollig G, Wahl HA, Svendsen MV. Primary school children are able to perform basic life-saving first aid measures. Resuscitation 2009;80:689–92.
12 Fleischhackl R, Nuemberger A, Sterz F, et al. School children sufficiently apply life supporting first aid: a prospective investigation. Crit Care 2009;13:R127.
13 Jones I, Whitfield R, Colquhoun M, et al. At what age can schoolchildren provide effective chest compressions? An observational study from the Heartstart UK schools training programme. BMJ 2007;334:1201–3.
14 Bollig G, Myklebust AG, Bintzing K. Effects of first aid training in the kindergarten— a pilot study. Scand J Trauma Resusc Emerg Med 2011;19:13.
15 Perkins GD, Handley AJ, Koster RW, et al; Adult Basic Life Support and Automated External Defibrillation Section Collaborators. European Resuscitation Council guidelines for resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81–99.
16 Zideman DA, De Buck ED, Singletary EM, et al. European Resuscitation Council guidelines for resuscitation 2015: Section 9. First aid. Resuscitation 2015;95:278–87.
17 Uray T, Lunzer A, Ochsenhofer A, et al. Feasibility of life-supporting first-aid (LSFA) training as a mandatory subject in primary schools. Resuscitation 2003;59:211–20.
18 Lubrano R, Romero S, Scoppi P, et al. How to become an under 11 rescuer: a practical method to teach first aid to primary schoolchildren. Resuscitation 2005;64:303–7.
19 Connolly M, Toner P, Connolly D, et al. The ‘ABC for life’ programme: teaching basic life support in schools. Resuscitation 2007;72:270–9.
20 Lukas RP, Van Aken H, 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.
21 Kelley J, Richman PB, Ewy GA, et al. Eighth grade students become proficient at CPR and use of an AED following a condensed training programme. Resuscitation 2006;71:229–36.
22 Drielsjens T, De Buck E, Verstraeten H, et al. Evidence-based recommendations on automated external defibrillator training for children and young people in Flanders-Belgium. Resuscitation 2013;84:1304–9.
23 Nasri S, Siddiqi H, Hussein SA, et al. School children training for basic life support. J Coll Physicians Surg Pak 2011;21:611–5.
24 Uhm TH, Jk O, Park JH, et al. Correlation between physical features of elementary school children and chest compression depth. Hong Kong J Emerg Med 2010;17:218–23.