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How Well are Cardiopulmonary Resuscitation and Automated External Defibrillator Skills Retained Over Time? Results from the Public Access Defibrillation (PAD) Trial

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How Well are Cardiopulmonary Resuscitation and Automated External Defibrillator Skills Retained Over Time? Results from the Public Access Defibrillation (PAD) Trial

Abstract

Background: The current standard for cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) retraining for laypersons is a four-hour course every two years. Others have documented substantial skill deterioration during this time period.

Objectives: To evaluate 1) the retention of core CPR and AED skills among volunteer laypersons and 2) the time required to retrain laypersons to proficiency as a function of time since initial training.

Methods: This was an observational follow-up study evaluating CPR and AED skill retention and testing/retraining time up through 17 months after initial training. The study took place at 1,260 facilities recruited by 24 North American clinical research centers, and included 6,182 volunteer laypersons participating in the Public Access Defibrillation (PAD) Trial. Training to proficiency in either CPR only (*N*= 2,426) or CPR+AED (*N*= 3,756) was followed by testing/retraining provided three to 17 months later. Retraining was done in brief, one-on-one, individualized, interactive sessions. The outcome studied was instructors' global assessments of performance of CPR and AED skill adequacy, i.e., whether CPR actions would likely result in perfusion (yes/no) and whether AED actions would result in a shock through the heart (yes/no).

Results: For global CPR performance, 79%, 73%, and 71% of volunteers tested for the first time since initial training three to five, six to 11, and 12 to 17 months after initial training, respectively, were judged by their instructors as having adequate performance ($p < 0.001$, chi-square for linear trend). For global AED performance, 91%, 86%, and 84% of volunteers, respectively, were judged as having adequate performance ($p < 0.001$). The mean (± standard deviation) times required to test and retrain volunteers to proficiency were 5.7 (± 4.0) minutes for CPR skills and 7.7 (± 4.6) minutes for CPR+AED skills.

Conclusions: Among PAD Trial volunteer laypersons participating in a simulated resuscitation, the proportions of volunteers judged by instructors to have adequate CPR and AED skills demonstrated small declines associated with longer intervals between initial training and subsequent testing. However, based on instructors' judgment, large majorities of volunteers still retained both CPR and AED core skills through 17 months after initial training. Furthermore, individual testing and retraining for CPR and AED skills were usually accomplished in less than 10 minutes per volunteer. Additional research is essential to identify training and evaluation techniques that predict adequate CPR and AED skill performance of laypersons when applied to an actual cardiac arrest.

Keywords

cardiopulmonary resuscitation, automated external defibrillators, skill retention, public-access defibrillation, cardiac arrest, bystander CPR, laypersons, training

Disciplines

Cardiology | Cardiovascular Diseases | Circulatory and Respiratory Physiology | Emergency Medicine | Medical Humanities | Medicine and Health Sciences | Nursing

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Are CPR and AED Skills Retained Over Time? Results from the Public Access Defibrillation (PAD) Trial.

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Abstract

CONTEXT: Bystander cardiopulmonary resuscitation (CPR) for cardiac arrest is associated with improved survival, with further improvement when lay responders use automated external defibrillators (AEDs).

OBJECTIVE: To evaluate 1) the retention of core CPR and AED skills among lay volunteer responders, and 2) the amount of time required to retrain responders to proficiency as a function of time since initial training.

DESIGN: Observational follow-up study evaluating CPR/AED skill retention and retraining time up through 17 months after initial training.

SETTING: 1,260 facilities recruited by 24 North American clinical research centers.

PARTICIPANTS: 6,182 layperson volunteers (without an official duty to respond to medical emergencies).

INTERVENTIONS: Training to proficiency, with retraining in either CPR-only (2,426) or CPR+AED (3,756). Subsequent retraining from 3 through 17 months, using one-on-one individualized, interactive retraining.

MAIN OUTCOME MEASURES: Instructors' global assessments of performance of CPR and AED skills – i.e., would CPR actions likely result in perfusion (yes/no) and would AED actions result in a shock through the heart (yes/no).

RESULTS: For global CPR performance, 79%, 73%, and 71% of volunteers tested 3-5, 6-11, and 12-17 months after initial training, respectively, were judged adequate ($p<0.001$). For global AED performance, 91%, 86%, and 84% of volunteers were judged adequate when tested at 3-5, 6-11, and 12-17 months ($p<0.001$). The mean (+/-SD) time required to test and retrain volunteers to proficiency was 5.7+/-4.0 minutes for CPR skills and 7.7+/-4.6 min for CPR+AED skills.

CONCLUSIONS: The majority of lay volunteers trained in CPR (+/-AED) retained core skills over a 17-month period. Individual testing and retraining for CPR and AED skills can usually be accomplished in less than 10 minutes per volunteer. A retraining strategy of one-on-one testing with targeted corrective training may be an effective alternative to traditional 3-4 hour retraining classes.

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Introduction

The true incidence of out-of-hospital cardiac arrest (OOH-CA) is unknown; however, it is estimated that at least 340,000 people die of cardiovascular disease each year outside of the hospital. [1] Bystander-initiated cardiopulmonary resuscitation (CPR) including CPR deemed to be of poor or questionable quality is associated with improved survival and neurologic outcome after cardiac arrest. [2-9] Early defibrillation is the most effective treatment for patients whose initial arrest rhythm is ventricular fibrillation. [10] One strategy for increasing survival from OOH-CA aims to increase the number of laypersons trained to perform CPR and defibrillation. Since any individual layperson will rarely witness an OOH-CA during the course of a lifetime, training must focus on essential skills that are easy to remember and perform during an actual OOH-CA.

Over the past two decades, CPR (and more recently, AED) training programs have been implemented throughout the world. Despite these efforts reported rates of bystander CPR during episodes of OOH-CA remain low, varying from 0-61% (mean 25%). [11-16] Diverse methodologies have been used for CPR training and assessment of skill retention.[17-21] Studies in simulated environments show that CPR skills are difficult to master for both professionals and laypeople, and skill retention declines significantly over time. [22-33] Although not as extensively studied, AED process skills appear to be easier to learn and retain.[34-37] Current American Heart Association (AHA) CPR and AED training courses certify laypersons for two years, but the optimal retraining frequency required to maintain these skills has not been rigorously established. [38]

The Public Access Defibrillation (PAD) Trial used an approach to training that emphasizes practice over didactic methods. The purpose of this study was to evaluate CPR and AED skill retention in laypersons after initial training.

Methods

The PAD Trial was a prospective, multicenter, randomized, controlled community trial which demonstrated that adding AEDs to a CPR-trained, layperson volunteer response system doubled the number of survivors of cardiac arrest**.** [39, 40] Twenty-four North American research centers recruited layperson volunteers from 1260 community facilities that were randomized to receive CPR-only or CPR+AED training. A secondary objective was to evaluate CPR and AED skill retention in volunteers over time. Written consent was obtained from volunteers prior to training.

Volunteer Population, Training, and Retraining

Volunteers, who had no advanced medical training nor a primary duty to respond to medical emergencies, were trained to recognize a cardiac arrest, call 911, and provide CPR until Emergency Medical Services (EMS) arrival. In facilities randomized to CPR+AED, volunteers received additional AED training and access to on-site AEDs.

Instructors were required to have at least Basic Life Support Instructor (BLS) certification. Most centers had two or three instructors (range 1-8) conduct the training. PAD training guidelines closely followed the American Heart Association HeartSaver AED[©1998] course which was used by most centers. Any course meeting the following criteria was allowed: class length of 3-4 hours, depending on whether AED training was included; student-to-instructor ratio of not more than 6:1 (preferably 4:1); no more than 12 students per class; case-based training scenarios; at least 20 minutes of skill practice per trainee (preferably 30 minutes), and not more than 45 minutes of lecture and demonstration. Use of a skills video was recommended. PAD training guidelines did not require a written evaluation or proficiency in a pulse check. All centers taught ventilations using a pocket mask or a face shield. Barrier devices were distributed to facilities and packaged with AEDs.

Logistical issues caused variation in how quickly retraining was conducted, with the majority of volunteers retrained 3-17 months after initial training. Just prior to retraining, each volunteer completed a skills test conducted on a one-to-one basis. The volunteer was asked to demonstrate CPR (+/-AED) skills on a manikin, without prompting, while the instructor completed a skills checklist. The test consisted of 1-5 cycles of CPR and 1-4 cycles of AED shocks, depending on how well the volunteer performed during the first cycle. After the test, the instructor would retrain the volunteer, correcting skills as needed to re-establish proficiency. The total amount of time needed to test and retrain a given volunteer was also collected. In some cases retraining was performed in a group fashion after all volunteers completed the skills test.

Proficiency was evaluated for five core CPR skills and five core AED skills, using a checklist with predefined criteria for each skill (Table 1). In addition, instructors were asked for an overall global assessment: whether the CPR performed would have been adequate to "produce perfusion" (yes/no) and whether the AED usage would have delivered a shock "approximately through the heart" (yes/no). Thus, an instructor may have judged overall CPR as adequate for perfusion, even if one or more individual CPR skills were not completed successfully.

Statistical Methods

The primary CPR and AED skill retention outcome measures were the instructors' overall global assessments of whether skills were performed adequately (yes/no). Two more traditional alternative performance measures were constructed using some or all of the CPR and AED individual skill assessments: 1) the "strict" CPR and AED measures were defined as the completion of all 5 CPR (or all 5 AED) actions performed adequately and in sequence (yes/no); and 2) the "relaxed" measures disregarded sequencing and required only adequate performance of ventilations, hand placement, and compression depth for CPR actions and adequate electrode placement and delivery of a shock within 90 seconds for AED actions.

In addition, the number of minutes required to test/retrain an individual to proficiency was also evaluated. The relationship of these measures to months since initial training was the primary objective of the evaluation.

Analyses excluded volunteers who reported participation in any additional skills refresher or retraining courses (or in a real or "mock" OOH-CA) between initial training and scheduled retraining, volunteers who were tested/retrained before 3 months or after 17 months, and volunteers for whom the testing protocol was not followed. Deviations in testing protocol included CPR-only trained volunteers tested in CPR+AED, group testing, and a small number of centers with artificially high "pass rates" (e.g., 100% proficiency in all volunteers on all skills); corrective actions were taken at these centers. Volunteers retrained in groups were excluded from analyses involving the number of minutes needed in retraining to proficiency.

For descriptive purposes volunteers were grouped into those retrained 3-5, 6-11, or 12-17 months after initial training (groups 1, 2, and 3, respectively). Frequencies, means, and error bar plots of skill retention were generated.

Volunteer characteristics were compared among groups using t-tests or ANOVA, as appropriate, for continuous measures and chi-square tests for categorical measures. Logistic Generalized Estimating Equations (GEE) models, using an exchangeable correlation structure to model correlation within a given facility, and adjusted for center and volunteers' age, gender, and previous CPR training, were used to evaluate the relationship between the instructors' global assessment and the natural logarithm (ln) of the number of months since initial training. Mean predicted probabilities were computed from these models. In addition, linear GEE models (also adjusted for center and volunteer's age, gender, and previous CPR training) were employed to evaluate the relationship of minutes to test/retrain with number of months since initial training. Natural log transformations were used on both measures to accommodate model assumptions. In order to evaluate potential center effects, sensitivity analyses were performed for the GEE models, excluding centers with heavy influence in the early or late months of the interval studied.

Due to the large sample size, a p-value of 0.01 was considered to be statistically significant.

Results

Of 19,320 volunteers who received initial training prior to January 1, 2003, 8,241 were not retrained (18% due to attrition; 12% were at facilities where retraining was not offered, 8 % were not active when retraining occurred; and 62% were active but did not attend retraining sessions offered at their facilities) (Table 2). Another 4,144 were excluded due to retraining occurring <3 or ≥18 months (38%), interim training (33%) or failure to follow the testing protocol. In addition, retraining status was unknown for 753. Thus, a total of 6,182 volunteers were included in the final analysis.

Volunteers included in the analysis compared to those excluded were older (41±14 vs. 38±14 years, p<0.001) but otherwise had similar baseline characteristics (gender, education level, history of previous CPR class)(Table 2). Volunteers who did not attend scheduled retraining, but were presumably active (n=5,105) were younger (39±15, p<.001).

Between intervention groups volunteers tested in CPR-only tended to be younger than those tested in CPR+AED (40.5±12.8 years vs. 42.1±14.6 years, respectively, p<0.001) and to have less education (30% high school or less vs. 26%, p=0.006). There were no differences between training groups for gender (52% male vs. 54% male), prior CPR training (54% vs. 55%) and the time from initial training to retraining (7.4±3.6 vs. 7.5±3.6 months).

There were 2,839 (Group 1), 2549 (Group 2), and 794 (Group 3) volunteers retrained 3-5, 6-11, and 12-17 months respectively after initial training (Table 3). Volunteer age increased and prior CPR training decreased among groups 1-3.

Univariate differences emerged among groups for both CPR and AED individual skill components and the instructors' global assessment ($p \leq 0.001$, all measures, Table 3). The proportions of volunteers performing adequate CPR as rated by the instructors' global assessment were 79%, 73% and 71% for Groups 1-3. Among individual CPR skills, ventilations showed the largest differences, with 82%, 76%, and 70% performing adequate ventilations (maximum difference of 12%, compared with 4-5% for the remaining individual skills). Higher proportions of volunteers were judged adequate on AED skills than on CPR skills; however, relative differences were similar to those for CPR: 91%, 86%, and 84%, for Groups 1-3, respectively. Among individual AED skills, moderate differences (>5%) occurred between groups for electrode placement, the "clearing" actions, and shocking within 90 seconds.

Among the 1504 volunteers unable to perform adequate CPR, over 50% failed the individual "ventilation," "hand placement," and/or "compression depth" skills. For those with adequate CPR, the failure rate was under 20% on all individual skills (Figure 1).

Among volunteers unable to perform adequate AED skills, 90% failed correct electrode placement (Figure 2).

While overall adequacy differed substantially according to the severity of the assessment criteria (i.e., “global,” “strict,” and “relaxed” performance measures) all three measures showed small to moderate decreases among groups 1, 2, and 3 (Figures 3 and 4).

Mean testing/retraining time differed, with longer times noted for longer intervals between initial training and retraining (Table 3).

After adjusting the GEE model for center and volunteers’ age, gender, and previous CPR training, time since initial training was significantly associated with the global CPR assessment ($p<.001$, Table 4). Each of the individual CPR skills was also significantly associated with time to retraining, with the strongest relationships seen for the ventilations and assessment actions. The initial type of training (CPR-only or CPR+AED) did not affect this relationship ($p=.479$).

The number of months since initial training was not associated with the global AED assessment after adjustment ($p=0.253$, Table 4). Among individual AED skills, baring the chest, placing the electrode pads correctly, and verbally clearing the area were significantly associated with number of months to retraining.

For the global CPR and AED outcomes mean predicted probabilities were obtained from the GEE models. Mean predicted probabilities for the three retraining interval groups did not vary materially from the unadjusted probabilities reported in Table 3.

After adjusting GEE models for center and volunteer's age, gender, prior CPR training, type of initial training (CPR-only vs. CPR+AED), and AED arrival time for the AED group, total testing/retraining time was positively associated with the number of months since initial training, i.e., $\log(\text{minutes}) = \alpha + \beta \log(\text{months})$: β (SD) = 0.16 (0.07), $p=.017$ for CPR-only; β (SD) = 0.19 (0.03), $p<.001$ for CPR+AED. Thus, a typical volunteer tested and retrained in CPR-only skills at 17 months took, on average, 1.8 minutes longer to retrain than a comparable volunteer tested and retrained at three months. Similarly, a volunteer tested/retrained in CPR+AED skills at 17 months took 2.6 minutes longer, on average, than a comparable volunteer tested/retrained at three months.

Research centers varied in the number of elapsed months from initial training to retraining and in the proportion of volunteers judged adequate (i.e., instructors' global assessment). Mean (SD) time to retraining, based on all retrained, varied among centers from 5.0 (2.8) months to 18.5 (7.8) months (Figure 5, $p<0.001$). Among those included in the analyses the mean percent of CPR skills tests judged adequate ranged across centers from 44% to 98% ($p<0.001$), and AED skills tests from 59% to 100% ($p<0.001$). However, associations with the number of months since initial training were similar when sensitivity analyses excluding potentially confounding centers were conducted.

Discussion

Approximately three-quarters of layperson volunteer responders in PAD were able to provide perfusing CPR up through 17 months after initial training, according to the instructors' global assessment. Approximately 90% were able to provide an effective defibrillatory shock. Ability to perform CPR was similar in both treatment arms, implying that the addition of AED instruction does not diminish CPR skill acquisition or retention.

These results differ from most studies of resuscitation skill retention, which generally report that CPR skills deteriorate considerably over a short time period. Moser et al. studied CPR skill retention in 31 family members of cardiac patients. Of those tested at seven months, more than half were rated "poor" in initial assessment, chest compression, ventilation, and overall CPR. [22] Others studying CPR skill retention in parents of infants at risk for cardiac arrest [23, 24] and CPR skill retention in lay volunteers, [25-28] also reported poor overall CPR skill retention over time**.**

Discrepancies between the PAD Trial results and other studies are likely related to a number of factors. First, the primary outcome measure for this study was the instructors' global assessment of overall performance rather than a composite summary score based on individual skill components. Using the global assessment, 71% of volunteers tested from 12 through 17 months were judged able to "perfuse the patient," in contrast to the 31% of volunteers performing adequate CPR based on the more traditional "strict" criteria (figure 3). PAD Trial testing did not require recording manikins or detailed criteria (such as counting of ventilations and chest compressions), or a written post-test. Instead, the global assessment focused on the skills considered critical to providing perfusion and/or an effective shock, and downplayed skills considered possibly artificial, e.g., calling 911 or verbally clearing the manikin prior to shock. While actions such as calling 911 are important in an actual arrest situation, it is unclear how meaningful their performance (or lack thereof) is in an artificial testing environment. During testing, roughly 20% of volunteers failed to call 911; however, there were no reported instances of failure to call 911 during the 3413 actual emergency events reported during the trial. Similarly, up to 36% of volunteers failed to clear the area verbally during testing, but there were no reported instances of volunteers or bystanders receiving a shock during the trial.

Second, there are differences in the populations studied. Volunteers in the PAD Trial agreed to be part of the emergency response team and to attend training and retraining sessions and thus may have been more highly motivated to learn and retain emergency skills than other layperson populations studied. Tweed et al. reported excellent skill retention in motivated, mature layperson rescuers. [41] Furthermore, over half of the PAD Trial volunteers had received CPR training prior to study participation, although the analysis adjusted for this factor. In addition, many previous studies have focused on skill retention among spouses or parents of individuals at risk of cardiac arrest. These populations may be different from the PAD trial population (e.g. older) or have stronger emotional stressors in performing resuscitation skills.

Third, CPR course content, as well as training and evaluation techniques are constantly evolving.[42] Since 1998, the AHA HeartSaver AED©1998 course has de-emphasized didactic lecture in favor of video-based learning and substantial amounts of "hands-on" practice time using case-based scenarios. In the PAD Trial, initial training methods closely followed the AHA Heartsaver AED course allowing significant time for skills practice, while skills such as foreign body airway obstruction, infant/child resuscitation, pulse check and written test were not required. It is possible that minimizing content and complexity in resuscitation skills training leads to better skill retention.

Clinical resuscitation standards are evolving away from the previously held notion that effective CPR requires high precision in the performance of complex tasks. Researchers have reported that even imperfect bystander CPR is associated with increased survival from cardiac arrest.[2-4] Not surprisingly, in the PAD Trial, among individual CPR skills, ventilations producing chest rise appeared to be the most difficult skill to retain. If ventilation training were de-emphasized, further emphasis could be applied to teaching adequate chest compression technique. Hallstrom et al. found a trend toward greater survival when dispatchers instructed bystanders to perform compression-only CPR versus standard CPR. [43, 44] Using a simulated CPR model, Woollard et al. found that ventilations were generally ineffective and more compressions were delivered in a given time period when ventilation instructions were omitted. [21] One recent study reported decreased cerebral and coronary blood flow with interruption of compressions for ventilation. Perhaps a more simplified approach to CPR training and evaluation is warranted and would result in improved outcomes.

AED skill retention was higher than CPR skill retention in all groups possibly because AED skills require less psychomotor coordination and because the AED audibly prompts the responder to perform actions. Interestingly, among volunteers assessed as inadequate in overall AED skills (figure 2), placing electrodes correctly, a skill not specifically addressed by verbal prompts, had the highest failure rate. The AED skills with the largest differences in the proportions of volunteers performing adequately were the "clearing" actions and the ability to shock within 90 seconds of the AED arrival (Table 3). Cummins et al. also reported an increase in time to deliver the first AED shock as the duration from initial training increased. [37] Nevertheless, in this study, most volunteers functioned adequately, even 12-17 months after initial training.

Another significant observation was the short time required to retrain volunteers back to proficiency after they inadequately performed part or all of the individual CPR/AED skills during the test. This finding may have important implications for organizations evaluating the costs of implementing or enhancing an emergency response program. These data challenge the notion that laypersons must complete a 4-hour refresher course in CPR and AED skills every 2 years. A shorter, one-on-one approach may be as beneficial to the individual, where retraining can be tailored to specific needs. Based on the PAD Trial approach, approximately 10 individuals could be comfortably evaluated and retrained, by one instructor, during a 2 hour time period. Nevertheless, standard performance assessment and retention criteria must be developed and validated before this approach is widely adopted.

Limitations

It is possible instructors were biased toward assigning positive outcomes in order to have high "pass rates." An attempt was made to control for this possibility by excluding data from centers/instructors with unreasonably high (e.g., 100%) pass rates. There was substantial variability in the remaining data.

The ability of instructors to determine whether a trainee has demonstrated the ability to provide perfusing CPR and/or an adequate shock is open to question.[27, 45] Unfortunately, as is the case with most training studies, very little is known about how classroom content, instruction, and evaluation of performance in a simulated environment are associated with performance during an actual cardiac arrest.[46] There is an urgent need to identify reliable methods for evaluating classroom performance of CPR and AED skills and relating them to performance in the field.

Finally, there is a potential for confounding of these analyses because of volunteer attrition over the time period studied (i.e., volunteers tested and retrained later were more likely to be older, male, and were less likely to have had the CPR training prior to the PAD Trial). We adjusted for measured covariates in the multivariable analysis.

Conclusions

The majority of PAD Trial layperson responders maintained essential CPR and AED skills up through 17 months after their initial training, although resuscitation skills degrade somewhat over time. CPR and AED skill retraining can be accomplished in under 10 minutes per volunteer for most volunteers. Additional research is essential to identify course content and instruction and evaluation techniques that predict adequate CPR and AED skills performance of laypersons during an actual arrest.

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Figure Legends

Figure 1. Percent of volunteers failing CPR actions by CPR global assessment.

Figure 2. Percent of volunteers failing AED actions by AED global assessment.

Figure 3. CPR skill retention over time as a function of testing criteria.

Figure 4. AED skill retention over time as a function of testing criteria.

Figure 5. Time to retraining by center.

Table 1. Performance Skills Checklist

CPR Skill	**Description**
Assess Responsiveness	The volunteer must have physical contact with the manikin and vocalize loud enough to awaken victim, if possible.
Access 911	The volunteer must pretend to call 911 or send someone to call 911.
Provide Adequate Ventilations (use of barrier device optional)	The volunteer must provide adequate ventilations to the manikin, using the head tilt, chin lift maneuver necessary to open the airway, sufficient to cause the chest to rise.
Apply Proper Hand Placement	The volunteer must demonstrate the proper hand position over the sternum.
Provide Adequate Compression Depth	The volunteer must depress the chest of the manikin approximately 1½-2 inches. The reviewers may use the manikin click as an indication of appropriate depth.

AED Skill	**Description**
Bare Chest for Electrode Pad Placement	The volunteer must remove all clothing over chest of the manikin prior to applying AED pads in order to successfully accomplish this action.
Place Electrode Pads Correctly	The volunteer must remove the protective backing and affix the AED pads to the manikin's bare chest. The volunteer must make an attempt to secure the AED pads to the contour of the manikin's chest. One pad is placed on the right upper chest to the right of the sternum, and the second pad is placed on the lower left chest, covering the anterior axillary line.
Clear Self	The volunteer must remain clear of the manikin, manikin clothing, cables, and AED from the time the AED begins analyzing. The volunteer must also be alert to potential contact by others in the situation.
Verbally Clear Area	The volunteer must call "all clear" and clear others prior to pushing the shock button.
Deliver shock within 90 seconds of AED arrival	Timing starts as soon the AED arrives at the side of the manikin.

Table 2. Characteristics of Volunteers by Retraining Status[1]

		Excluded from analysis								Analyzed	p-value*
		Volunteers with no retraining					<3 or ≥ 18 mo	Interim training	Protocol problem		
		not offered	not eligible	Dropped /moved	Did not attend	Total					
N		995	623	1518	5105	8241	1577	1381	1186	6182	
Age of volunteer	Mean	37.7	36.4	33.1	38.6	37.3	40.4	38.3	42.1	41.4	<.001
	S.D.	13.5	14.5	12.7	14.8	14.4	13.9	13.1	14.3	13.9	
Gender, male	%	50.1	52.8	55.7	55.3	54.5	57.6	52.0	55.0	53.4	.088
% ≤ HS	%	34.0	33.1	29.6	26.1	28.3	26.8	23.4	30.9	27.4	.610
% Previous CPR training	%	44.8	53.1	57.6	52.3	52.4	59.9	73.1	50.9	54.7	.264
% Passed initial training w/o extra help	%	97.4	98.9	97.0	98.4	98.1	99.2	98.8	99.5	98.4	.698

HS = high school

[1] excludes 753 volunteers (397 CPR-only, 356 CPR+AED) with retraining status unavailable

*P-values are for comparison of analyzed group vs. the excluded group (total)

Table 3 Characteristics of volunteers by retraining period

	3-5 mo	6-11 mo	12-17 mo	P-value
N (total = 6,182)	2,839	2,549	794	
Age at time of initial training	41 (14)	42 (14)	43 (15)	<.001
% Male	54%	52%	57%	.025
% High School education or less	27%	27%	30%	.177
% previous CPR class (last 5 yrs)	57%	55%	46%	<.001
% passed initial training w/o extra help	99%	98%	98%	.645
% Pretest CPR Adequate (by GA)**	79%	73%	71%	<.001
% Assess responsiveness	89%	87%	84%	<.001
% Access 911	83%	80%	78%	<.001
% Adequate ventilation/chest rise	82%	76%	70%	<.001
% Correct hand placement	81%	78%	77%	.001
% Adequate compression depth	87%	85%	83%	.002
N (total=3756)	1717	1581	458	
% Pretest AED Adequate (by GA)**	91%	86%	84%	<.001
% Bare chest	96%	94%	89%	<.001
% Correct electrode placement	87%	78%	78%	<.001
% Clear self	85%	72%	79%	<.001
% Verbally clear area	78%	68%	64%	<.001
% Deliver shock within 90 seconds (N-3715)	81%	74%	70%	<.001
AED arrival after time zero* (N=3369)	84%	77%	72%	
AED arrival at time zero* (N=227)	61%	35%	47%	
% Deliver shock (no time limit). (N=3715)	97%	94%	91%	<.001
Mean (SD) sec from AED arrival to shock (N=3522)	68 (29)	71 (35)	74 (41)	.005
AED arrival after time zero (N=3238)*	66 (27)	68 (30)	72 (38)	<.001
AED arrival at time zero (N=219)*	93 (38)	139 (70)	119 (73)	<.001
Mean (SD) sec from AED arrival to shock, for shock delivered > 90 sec (N=669) [range]	115 (27) [91, 288]	122 (37) [91, 302]	129 (48) [91, 375]	.002
Mean (SD) test/retrain time (min), CPR-only (N=2142)	5.6 (3.5)	5.5 (4.0)	7.3 (5.1)	<.001
Mean (SD) test/retrain time (min), CPR+AED (N=3346)	6.8 (4.1)	8.3 (5.0)	9.1 (4.7)	<.001

*During testing most volunteers in the CPR+AED arm performed all CPR steps while the AED was brought to the manikin. However, these volunteers responded to the test with an AED performing only the “assessment” and “ventilation” steps before applying the AED resulting in artificially longer AED-arrival-to-shock times.

**GA=global assessment

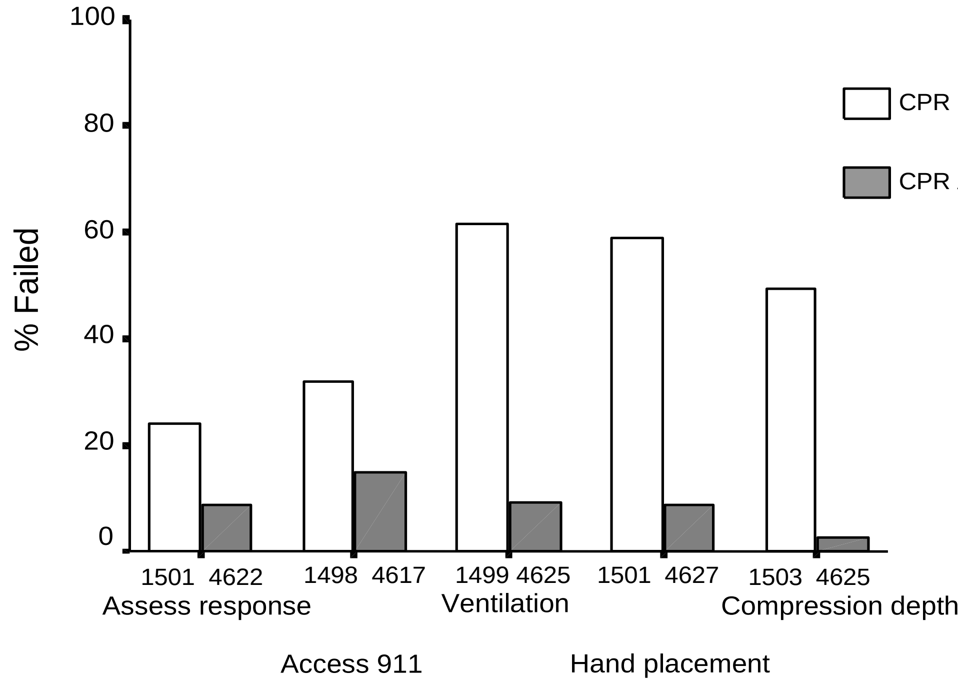
Table 4. Estimated Odds Ratios* for "Adequate Performance" of CPR and AED Skills

	OR	95% CI	P-value
Adequate CPR (perfused)	0.68	[0.56, 0.84]	<.001
Assess responsiveness	0.58	[0.46, 0.74]	<.001
Access 911	0.74	[0.60. 0.90]	.002
Adequate ventilations	0.64	[0.52, 0.77]	<.001
Proper hand placement	0.75	[0.61, 0.91]	.004
Adequate compression depth	0.72	[0.57, 0.90]	.004
Adequate AED (shock delivered through heart)	0.81	[0.57, 1.16]	.253
Bare chest for electrode placement	0.50	[0.31, 0.79]	.003
Place pads correctly	0.63	[0.47, 0.83]	.001
Clear self	0.94	[0.69, 1.28]	.695
Verbally clear area	0.66	[0.51, 0.85]	.001
Deliver shock within 90 seconds**	0.76	[0.58, 0.99]	.039

* These odds ratios approximate how much less likely it is that a volunteer retrained at a later date (e.g., at t2) would perform the skill of interest adequately relative to a volunteer trained earlier (at, say, t1) . The odds ratios reported in the table are associated with a unit increase in the LN(months since initial training), i.e., LN(t2) – LN(t1) = 1. The (GEE) models were adjusted for site, age, sex and prior CPR training.

** Also adjusted for AED arrival time = 0 (see footnote Table 3).

Figure 1


100
80
60
40
20
0
% Failed
CPR Not Adequate
CPR Adequate
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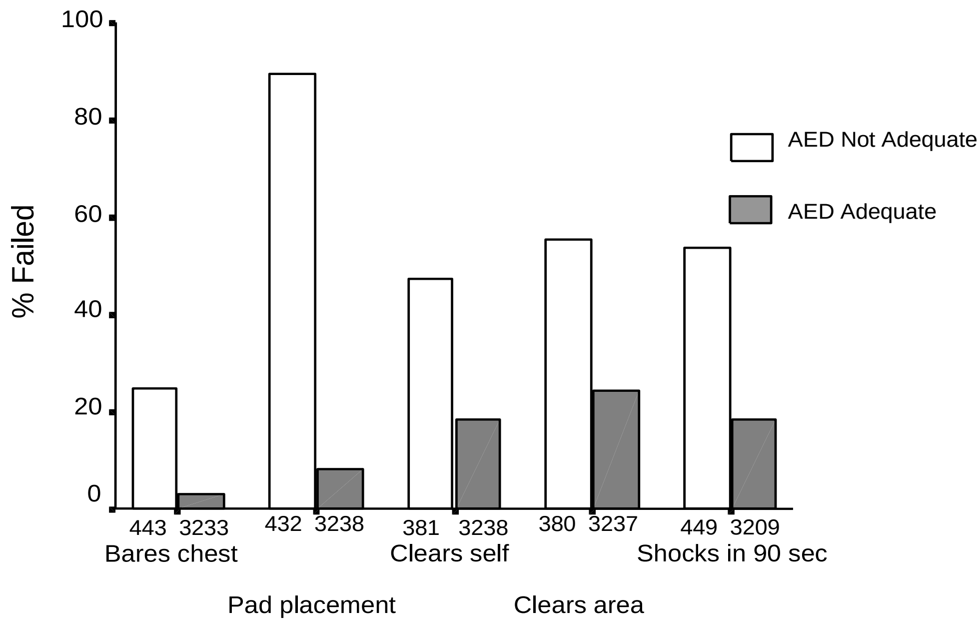
1498 4617
1499 4625
1501 4627
1503 4625
Assess response
Ventilation
Compression depth
Access 911
Hand placement

Figure 2



100
80
60
40
20
0
% Failed
AED Not Adequate
AED Adequate
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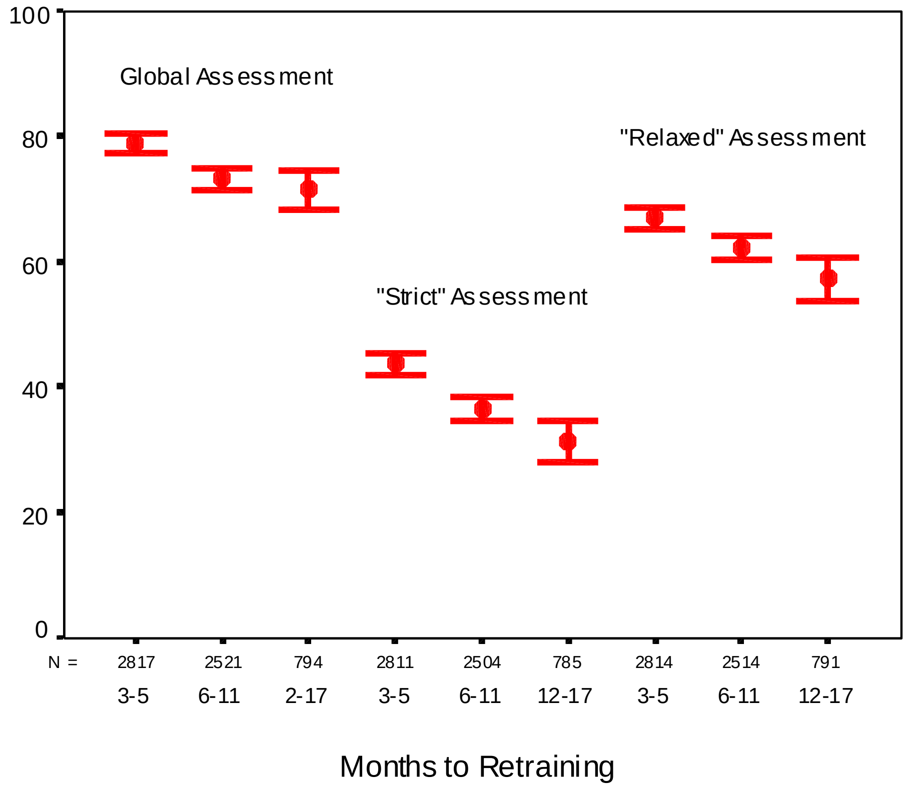
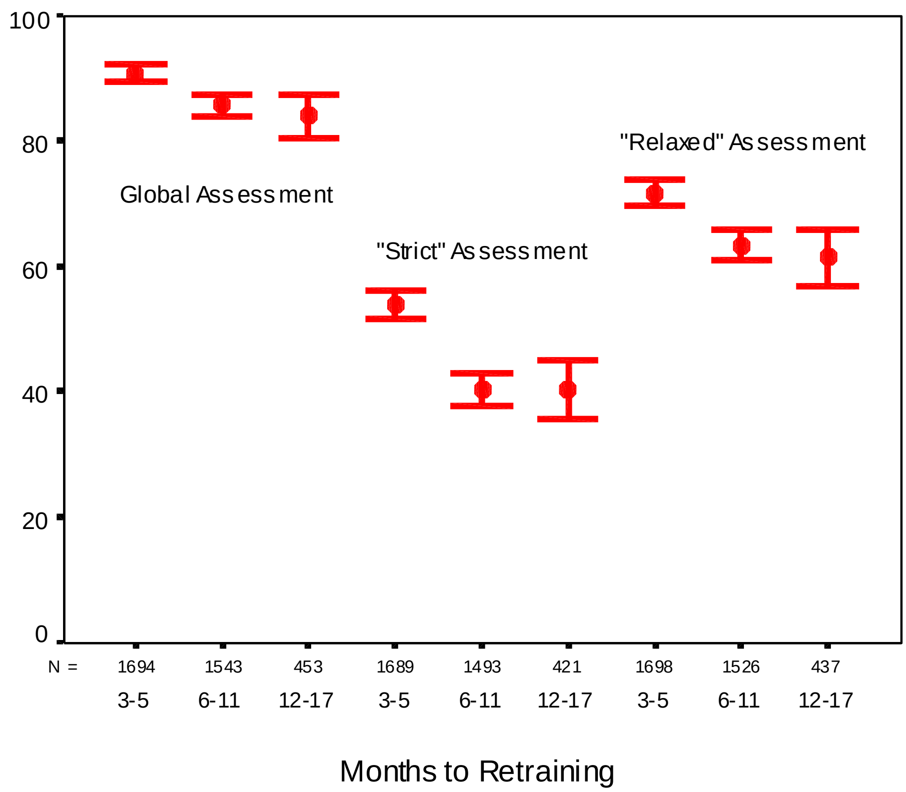
381 3238
380 3237
449 3209
Bares chest
Clears self
Shocks in 90 sec
Pad placement
Clears area

Figure 3



100
80
60
40
20
0
Global Assessment
"Relaxed" Assessment
"Strict" Assessment
N =
2817
2521
794
2811
2504
785
2814
2514
791
3-5
6-11
2-17
3-5
6-11
12-17
3-5
6-11
12-17
Months to Retraining

Figure 4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80
60
40
20
0
Global Assessment
"Strict" Assessment
"Relaxed" Assessment
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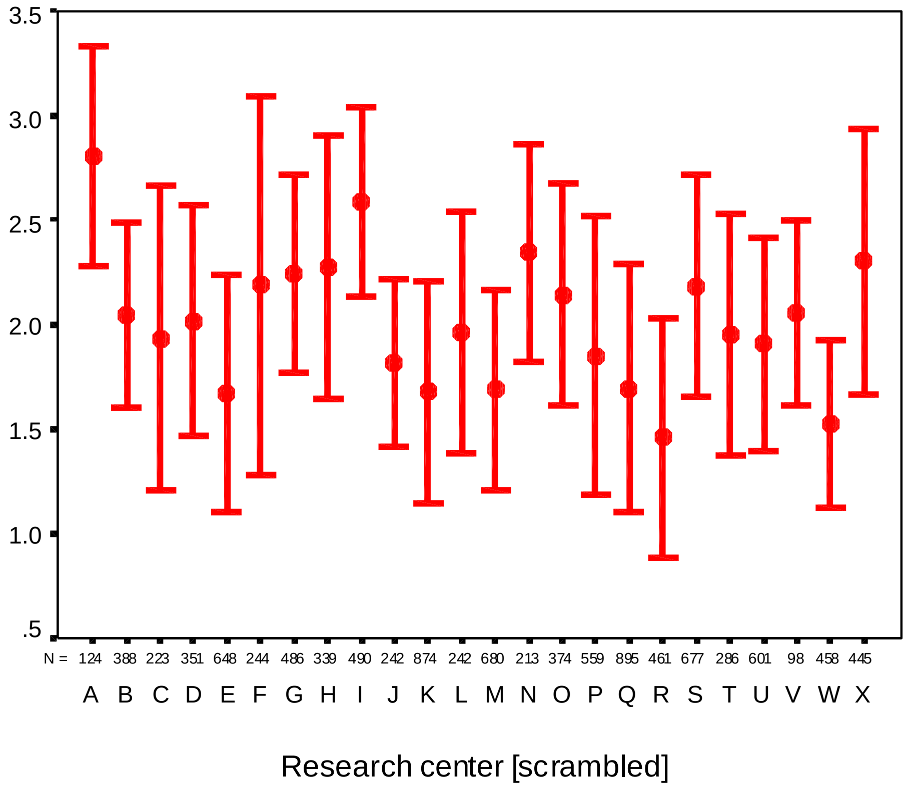
3-5 6-11 12-17 3-5 6-11 12-17 3-5 6-11 12-17
Months to Retraining

Figure 5.


3.5
3.0
2.5
2.0
1.5
1.0
.5
N = 124 388 223 351 648 244 486 339 490 242 874 242 680 213 374 559 895 461 677 286 601 98 458 445
A B C D E F G H I J K L M N O P Q R S T U V W X
Research center [scrambled]