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The effect of time on CPR and automated external defibrillator skills in the Public Access Defibrillation Trial

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Abstract

Background—The time to skill deterioration between primary training/retraining and further retraining in Cardiopulmonary resuscitation (CPR) and automated external defibrillation (AED) for lay-persons is unclear. The Public Access Defibrillation (PAD) Trial was a multi-center randomized controlled trial evaluating survival after CPR-only vs. CPR+AED delivered by onsite non-medical volunteer responders in out-of-hospital cardiac arrest.

Aims—This sub-study evaluated the relationship of time between primary training/retraining and further retraining on volunteer performance during pretest AED and CPR skill evaluation.

Methods—Volunteers at 1260 facilities in 24 North American regions underwent training/retraining according to facility randomization, which included an initial session and a refresher session at approximately 6 months. Before the next retraining, a CPR and AED skill test was completed for 2729 volunteers. Primary outcome for the study was assessment of global competence of CPR or AED performance (adequate vs not adequate) using Chi-square tests for trends by time interval (3, 6, 9, and 12 months). Confirmatory (GEE) logistic regression analysis, adjusted for site and potential confounders.

Results—The proportion of volunteers judged to be competent did not diminish by interval (3,6,9,12 months) for either CPR or AED skills. After adjusting for site and potential confounders,

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6. Conflict of Interest
None of the authors have conflicts of interest.

longer intervals before to further retraining was associated with a slightly lower likelihood of performing adequate CPR but not with AED scores.

Conclusions—After primary training/retraining, the CPR skills of targeted lay responders deteriorate nominally but 80% remain competent up to one year. AED skills do not significantly deteriorate and 90% of volunteers remain competent up to one year.

Keywords

automated external defibrillator (AED); bystander CPR; cardiac arrest; cardiopulmonary resuscitation (CPR); skill retention; training; public access defibrillation

1. Introduction

The incidence of cardiac arrest is estimated to be 55 EMS-treated events per 100,000 population[1] or roughly 220,000 cases per year in North America. Early defibrillation when applied effectively by laypersons is effective[2] and bystander cardiopulmonary resuscitation (CPR) is one of the most powerful predictors of increased survival.[3] Organized and efficient training of lay people in the use of automated external defibrillators (AEDs) and CPR is essential if we are to maximize the benefit of these actions at the time of sudden cardiac death.

The skills required in basic cardiopulmonary resuscitation (CPR) have been characterized as difficult to teach [4, 5] and once taught, difficult to retain.[4, 6–15] The component skills needed to use an automated external defibrillator (AED) have been less well studied but may be easier to learn.[16–21] The American Heart Association currently recommends that CPR and AED retraining in PAD programs "should occur at least once every 2 years. More frequent training is recommended and may be dictated by local policies and regulations".[22] However, objective information on learning and retention is lacking, especially in public settings with organized emergency response by motivated volunteers. The Public Access Defibrillation (PAD) trial[2, 23] measured retention of CPR and AED skills prospectively at each training and retraining session. The purpose of this PAD sub-study was to describe the degradation in performance of CPR and AED skills between primary training and maintenance retraining according to time interval.

2. Methods

Summary of PAD Methods

The PAD Trial was a multi-center, prospective, randomized, controlled clinical trial evaluating the effect of volunteer, non-medical responder AED use on survival from out-of-hospital cardiac arrest. The study involved 24 clinical centers in North America and was coordinated by the Clinical Trials Center at the University of Washington in Seattle. Institutional review boards at University of Washington and at each local center reviewed and approved the study.

The methods and primary results have been previously published.[23] Briefly, a total of 1260 facilities such as office complexes, shopping centers, hotels, golf courses, etc. were recruited to participate. Volunteers without a duty to respond to health emergencies and without an advanced medical degree were recruited to respond to medical emergencies. Informed consent was obtained before training. All volunteers were instructed in assessment of cardiac arrest, accessing 911 and providing CPR until EMS arrival. Half the facilities were randomized to receive additional training in AED use.

CPR and AED training

Training was structured and standardized. Primary training included an initial training course using guidelines closely following those of the American Heart Association HeartSaver AED course (with or without the AED) and a refresher training session. Any approved course was acceptable if the following guidelines were followed: class length 3–4 hours depending on course content, student/instructor ratio of not more that 6:1 and preferably 4:1, no more than 12 students per class, scenario-based training, individual skills practice of approximately 30 minutes, lecture/demonstration (preferably using a skills video) of not more than 45 minutes, and a minimum instructor qualification of BLS instructor certification. PAD training guidelines did not require proficiency in a pulse check or any written evaluation. Primary training included refresher training planned 3–6 months after the initial training course and included evaluation and training to correct any deficiencies. The primary refresher training actually occurred approximately 6 months after the primary initial training. Facilities were randomized to deliver maintenance retraining 3, 6, 9 or 12 months after primary initial and refresher training were completed. Volunteers who received maintenance retraining from 1.5 to 13.5 months later are the subject of this report.

Maintenance retraining sessions commenced with an individual skills test prior to any retraining information allowing the volunteer to demonstrate CPR (and/or AED) skills without any prompts while the instructor evaluated the skills and completed a checklist. After the test, the instructor provided remediation focusing on identified deficits in performance.

Proficiency was evaluated in five core CPR skills and five core AED skills. These skills were scored using a CPR and AED performance skills checklist which included criteria for passing each skill.(Table 1). In addition, each volunteer was given a global assessment of competence of the effectiveness of CPR and AED performance. Specifically, instructors determined if the CPR performed “would have been adequate to produce perfusion”. Improper sequence was not considered incompetence as long as compressions were adequate to provide perfusion. In AED testing, trainers evaluated global assessment of competence as delivery of a successful shock regardless of minor mistakes in other components not critical to that specific outcome.

Volunteer Inclusion and Exclusion Criteria

For this analysis we included only volunteers who completed primary training (including initial and refresher sessions) and one maintenance retraining session. We excluded volunteers whose maintenance retraining occurred earlier than 1.5 months or later than 13.5 months after primary training, volunteers who were trained in one intervention but tested in the other and volunteers for whom the testing protocol was not followed (e.g. volunteers tested in groups rather than individually). In addition, interim data quality control checks identified a small number of sites with artificially high scores (i.e., 100% proficiency in all volunteers on all skills because e.g., “volunteers were allowed to start over again if a mistake was made”). Remedial measures were taken with these sites and volunteers retrained prior to remediation were excluded.

Outcomes

The primary outcome of this study was the assessment of overall competence of CPR or AED skill retention as determined by the instructor prior to maintenance retraining. Secondary endpoints included successful demonstration of individual skill components (Table 1), a simple composite score of a maximum of 5 (1 point for each individual skill) and time required to retrain to proficiency.

Statistical Analysis

Volunteer facilities were initially randomized to receive maintenance retraining, at 3, 6, 9 or 12 months following primary training; however, due to the larger than expected training/retraining burden in the study, centers were unable to adhere closely to assigned groups. Thus, outcomes were evaluated with respect to the actual time interval since initial training (1.5–4.5, 4.5–7.5, 7.5–10.5, and 10.5–13.5 months), rather than the assigned interval. Volunteers excluded from analysis were grouped according to study participation status (i.e., active, moved, dropped/unknown). Means (± SD) and percents summarizing measured characteristics were computed for volunteers within each interval. Proportions, means (± SD), and error bar plots were generated to describe patterns of skill retention by maintenance retraining group for the specified outcome measures. Volunteer-level tests were performed for both primary and secondary outcome measures: Chi-square tests for trend were computed for the overall assessment and individual component measures, the non-parametric Kruskal-Wallis test was computed for the composite scores and ANOVA F-tests for linearity were computed for total testing/retraining time. Confirmatory analyses using logistic Generalized Estimating Equations (GEE) models were performed for the AED and CPR global assessment measures. An exchangeable correlation structure was used to model correlation within a given community unit. Models were adjusted for site, however this required excluding a small number of sites which had too few volunteers to obtain stable estimates. Potential confounders and important covariates/interactions were included in the model via backward stepwise regression, using p=.05 as the entry criterion. No adjustment was made for multiple comparisons. To illustrate an age-by-retraining-interval interaction, volunteers were grouped into four age quartiles and an error bar plot generated to display mean predicted probabilities from the logistic model with 95% confidence intervals in each of the four retraining intervals. All analyses were performed using SPSS (SPSS, Inc, Chicago, IL), Stata (Stata Corporation, College Station, TX), or S-Plus (S-Plus 2000, Mathsoft, Inc., Cambridge, MA).

3. Results

This analysis was performed on data collected from August, 2000 through April, 2003. Of a volunteer cohort of 8,788 in the CPR-only group and 11,758 in the CPR+AED group, 977 and 1,752 volunteers respectively had primary training and maintenance retraining and met additional inclusion criteria. Table 2 shows the numbers of volunteers excluded for each criterion by participation status. Approximately 80% of volunteers did not receive both primary training and maintenance retraining. Of the 6065 volunteers without any maintenance retraining, 71% appeared to be actively participating in the study, 24% had moved from the facility in which they had volunteered and 5% had dropped out of the study for other reasons.

Volunteer characteristics by participation status are shown in Table 3. There were no differences in baseline characteristics of the four groups compared by time interval to maintenance retraining (Table 4). The primary and secondary outcome measures for CPR and AED skills for each maintenance retraining interval are detailed in Table 5. There were no clinically significant trends across intervals. Overall, 81% of volunteers analyzed were able to perform acceptable CPR (i.e., were likely to provide perfusion in the instructor's judgment). For AED skills, approximately 90% of volunteers were judged likely to be able to deliver an effective shock at each interval and this figure did not diminish over time.

Figure 1 shows the overall proportion of volunteers judged to be competent overall by the instructor for each maintenance retraining interval. When the continuous maintenance retraining interval measure (time in months) was analyzed using the logistic model and adjusting for potential confounders, a statistically and clinically significant association was seen between time to maintenance retraining and overall CPR performance. This interaction was dependent on the age of the volunteer (i.e. there was an interaction between retraining interval and age). Results of the model estimation are reported in Table 6a. Not surprisingly, volunteers achieving proficiency during the primary refresher training were three times more likely to perform adequate CPR compared to those who didn't (p=.006) and lifeguards were roughly 2.5 times more likely to perform adequately relative to others (p=.005). Better CPR performance was also associated with male sex (p=.044), white race (p=.034) and previous experience responding to an emergency or seizure (p<.001). The age-by-time interaction is illustrated in Figure 2 using predicted probabilities from the model. In general, CPR performance appeared to be lower in the longest interval. Among volunteers in the highest age category, this decrease was smaller; however, the estimated probability of performing adequate CPR in this group is lower than that of the other groups over all periods – markedly so in the first three. Longer intervals to maintenance retraining were not associated with the probability of performing adequate AED skills (Table 6b); however, age was associated with a small but significantly lower probability of performing these skills (about 2.5% per additional year of age, p=.001). Volunteers speaking English as a primary language were over three times more likely to perform adequate AED skills (p=.001) relative to those with another primary language, and volunteers reporting the ability to operate a computer were almost twice likely to perform well compared to those who did not (p=.045).

4. Discussion

Results of this study strongly suggest that committed volunteers acting within a structured emergency response plan retain core CPR and AED skills up to 12 months after primary initial and refresher training. CPR skills do degrade minimally over the next 12 months but more than 80% of volunteers in all CPR groups and more than 90% in AED groups remained competent overall at 12 months. These findings provide valuable information for those recommending training schedules in public access emergency response settings.

Effective CPR training has been an elusive goal since the inception of the "chain of survival" concept. CPR is a complex cognitive and psychomotor task and past evidence suggests that fewer than half of traditional CPR trainees are able to perform immediately following training.[4, 5] The retention of CPR skills also has been documented to be poor.[6–11] Nyman & Sihvonen[12] describe CPR skill retention in 298 nurses and nursing students. They found no degradation in overall performance between those who had received training within 6 months and those who had not, but the results were uniformly dismal, identifying overall that 36% first assessed the patient's response, 67% opened the airway, 21% performed chest compressions correctly for at least half of the test, and 33% ventilated correctly at least half of the time. They conclude that skills of the participants in that study could not be considered adequate. Many studies document the difficulty in learning and remembering the correct sequence of steps in CPR.[24–28]

Attempts to identify improved methods for delivering CPR training have included simplification of CPR protocols, most recently by removing mouth-to-mouth resuscitation.[10, 29] Alternatives to the classroom approach have been investigated most notably by Braslow[30] who demonstrated improved skill mastery and retention among laypersons who completed video self-instruction in CPR compared to laypersons who attended traditional CPR training. Subsequent work has found similar results[5, 31] but while different educational modalities have shown improvements on initial learning, the overall proportion of trainees who retain CPR skills are typically less than 50% at 6 months.

Formal evaluation of AED skill acquisition and retention is less frequent but the small number of studies reported suggest that AED skills may be easier to learn and maintain than CPR.[17–21] One of the prime reasons may be the benefit of voice and visual prompts provided on modern AEDs.

Our experience is in contrast to many previous skill-retention studies, presumably because of a different design and a different study population. The most common testing model involves performing a set of distinct skills in sequence on artificial manikins according to objective measures in a classroom situation. The combination of skills measured is complex and the evaluation process is stressful. It is unknown whether passing or failing scores in this type of environment reflect the ability to perform core skills that improve survival at a real cardiac arrest event. The most common mistake in CPR testing was failure to activate 911 but no instances of failure to do so were recorded in 3413 actual events. Due to the large number of volunteers requiring CPR training, we chose to measure competence in an overall manner focusing on compressions, the key act that would most likely save a life. Bystander CPR does not have to be perfect to be associated with increased survival from cardiac arrest.[32, 33] Although most agree that optimizing CPR is important, even CPR by professional advanced trained responders is not always ideal.[34]. Our global evaluation of AED skills, which focused on the delivery of an acceptable shock, and our reinforced primary training strategy may also explain the high rates of competence in this study. The most common mistake in AED testing was failure to clear the patient verbally prior to defibrillation attempt, but no cases of electrical shock to volunteers of bystanders were recorded during the PAD trial. We are convinced that our overall assessment of both CPR and AED skills is a practical and relevant method of evaluation. There was no formal attempt to measure the inter-observer reliability of the overall score applied by a large number of instructors.

We sought to optimize skill retention by providing all volunteers with primary training that included the initial course combined with testing and focused refresher training if necessary, 3 to 6 months later. The method of maintenance retraining in this study was one-to-one and individualized. The pre-test allowed the instructor to focus on deficiencies thus providing efficient testing often within the work environment. In our model, testing for competence, identification of weaknesses and retraining to CPR proficiency took an average of 4.9 (± 2.7) minutes per volunteer. The average time for AED plus CPR testing and maintenance retraining was 7.2 (± 3.4) minutes demonstrating that 2 or 4 hour retraining sessions are not necessary in most cases. Information about the frequency of retraining volunteer emergency responders is important to agencies delivering training programs and facilities incorporating CPR or AED response plans. This study suggests that after primary training, yearly maintenance retraining will result in modest reduction in mean CPR composite skill scores but without reduction in the proportion of volunteers able to perform adequate chest compressions and no significant reduction in the proportion of volunteers able to deliver a shock with an AED. There is no consensus on an appropriate and achievable goal for the absolute proportion of volunteers who should be able to respond appropriately. Although 100% is optimal, it is unrealistic. It is unknown whether more frequent training would increase the proportion of volunteers who perform proficiently and this study cannot predict performance beyond 12 months after primary initial and refresher training. Of importance, volunteers with poor performance on previous training sessions likely require more intense remediation than these group results would suggest. Other characteristics associated with CPR successful performance include younger age, male sex, white race, previous response to a health emergency and prior lifeguard training. Characteristics associated with AED success include young age, English as a primary language and ability to operate a computer. These predictors of success can be used to identify volunteers who are likely to succeed and conversely those who may require more intense training. They are consistent with a previous analysis of PAD volunteer performance at the primary refresher training session.[35]

It must be emphasized that the volunteer cohort in this trial was motivated, had responsibility for responding during specific hours and worked in an environment of relative high risk; conditions that likely increased learning and retention. Some also had experience responding to emergencies (first aid attendants, security guards, lifeguards) and are not directly comparable to lay groups in many previous studies.

The results of this study should be considered with an understanding of the limitations. The overall assessment model may reflect more accurately whether the trainee is able to remember and perform the fundamentals of CPR or AED use that are important to successful resuscitation but it can be challenged on its lack of standardization and unknown inter-observer reliability. It was however, defined and collected on identical scoring sheets for consistency. Overall scores were consistent with simple composite scores providing some evidence of internal validity and some confidence in the global score as a reasonable measure. Subjects analyzed included only 20% of those who were primarily trained and 40% of those who had initial refresher retraining. This circumstance was largely due to a retraining burden that was too great for sites to complete on allocated resources and the completion of this study prior to scheduled retraining. An additional group of volunteers could not be retrained because they left the facility (e.g., changed jobs) thus, it is possible that the analyzed sample is biased. For example, difficult facilities or volunteers may have been a lower priority for retraining resources, or volunteers performing poorly previously may have refused to attend a subsequent retraining. Despite our attempts to control for potential bias using measured volunteer characteristics there may have been an imbalance in important unmeasured characteristics. Any program that trains volunteer responders in similar settings must expect significant turnover and plan training of new volunteers accordingly. The intended analysis according to randomization of training by time interval was impossible due to the large variability in actual retraining timing intervals. Adherence to the planned training schedule encountered practical difficulties in the coordination of simultaneous training in multiple facilities. Significant logistic scheduling problems are likely to also occur in many real-world settings.

Despite limitations outlined above, this trial is the largest published trial of volunteers who were actually involved in CPR or AED response plans in their respective environments. This volunteer group was committed to the PAD trial and training and therefore more closely represents real-world training and skill retention than other studies of subjects with no immediate responsibilities to respond.

5. Conclusion

After receiving primary training, CPR skills of targeted lay responders deteriorate nominally as time between retraining increases but 80% remain competent up to one year. AED skills do not significantly deteriorate and 90% remain competent up to one year. Consensus of realistic targets for maintaining skill retention can be developed and these data used to plan training programs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix

Appendix

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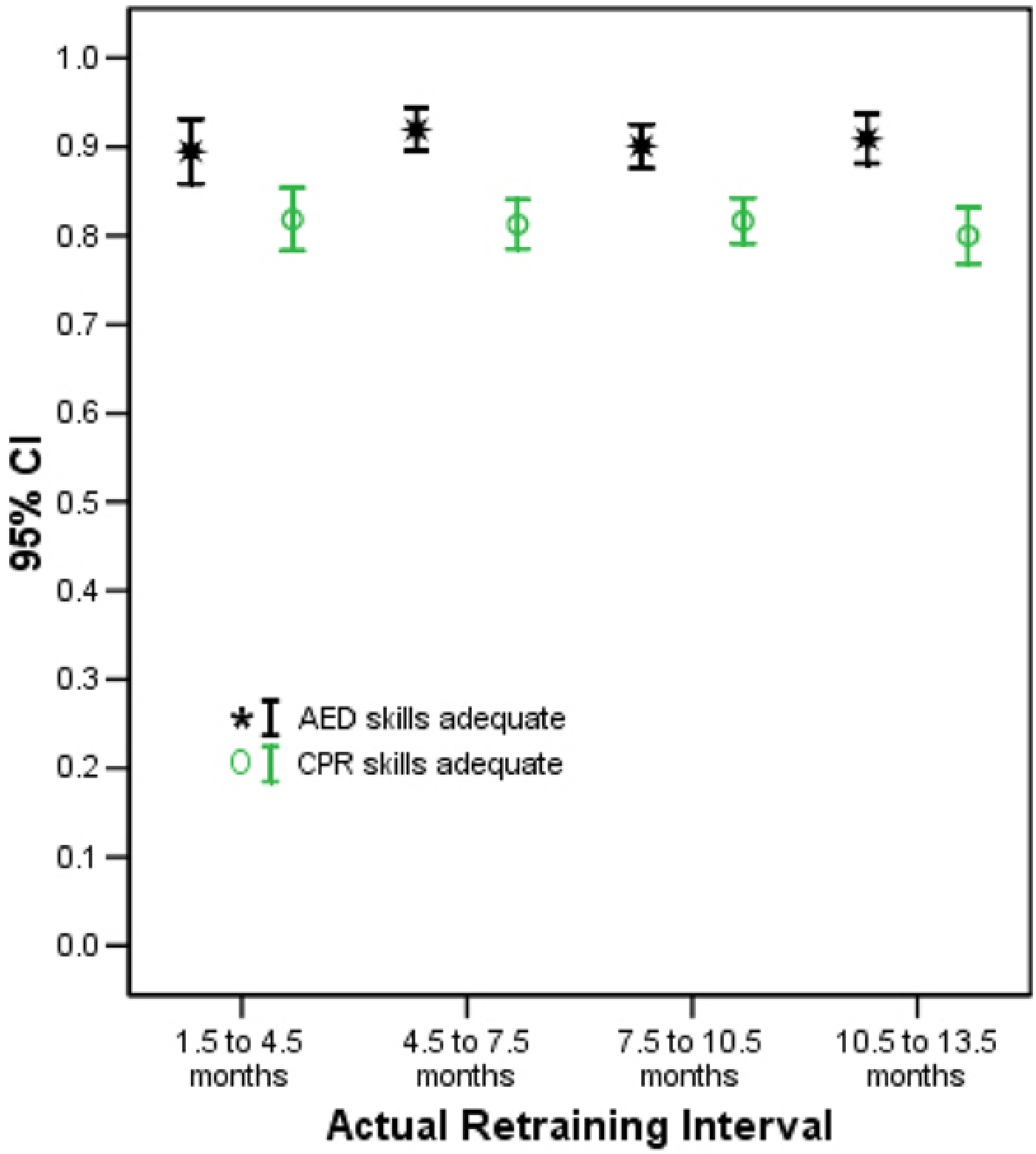

Figure 1.
Proportion of Volunteers with adequate CPR and AED skills by time interval

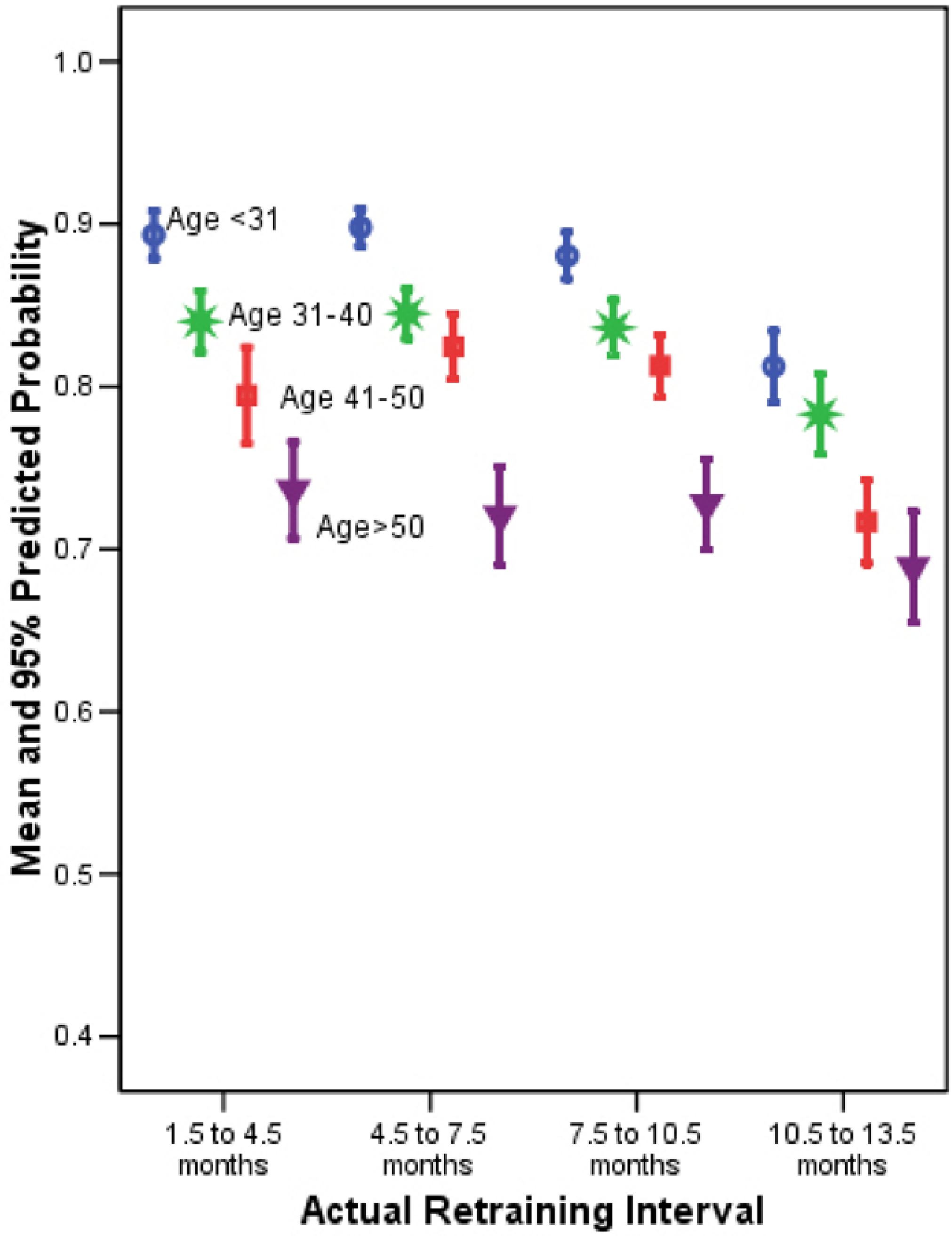

Figure 2.
Mean predicted probabilities and 95% CIs for performing adequate CPR by age category and maintenance retraining interval group

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Table 1

Component criteria for evaluation of skill performance

CPR skill components	
	assess responsiveness
	access 911
	adequate ventilation/chest rise
	proper hand placement
	adequate compression depth
AED skill components	
	bare chest for pad placement
	place pads correctly
	clears self
	verbally clears area
	shock patient within 90 sec of AED arrival

Table 2

Volunteers excluded from analyses

	Total
Volunteers with Primary Initial Course	20546
No Primary Refresher training	10209
No Maintenance retraining	6065
Protocol Violation	826
Crossover	174
Outside 1.5–13.5 mo. training window	543
Volunteers included	2729

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Table 3

Characteristics of Volunteers by Exclusion status

	Analyzed[1]	Active[2]	Moved[3]	Other Drop/Unknown[4]
N	2729	4313	1480	271
Mean (± SD) age	41.1 (13.8)	41.8 (13.8)	35.3(14.1)	36.5 (17.3)
% male	53%	53%	58%	51%
% white	83%	79%	79%	85%
% randomized to CPR only	36%	43%	44%	40%
% Previous CPR, First Aid or advanced training	66%	55%	64%	60%
% aided in emergency or seizure	60%	53%	59%	49%
% with friend or family with OOHCA	51%	48%	46%	45%
% with English as native language	94%	95%	95%	92%
% attended college or higher	73%	73%	72%	54%
% operate a computer	89%	86%	87%	84%
% with back problems	8%	9%	9%	9%
% with arthritis	5%	6%	5%	7%
% security guard	17%	13%	22%	19%
% lifeguard/aqua instructor	5%	2%	4%	19%

[1] volunteers included in analyses

[2] active volunteers excluded from analysis, largely due to missing primary refresher and/or maintenance retraining

[3] volunteers who moved from the unit

[4] volunteers who discontinued participation for other reasons or were lost to follow-up.

Table 4

Baseline characteristics (covariates) of analyzed groups by time strata (n = 2729)

	1.5 – 4.5	**4.5 – 7.5**	**7.5 – 10.5**	**10.5 – 13.5**
N	457	769	873	630
Months from primary initial to primary refresher training: Mean (±SD)	6.4 (±4.1)	6.3 (±3.7)	6.7 (± 3.5)	6.5 (± 3.3)
Months from completion of primary training to maintenance retraining: Mean (±SD)	3.5 (±0.6)	6.1 (±0.8)	8.9 (±0.8)	12.1 (±0.8)
% Previous CPR, FA or advanced training	62	66	68	64
% male	52	50	53	56
% white	76	85	83	84
Age, Mean (± SD)	41 (±14)	41 (±15)	41 (±13)	41 (± 14)
% using computer/video aids (2nd retraining)	1	3	0	2
% with previous mock or real arrest (1st retrain)	6	9	11	9
% previous mock or real cardiac arrest (2nd retrain	9	16	16	15
% randomized to CPR only	39	37	33	35
% aided in emergency or seizure	60	57	61	60
% with friend or family with OOHCA	49	50	51	51
English as native language	91	95	95	93
% attended college or higher	73	73	74	73
% operate a computer	89	88	90	88
% with back problems	11	8	7	7
% with arthritis	5	6	5	3
% trained to proficiency (first retrain)	99	98	99	100
% security guard	27	14	15	14
% lifeguard/aqua instructor	5	8	5	2

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Table 5

Table 5a. Primary and secondary outcome measures by maintenance retraining interval for CPR skills

	Total	1.5 – 4.5	4.5 – 7.5	7.5 – 10.5	10.5 – 13.5	p-value
N	2729	457	769	873	630	
% Competent by global assessment (likely to provide perfusing CPR)	81%	82%	81%	82%	80%	.502[1]
% assessing responsiveness	87%	89%	85%	89%	84%	.261[1]
% accessing 911	71%	72%	71%	71%	68%	.158[1]
% providing adequate ventilation	81%	83%	81%	81%	78%	.047[1]
% placing hands properly	82%	86%	84%	79%	80%	.004[1]
% demonstrating adequate compression depth	88%	91%	88%	87%	87%	.059[1]
Mean Composite CPR score	4.1 (1.1)	4.2 (1.1)	4.1 (1.2)	4.1 (1.1)	4.0 (1.2)	.012[2]
Time (min.) to test & train, CPR (N=801)	4.9 (2.7)	4.6 (2.3)	4.7 (2.5)	5.2 (3.1)	5.2 (2.9)	.038[3]

Table 5b. Primary and secondary outcome measures by maintenance retraining interval for AED skills

	All	1.5–4.5 mo	4.5–7.5 mo	7.5–10.5 mo	10.5–13.5 mo	p-value
N	1752	278	482	581	411	
% competent by global assessment (likely to provide effective shock)	91%	89%	92%	90%	91%	.893[1]
% baring chest for pad placement	96%	97%	95%	94%	98%	.837[1]
% placing pads correctly	84%	82%	84%	83%	86%	.208[1]
% clearing self	84%	86%	86%	83%	84%	.222[1]
% verbally clearing area	75%	73%	76%	74%	78%	.271[1]
% able to shock within 90 sec.	80%	82%	80%	80%	78%	.262[1]
Mean Composite AED score	4.2 (1.1)	4.2 (1.1)	4.2 (1.1)	4.1 (1.2)	4.2 (1.1)	.445[2]
Time to test & train, AED (min.) (N=1342)	7.2 (3.4)	6.6 (3.5)	7.1 (3.4)	7.1 (3.2)	8.2 (3.5)	<.001[3]

[1] Chi-square test for linearity

[2] Kruskal-Wallis test

[3] ANOVA F-test for linearity

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Table 6

Table 6a. Independent predictors of CPR skill competence by regression modeling

Independent Predictors of Adequate CPR[1]	Exp{B}, (robust SE)	P-value
Maintenance retraining interval (mr6onths)	0.842 (0.050)	.004
Age (years)	0.937 (0.012)	<.001
Age by Maintenance retraining interval interaction	1.003 (0.001)	.013
Gender	1.276 (0.154)	.044
White race	1.509 (0.293)	.034
Previously responded to seizure/emergency situation	1.600 (0.204)	<.001
Achieved proficiency at primary refresher training	3.049 (1.245)	.006
Lifeguard	2.676 (0.933)	.005

Table 6b. Independent predictors of AED skill competence by regression modeling

Independent Predictors of Delivery of AED Shock[1]	Exp(B) (robust SE)	P-value
Maintenance retraining interval (months)	0.956 (0.039)	.267
Age	0.975 (0.007)	0.001
English primary language	3.125 (1.073)	0.001
Able to operate a computer	1.891 (0.601)	0.045

[1] Model also adjusted for site