

## Video-Only Cardiopulmonary Resuscitation Education for High-Risk Families Before Hospital Discharge A Multicenter Pragmatic Trial

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**Background**—Cardiopulmonary resuscitation (CPR) training rates in the United States are low, highlighting the need to develop CPR educational approaches that are simpler, with broader dissemination potential. The minimum training required to ensure long-term skill retention remains poorly characterized. We compared CPR skill retention among laypersons randomized to training with video-only (VO; no manikin) with those trained with a video self-instruction kit (VSI; with manikin). We hypothesized that VO training would be noninferior to the VSI approach with respect to chest compression (CC) rate.

**Methods and Results**—We performed a prospective, cluster randomized trial of CPR education for family members of patients with high-risk cardiac conditions on hospital cardiac units, using a multicenter pragmatic design. Eight hospitals were randomized to offer either VO or VSI training before discharge using volunteer trainers. CPR skills were assessed 6 months post training. Mean CC rate among those trained with VO compared with those trained with VSI was assessed with a noninferiority margin set at 8 CC per min; as a secondary outcome, mean differences in CC depth were assessed. From February 2012 to May 2015, 1464 subjects were enrolled and 522 subjects completed a skills assessment. The mean CC rates were 87.7 (VO) CC per min and 89.3 (VSI) CC per min; we concluded noninferiority for VO based on a mean difference of  $-1.6$  (90% confidence interval,  $-5.2$  to  $2.1$ ). The mean CC depth was 40.2 mm (VO) and 45.8 mm (VSI) with a mean difference of  $-5.6$  (95% confidence interval,  $-7.6$  to  $-3.7$ ). Results were similar after multivariate regression adjustment.

**Conclusions**—In this large, prospective trial of CPR skill retention, VO training yielded a noninferior difference in CC rate compared with VSI training. CC depth was greater in the VSI group. These findings suggest a potential trade-off in efforts for broad dissemination of basic CPR skills; VO training might allow for greater scalability and dissemination, but with a potential reduction in CC depth.

**Clinical Trial Registration**—URL: <https://www.clinicaltrials.gov>. Unique identifier: NCT01514656.

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**Key Words:** cardiopulmonary resuscitation ■ cardiovascular diseases ■ randomized controlled trial ■ resuscitation ■ heart arrest

Prompt delivery of cardiopulmonary resuscitation (CPR) increases the probability of survival from sudden cardiac arrest (SCA) by 2- to 3-fold, yet >60% of SCA victims in the United States do not receive bystander CPR.<sup>1-4</sup> Despite the availability of CPR certification programs for the lay public, a recent investigation documented that training rates in the United States are strikingly low.<sup>5</sup> Given that >75% of SCA events occur in the home environment, training family

members of patients with at-risk cardiac conditions could have a significant impact on initial care and survival from SCA, which leads to >200 000 out-of-hospital deaths each year in the United States.<sup>4,6-8</sup> Highlighting the public health burden of SCA, the Institute of Medicine recently published a report entitled *Strategies to Improve Cardiac Arrest Survival: A Time to Act* that includes a call for increased engagement of the lay public as SCA first responders.<sup>9</sup>

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\*A list of all CHIP study participants is given in the Appendix.

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### WHAT IS KNOWN

- Bystander CPR improves survival from sudden cardiac arrest, yet rates are low in many US communities.
- Studies have suggested that simplified methods for CPR training may promote broader dissemination and increase bystander delivery rates, but the minimum CPR training curriculum to encourage broad implementation and to ensure long-term retention remains poorly understood.

### WHAT THE STUDY ADDS

- We have conducted the first large, prospective cluster randomized trial examining the effectiveness and long-term retention of lay bystanders trained with VO education compared with VSI paired with inflatable manikins.
- VO training yielded a statistically indistinguishable difference in CC rate compared with VSI training at 6 months post training, while the compression depth was more shallow at 6 months post training.
- When considering CPR education modalities, the current investigation presents a possible tradeoff; specifically, video-only training may confer broader dissemination potential at low cost with noninferior CC rate, whereas manikin-based instruction may result in somewhat better CPR skill performance at higher cost (and possibly less broad dissemination).

Many key barriers are inherent in the prevailing approach to layperson CPR training; these include the need for CPR-certified instructors, logistical constraints (such as course duration and costs), and low motivation for CPR training among the general public.<sup>10,11</sup> Recent investigations have evaluated methods to disseminate CPR education that are simpler, less costly, and more expedient. These approaches have included the use of hands-only CPR (chest compressions [CC] with no rescue breaths), video self-instruction (VSI) kits, and highly abbreviated training programs.<sup>12–18</sup> The minimum training curriculum that reduces training barriers and provides adequate long-term CPR skill retention is unknown.

To address this knowledge gap, we conducted a multicenter, pragmatic randomized trial of 2 educational strategies for CPR training of the lay public. Family members of hospitalized patients with cardiac risk factors were offered either standard training via a kit that included a video along with an inflatable manikin (VSI), or video-only training without a manikin for psychomotor practice (VO). We hypothesized that trained laypersons who receive VO training would perform CCs 6 months post training, at a rate that is noninferior to those who trained using a VSI kit. As a secondary outcome, we assessed the mean difference in CC depth between cohorts. If a VO CPR strategy yielded similar long-term skill retention, it would have important implications for dissemination to millions of potential layperson trainees worldwide.

## Methods

### Study Population and Setting

The CHIP trial (CPR Hospital-Initiated Project) was conducted on the inpatient wards at 8 acute care hospitals in the southeastern Pennsylvania region (Hospital of the University of Pennsylvania, Penn Presbyterian Medical Center, Pennsylvania Hospital, Crozer-Chester Medical Center, Albert Einstein Medical Center Philadelphia, Temple University Hospital, Chester County Hospital, and Taylor Hospital). Adult family members of patients hospitalized with coronary disease on cardiology service line wards, telemetry, or observation units were eligible for participation. The trial was conducted between February 2012 and May 2015.

This investigation was approved by the relevant Institutional Review Boards at each study site (University of Pennsylvania and Health System [includes 3 study sites], Crozer-Keystone Health System [includes 2 sites], Albert Einstein Healthcare Network, Temple University, and the Chester County Hospital) and was registered with the national clinical trials registry (NCT01514656, ClinicalTrials.gov, National Institutes of Health). Enrollment was conducted after written informed consent.

### Study Design

This study was structured as a pragmatic, randomized trial assessing the comparability of training individuals in CPR with VO (no manikin) to training with a VSI kit (manikin). Hospitals were randomized to sequential 6-month periods of training with either VSI or VO. To account for secular trends, the randomization scheme ensured that across all hospitals, the number of subjects receiving VO or VSI training at any point in time was similar.

### Subject Recruitment

Subjects were enrolled from February 2012 to December 2014 and underwent quantitative CPR skills assessment 6 months after the hospital-based training. Volunteer enrollers (registered nurses and students in the health sciences) at each study site offered video CPR instruction to family members of hospitalized patients; this pragmatic approach was used to assess generalizability for future broad implementation. Before participation in the study, the volunteer enrollers completed a 1-hour training session led by study investigators. A reference manual containing training and study information was provided, and study investigators were available on a daily basis for real-time enrollment-related questions. Details of the training process and volunteer recruitment are described in a recent publication.<sup>19</sup> Subjects were eligible for enrollment if they met the following criteria: (1) the family member was physically present with the patient on the floor or unit; (2) the patient had an admission diagnosis potentially related to underlying coronary disease; (3) the patient was in stable condition; (4) the family member was  $\geq 18$  years; (5) the family member felt fit and able to perform moderate physical activity at the time of enrollment; and (6) the family member had sufficient English competency. Eligible family members who satisfied the inclusion criteria were enrolled using a standard written informed consent form and completed a pretraining demographic survey.

### CPR Training Intervention

We utilized a validated video training program and VSI kit (CPR Anytime for Family and Friends, American Heart Association, Dallas, TX, and Laerdal Medical, Stavanger, Norway), described in previous investigations.<sup>20,21</sup> In accordance with the 2010 American Heart Association resuscitation guidelines, both study arms used hands-only CPR as the mode of instruction (CC without accompanying ventilations). The control group received a VSI kit that included an inflatable head/torso manikin and a 22-minute instructional DVD. The experimental VO group received a training video on DVD (no manikin). The DVD instruction was based on consensus CC goals of  $>100$  CC per min (cpm) and CC depth of  $>50$  mm. After the training session, subjects completed a post-training survey designed to assess their comfort with the training process. Per-trial protocol, volunteer

registered nurses and students facilitated the family member training process, but refrained from coaching or teaching the subjects during training sessions.

### Post-Training Assessment

Six months post training, subjects were contacted and asked to complete a brief in-person interview where subjects' perspectives on the training experience and perceived self-efficacy on performing CPR were captured. Subjects that lived >2 hours away from the University of Pennsylvania were excluded from follow-up. On completion of the in-person interview, the subject was asked to perform a 2-minute CPR skills assessment (skills test) using a CPR-recording manikin (SkillReporter ResusciAnne, Laerdal Medical, Stavanger Norway). The manikins were designed and calibrated to require consistent force to compress 50 mm. After  $\approx 25\,000$  compressions, the manikins were sent to the manufacturer for calibration testing to confirm ongoing consistency. Data from the CPR skills test were extracted from the recording software and imported into the study database for subsequent quantitative analysis.

Leading up to the 6-month skills assessment, the subject was not notified beforehand that they were being asked to perform a skills check (ie, the skills test was a surprise), minimizing the likelihood that the subject would practice CPR skills immediately before the home visit. This surprise approach has been used in previous layperson resuscitation educational trials.<sup>22</sup> Subjects who fulfilled the in-person interview were given \$50 compensation.

### Statistical Approach and Analysis

All demographic and CPR data were compiled in a secure, internet-based database application (REDCap Software version 5.2.1; Vanderbilt University, Nashville, TN) and analyzed using statistical software packages (Stata 13; StataCorp, College Station, TX; and R version 3.3.0 with the ggplot2 package; The R Foundation for Statistical Computing, Vienna, Austria).

Although our volunteer enrollers offered training to all family members interested in the study, our primary analysis included a single individual trainee per family. For families with >1 enrolled subject (the minority of enrollment instances), we randomly selected 1 individual per family to include in the primary analysis. The distribution of the data was visualized using a histogram and smoothed using a kernel density estimator. Demographic data were compared between VO and VSI cohorts using a Pearson  $\chi^2$  test, as appropriate for categorical variables and a Student *t* test for continuous variables. The primary analysis used a *t*-statistic to test the null hypothesis that mean CC rate in the VO group was >8 cpm lower than the mean CC rate in the VSI group. Noninferiority was concluded based on a rejection of the null hypothesis. With a target sample size of 500, a type I error rate of 0.05 and a projected SD of 18 cpm, based on previous works,<sup>23,24</sup> the study had 80% power to declare noninferiority if VSI and VO differed by less than a mean of 3.5 cpm and 90% power to declare noninferiority if VSI and VO differed by less than a mean of 2.8 cpm. With this sample size, the width of the 90% CI for mean CC rate was anticipated to be 2.6 cpm.

CC depth was considered the secondary outcome, and in this case, we tested the null hypothesis that the 2 approaches yielded indistinguishable mean depth at 6 months. This analysis used a 95% confidence interval (CI).

The primary analysis was conducted with the subjects who agreed to a 6-month skills test. In a sensitivity analysis, we used inverse probability weighting (IPW) in the context of a linear model to estimate the mean differences in CPR skills. The propensity score for the likelihood of completing the 6-month follow-up included the following covariates: age, race, sex, highest education, previous training, number of subjects in a family, enrollment site, method of training, and method of training as an interaction with race, sex, age, and site. Between-group differences among those who agreed to follow-up and those who did not in baseline covariates before and after IPW were assessed to ensure that the propensity score was successful in achieving balance among the two groups. For individuals who were

missing baseline covariates (<4% of all subjects), we imputed the value of each of these covariates using a simple means model for continuous variables or mode for categorical variables. The final IPW model included site as a fixed effect and was weighted by the propensity for completing the 6-month skills test.

Finally, because the distribution of the original CC rate data appeared somewhat skewed, we assessed the differences in CC rate using a propensity-weighted overdispersed Poisson model.

## Results

### Subject Demographics

From February 2012 to December 2014, 1464 subjects were enrolled at 8 hospitals; an additional 146 family members received CPR training but were not included in the primary analysis. Characteristics of the cohort at initial enrollment and 6-month follow-up appear in Table 1. The mean age of initial enrollees was  $52 \pm 14$  years, and 1083 of 1442 (75%) were women. Of those initially enrolled, 1037 of 1456 (71%) had either never been trained in CPR or had been trained >10 years ago and 1163 of 1441 (81%) were spouses or immediate family members of the hospitalized patient. Recruitment of subjects across hospitals differed ( $P=0.01$ ), with sites A and B recruiting >310 subjects each compared with sites C through H where fewer than 230 subjects were recruited.

As shown in Figure 1, 230 subjects were not eligible for in-person follow-up because they lived >2-hour driving distance from the research institution or the patient or subject was deceased, whereas 533 could not be contacted or declined participation. From the initial enrollment cohort, 522 (36%) subjects completed a 6-month follow-up interview and CPR skills testing. Among the 522 subjects, 285 (54%) received VSI training whereas 237 (46%) received VO training. Of those who did not complete a 6-month skills assessment, 44 subjects underwent the in-person interview process but declined skills testing. Excluding those not eligible for follow-up because of distance, the skills assessment follow-up rate was completed in 522 of 1234 (42%).

We examined the demographics of those who completed skills assessments compared with those who did not; race was associated with follow-up, with blacks being more likely to complete follow-up ( $P<0.01$ ). Location of initial training was also significantly associated with follow-up ( $P=0.01$ ), but age, sex, relationship to the patient, educational level, or previous CPR training were not (Table 2).

### CPR Skills: CC Rate and Depth

The distribution of CC rate (A) and depth (B) appears in Figure 2. For both training groups, CC rate was skewed right whereas CC depth was skewed left. Among subjects who completed the 6-month skills assessment, mean CC rate in the VO cohort was 87.7 (90% CI, 85.1–90.4) cpm and 89.3 (90% CI, 86.8–91.8) cpm in the VSI cohort. The mean rate difference between cohorts was  $-1.6$  (90% CI,  $-5.2$  to  $2.1$ ) cpm, well under the predefined 8 cpm threshold for noninferiority; therefore, these findings are consistent with noninferiority at the 5% significance level.

The mean CC depth was 40.2 (95% CI, 38.7–41.7) mm in the VO cohort and 45.8 (95% CI, 44.5–47.1) mm in the VSI

**Table 1. Demographics of Subjects Who Initially Enrolled and Who Completed the 6-Month Skills Assessment and Were Included in the Final Analysis**

	Initial Enrollment			6-mo Skills Assessment		
	VO (n=695)	VSI (n=769)	P Value	VO (n=237)	VSI (n=285)	P Value
Age, mean±(SD)	52±14	52±14	0.68	52±14	52±14	0.89
Race, n (%)						
White	402 (59)	419 (55)	0.33	131 (56)	154 (55)	0.79
Black	224 (33)	270 (35)	...	88 (38)	109 (38)	...
Other	60 (8)	76 (10)	...	14 (6)	21 (7)	...
Sex, n (%)						
Women	499 (73)	562 (74)	0.94	174 (75)	215(75)	0.84
Men	180 (27)	201 (26)	...	59 (25)	70 (25)	...
Relationship, n (%)						
Spouse	241 (35)	264 (35)	0.41	89 (38)	103(37)	0.90
Immediate family	320 (47)	338 (45)	...	102 (43)	122 (43)	...
Other	122 (18)	156 (20)	...	44 (19)	57 (20)	...
Education, n (%)						
High school	253 (37)	296 (39)	0.81	77 (32)	101(35)	0.41
Some college	163 (24)	183 (24)	...	54 (23)	76 (27)	...
College	185 (27)	190 (25)	...	70 (30)	67 (24)	...
Graduate school	86 (12)	97 (12)	...	35 (15)	41 (14)	...
Previous training, n (%)						
Never	330 (48)	399 (52)	0.13	109 (46)	135 (48)	0.20
<2 y	53 (8)	54 (7)	...	16 (7)	30 (11)	...
2–5 y	98 (14)	77 (10)	...	35 (15)	29 (10)	...
6–10 y	68 (10)	69 (9)	...	29 (12)	26 (9)	...
>10 y	143 (20)	165 (22)	...	47 (20)	64 (22)	...
Location of training, n (%)						
A	193 (28)	194 (25)	0.01	59 (25)	58 (20)	0.01
B	149 (21)	170 (22)	...	60 (25)	75 (26)	...
C	95 (14)	83 (11)	...	30 (12)	31 (11)	...
D	64 (9)	54 (7)	...	23 (10)	16 (6)	...
E	118 (17)	117 (15)	...	40 (17)	38 (13)	...
F	20 (3)	45 (6)	...	7 (3)	19 (7)	...
G	42 (6)	83 (11)	...	16 (7)	40 (14)	...
H	11(2)	23 (3)	...	2 (1)	8 (3)	...

Initial missing variables are as follows: age: 60 years; race: 13; sex: 22; relationship: 23; education: 11; previous training: 8. Missing variables from the skills assessment cohort: age: 13 years; race: 5; sex: 4; relationship: 5; education: 1; previous training: 2. Hospitals: A indicates Hospital of the University of Pennsylvania; B, Penn Presbyterian Medical Center; C, Pennsylvania Hospital; D, Crozer-Chester Medical Center; E, Einstein Medical Center Philadelphia; F, Temple University Hospital; G, Chester County Hospital; H, Taylor Hospital; VO, video-only; and VSI, video self-instruction.

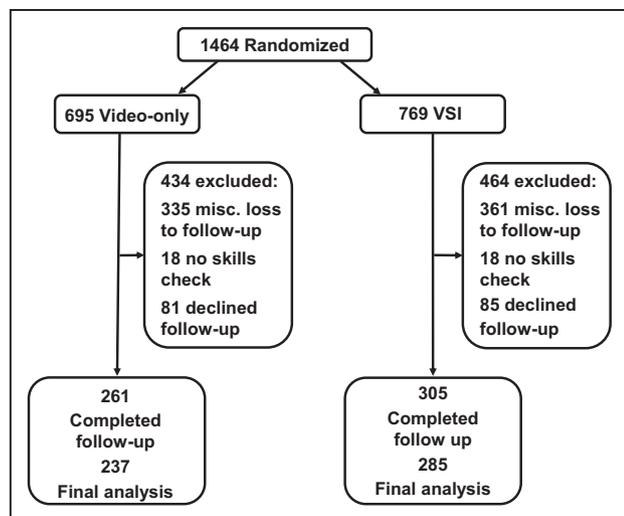
P values represent a *t* test for continuous variables and a  $\chi^2$  test for categorical variables.

cohort (Table 3). The mean depth was  $-5.6$  (95% CI,  $-7.6$  to  $-3.7$ ) mm shallower among the VO cohort, a difference that was statistically significant at the 5% significance level.

After using IPW to adjust for loss to follow-up, the difference in both mean CC rate and depth was not significantly altered. Our main findings were also confirmed with an IPW, overdispersed Poisson model (results not shown).

## Discussion

In a pragmatic, randomized multicenter trial of family CPR education, we assessed quantitative measures of CPR skill retention 6 months after training with either a standard VSI kit or a VO education, without the use of a manikin for psychomotor practice. CC rate for the 2 cohorts demonstrated non-inferiority of the VO training approach, with mean CC rate



**Figure 1.** Consort diagram of the pragmatic clinical trial randomization and subsequent subject follow-up. VSI indicates video self-instruction.

difference of <2 cpm and an upper bound on the difference of 5.2 cpm. By contrast, the difference in mean CC depth was 5.6 mm, with an upper bound (95% CI) of 7.6 mm. These results suggest that psychomotor practice with a manikin improves layperson CC depth during long-term skills assessment. To our knowledge, this represents the largest prospective trial of CPR training and long-term retention among lay providers. Findings from this investigation have important implications for future policy and education initiatives to improve layperson CPR, as VO training could be broadly disseminated at low cost.

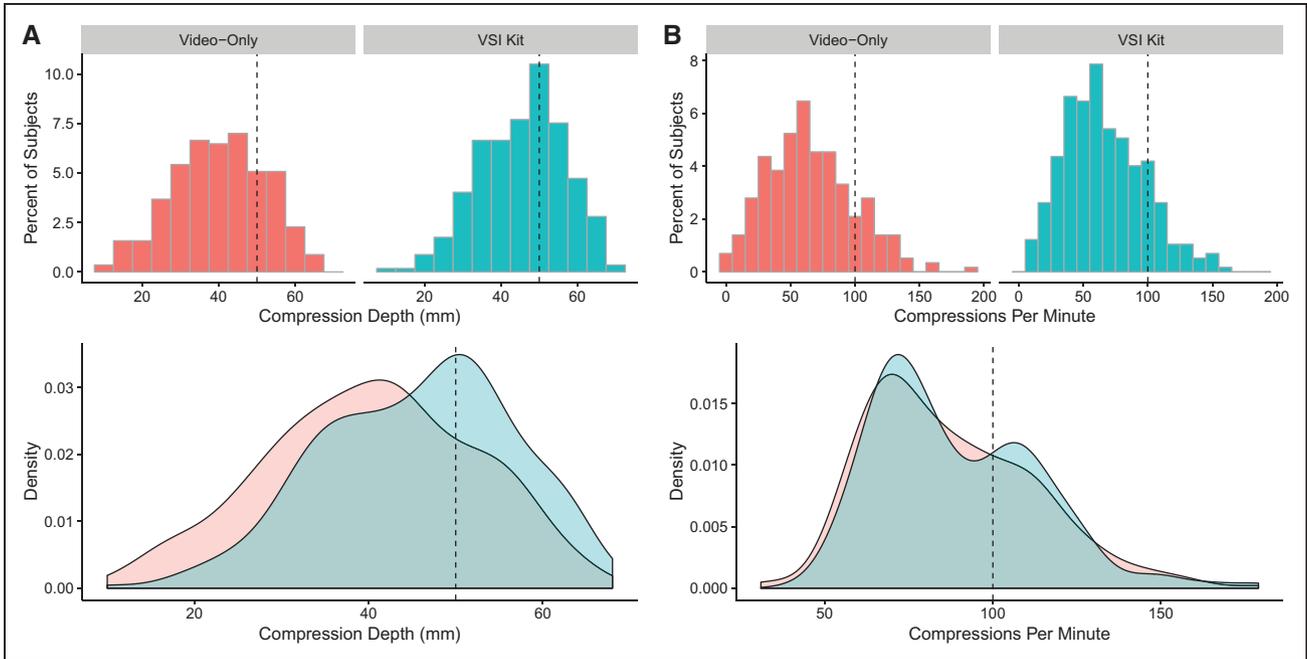
A recent epidemiological study demonstrated low CPR training incidence in the United States, likely contributing to low bystander CPR delivery rates in most communities.<sup>5</sup> Previous works have suggested that numerous barriers, including training access and logistics, have hampered public access to CPR training.<sup>10,11</sup> To address these challenges, the American Heart Association developed a low-cost approach to CPR education that relies on video-facilitated learning in the form of a self-contained VSI kit. The promise for broad implementation using these kits has been demonstrated in several large-scale training experiences, yet public uptake of the VSI kits has been variable, and kit costs may still be prohibitive for large-scale training of the US public.<sup>20</sup> Other work has suggested that barriers to training might be further reduced by brief VO training, eschewing the use of training kits altogether, and adding to the potential for greater scalability of CPR education.<sup>18</sup> It has been generally thought that psychomotor practice of CPR skills during training represents a crucial factor in long-term skill retention although this hypothesis had never been prospectively tested in a randomized trial. Our work suggests that psychomotor practice may yield small benefits with regard to retention of adequate CC depth, but these differences in depth may be small when compared with the enormous dissemination potential inherent in VO education. That is, our work highlights a public health trade-off between somewhat better CPR skills or a tool with much broader implementation potential. Further work will

**Table 2.** Characteristics of Subjects Who Did and Did Not Complete the 6-Month Skills Assessment

	Did Not Complete the Assessment (n=942)	6-mo Skills Assessment (n=522)	P Value
Age, mean±(SD)	51±15	52±14	0.60
Race, n (%)			
White	536 (57)	285 (55)	<0.01
Black	297 (32)	197 (38)	
Other	101 (11)	35 (7)	
Sex, n (%)			
Women	672 (73)	389 (75)	0.33
Men	252 (27)	129 (25)	
Relationship, n (%)			
Spouse	313 (34)	192 (37)	0.37
Immediate family	434 (47)	224 (43)	
Other	177 (19)	101 (20)	
Education, n (%)			
High school	371 (40)	178 (34)	0.12
Some college	217 (23)	129 (25)	
College	237 (25)	138 (26)	
Graduate school	107 (12)	76 (15)	
Previous training, n (%)			
Never	486 (52)	243 (47)	0.23
<2 y	61 (6)	46 (9)	
2–5 y	110 (12)	65 (12)	
6–10 y	82 (9)	55 (11)	
>10 y	197 (21)	111 (21)	
Hospital, n (%)			
A	272 (29)	118 (23)	0.01
B	184 (20)	135 (26)	
C	118 (12)	60 (11)	
D	79 (8)	39 (7)	
E	157 (17)	78 (15)	
F	39 (4)	26 (5)	
G	69 (7)	56 (11)	
H	24 (3)	10 (2)	
Mode of teaching, n (%)			
VSI Kit	458 (49)	237 (45)	0.24
Video-only	484 (51)	285 (55)	

Missing variables: age: 47 years; race: 13; sex: 22; relationship: 23; education, 11; previous training: 12. Hospitals: A indicates Hospital of the University of Pennsylvania; B, Penn Presbyterian Medical Center; C, Pennsylvania Hospital; D, Crozer-Chester Medical Center; E, Einstein Medical Center Philadelphia; F, Temple University Hospital; G, Chester County Hospital; H, Taylor Hospital; VSI Kit, video self-instruction kit.

P values represent a *t* test for continuous variables and a  $\chi^2$  test for categorical variables.



**Figure 2.** Histograms of (A) chest compression depth and (B) rate in video-only and video self-instruction stratified by training group. Vertical dashed lines show target rates of 50 mm and 100 compressions per min, respectively. The bottom panel in each frame conveys the data from the 2 histograms overlaid and smoothed with a kernel density estimator. VSI indicates video-self instruction.

be required to model this trade-off and to determine whether training a greater proportion of the population would result in more lives saved compared with our current paradigm that seems to yield somewhat higher CPR quality among a smaller population of trained individuals.

Our work also demonstrates an important CPR training opportunity that has been largely untapped, namely, hospital-based CPR education of the families of patients with cardiac disease before discharge. More than 1 million people in the United States are admitted for acute coronary syndromes and myocardial infarction annually, yet no system exists to offer CPR training to spouses or other family members during the point of capture opportunity afforded by hospital admission.<sup>14</sup> This gap is especially relevant given that patients with coronary events have a much higher annual risk of subsequent cardiac arrest than the general population.<sup>25,26</sup> Estimates of annual SCA incidence in this population range from 3% to 11% compared with the overall cardiac arrest annual incidence in the United States of  $\approx 0.1\%$ .<sup>27–32</sup> Because  $>70\%$  of arrest events occur in private residences, survival is dependent on the prompt action of spouses and other family members to deliver CPR until prehospital personnel arrive on scene.<sup>33–35</sup> Our previous work has shown that CPR training is well received by

families who reported satisfaction using the hospital environment to offer such education before discharge.<sup>14</sup>

Other venues for CPR education could become feasible through VO education, such as in clinic waiting rooms, public locations such as motor vehicle licensing facilities, or in transit system locations such as train stations or airports. In addition, VO training may allow for other methods of dissemination that remove the need for appropriate environmental settings. For example, the video curriculum could be incorporated into a mobile application for dissemination via mobile technology or integrated into video education programs on television channels. In addition, the video could be disseminated through the internet or various social media platforms.

When comparing the CPR skill retention within the 2 study cohorts, mean CC rate were almost identical, and yet CC depth was deeper in the VSI cohort (difference of 5.6 mm). Although current studies examining CC rates and depths from in and out of hospital providers demonstrate poor CPR quality, few studies have gathered data from actual layperson CPR performance. When comparing our findings with that of clinical studies of CPR performance, our VO cohort’s mean CC depth was similar to that of CC depth as delivered during clinical care.<sup>23,36</sup> Specifically, the CPR performance in our

**Table 3. CC Rate and Depth in the 2 Training Cohorts**

	Cohort		Mean Difference	
	VO (n=237)	VSI (n=285)	Difference	Adjusted Difference*
CC Rate, n/min	87.7 (85.1, 90.4)	89.3 (86.8, 91.8)	-1.6 (-5.2, 2.1)	-1.9 (-5.6, 1.8)
CC Depth, mm	40.2 (38.7, 41.7)	45.8 (44.5, 47.1)	-5.6 (-7.6, -3.7)	-5.2 (-7.4, -3.1)

Values shown are means. Rate: Mean and 90% confidence interval; depth: Mean and 95% confidence interval. Significance for both is established at the 5% significance threshold. CC indicates chest compressions; VO, video-only; and VSI, video self-instruction.

\*Inverse probability weighting propensity score adjusted with all of the demographic variables in Table 1.

cohort was remarkably similar to actual professional CPR performance during clinical care (mean depth in one prehospital cohort was 42 mm compared with 40 mm in our VO cohort).<sup>36</sup>

Although VSI training may yield improved psychomotor retention, VO training may afford cost savings and broad dissemination potential. Given the large effect size inherent in the delivery of bystander CPR and the presumably increased likelihood that a layperson will perform CPR if trained in these skills, our work suggests that VO training may be a useful method to ensure a basic CPR competency to a broad swath of the public who might otherwise remain untrained.

Several limitations are important to note on our investigation. Given our pragmatic design to test a low-cost generalizable approach to hospital-based CPR training, we did not embed research staff and CPR testing equipment at each training site. Thus, we did not test CPR skills at baseline immediately after training and could not compare these skills to the subsequent skills assessment at 6 months. Therefore, it is unknown whether shallow CC depths at 6 months represented skill deterioration or initial CPR quality with VO training. The work of Stiell et al<sup>23,36</sup> has shown that inadequate CC depth is pervasive during CPR provision by prehospital professionals during actual cardiac arrest resuscitation; shallow depth performance in our cohort may be consistent with the physical limitations of CPR delivery. Another limitation of our work was the lack of clinical outcomes from any actual SCA events among the hospitalized patient cohort. Assuming a 5% annual incidence arrest rate among patients with high-risk cardiac disease after hospital discharge, it is possible that 20 to 30 arrest events occurred among the families who received training in our study. Although cardiac arrest events and successful resuscitations were reported by families to our team at follow-up, we did not design our work to allow verification of these reports by clinical prehospital records nor would such verification have adequate statistical power to detect differences in the 2 arms. Furthermore, the study was powered to detect noninferiority in CC rate, but not in CC depth.

Questions about generalizability also arise in our study because of the large loss to follow-up. Our study was powered to detect noninferiority in CC rate for a sample size of 500 evaluable subjects. Despite the loss to follow-up, baseline characteristics of the original cohort and those evaluated at 6 months were reasonably similar. Using IPW to account for the missing data yielded similar conclusions to using only complete cases. This sensitivity analysis suggests that our work has reasonable generalizability to the population of interest, specifically family members of patients hospitalized with a cardiac diagnosis, who agree to volunteer-initiated CPR training.

The enormous promise inherent in VO education will require further work to test implementation models. Whether VO training could be embedded into modern communication tools such as mobile tablets, smartphones, or other delivery approaches remains to be assessed in clinical investigations. Recent investigations have demonstrated the potential promise of using smartphone apps in the domain of SCA.<sup>37</sup> The appropriate timing of CPR training for families before discharge, and the optimal model for staff proctoring of such training, also requires further study.

## Conclusions

VO training yielded statistically indistinguishable CC rates and somewhat shallower CC depths compared with those trained with a VSI kit. If appropriate practical questions are further addressed, offering VO CPR training to families before hospital discharge could become a routine patient and family-centered health educational opportunity in >4000 acute care hospitals that care for patients with cardiac disease in the United States.<sup>38</sup> If implemented broadly, CPR education could be well matched to a large population at high risk of subsequent cardiac arrest, establishing an opportunity to make important gains in survival from cardiac arrest. Furthermore, being able to train individuals with VO may allow for broader, more scalable dissemination of CPR training to the lay public; however, shallower CC depth at 6 months suggests that additional work to optimize VO strategies may be required.

## Appendix

This work is submitted on behalf of the CHIP (CPR Hospital-Initiated Project Study Group): University of Arizona, Sarver Heart Center: Bentley J. Bobrow, MD; Einstein Medical Center Philadelphia: Kenneth Deitch, DO, FACEP and Kathia Damiron, MD; Penn Presbyterian Medical Center: James Kurtz, MPH, BSN, RN and Ryan Dos Reis, BSN, RN; The Chester County Hospital: Donna Taylor, BSN, RN, Janice Baker, MSN, RN, and Shannon Delany, MSN, RN.

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## Video-Only Cardiopulmonary Resuscitation Education for High-Risk Families Before Hospital Discharge: A Multicenter Pragmatic Trial

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