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Simulation and education

# Socioeconomic disparities in layperson CPR training within a large U.S. city

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## Abstract

**Aim of the study:** We sought to understand how individual factors and neighborhood characteristics are associated with a layperson's likelihood of being trained in CPR. We hypothesized that higher socioeconomic status (educational attainment, and median household income (MHI)) would be associated with a higher likelihood of previous CPR training.

**Methods:** Through the Mobile CPR Project, a program providing hands-only CPR and AED education in Philadelphia, we surveyed participants regarding socioeconomic factors and prior CPR training. Survey questions pertained to race, gender, education, prior CPR training, automated external defibrillator (AED) awareness, and residential area. Community MHI was extrapolated via residential address and census tract data.

**Results:** From 7/2016 to 4/2018, 1703 subjects completed surveys, including location information, prior to participating in a Mobile CPR Project training event. Of these, 70% were female, 70% were non-white, mean age was 42 ± 20 years, and MHI was $39,318 [IQR $27,708–$60,795]. Subjects residing in census tracts with MHI below the cohort median were significantly less likely to have ever received CPR training (lowest quartile: OR 0.65, CI 0.49–0.85, $p = 0.002$). In multiple logistic regression controlling for age, race, gender, MHI, and education, higher educational attainment was associated with a higher likelihood of ever receiving CPR training (OR 7.96 Masters or Doctoral compared to less than high school, CI 5.24–12.11, $p < 0.001$).

**Conclusions:** There is a strong association between socioeconomic factors (MHI and educational attainment) and likelihood of prior layperson CPR training.

**Keywords:** Cardiopulmonary resuscitation, CPR education, AED training, Health disparities

## Introduction

Out-of-hospital cardiac arrest (OHCA) affects more than 350,000 adults each year in the United States with only 10.8% of victims surviving to hospital discharge.[1] As a critical link in the chain of survival, early delivery of bystander cardiopulmonary resuscitation (B-CPR) can increase the likelihood of survival more than two-fold.[1] Additionally, layperson use of automated external defibrillators (AEDs) prior to EMS arrival can further increase survival.[2] Across the United States, less than one third of OHCA victims receive B-CPR.[3] Epidemiologic evidence suggests that individuals residing in low socioeconomic status (SES) neighborhoods receive significantly lower rates of B-CPR and AED intervention.[4] Additionally, minority populations are less likely to receive B-CPR education[5] or AED training, which may be an underlying factor associated with the community disparity in B-CPR delivery and AED use prior to EMS arrival.[6]

Research using the Cardiac Arrest Registry to Enhance Survival (CARES) has shown significant racial, geographic and economic disparities associated with OHCA survival in major cities in the United

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States.[4] Furthermore, research has also shown neighborhood level factors including quality of local hospital care, neighborhood dependent risk factors and illness, and lack of social or economic capital are significantly associated with provision of B-CPR and overall OHCA survival.[4] Few studies have assessed disparities in CPR knowledge as they relate to community level characteristics, e.g. community SES as measured by surrogates such as median household income (MHI). The objective of our study was to better understand the association between neighborhood level factors and the likelihood of previous CPR training. Characterizing this relationship could help in guiding targeted CPR education efforts by identifing communities that are likely to have a lower likelihood of CPR training via surrogate demographic measures such as MHI.

## Methods

This analysis is a cross-sectional cohort study of adult laypersons in Philadelphia who participated in a community CPR training with The Mobile CPR Project. The study protocol was reviewed by the University of Pennsylvania Institutional Review Board and deemed exempt.

### *The Mobile CPR Project*

Participant enrollment was conducted through The Mobile CPR Project, a public health initiative providing CPR, AED and opioid overdose reversal education to the communities of Philadelphia and surrounding counties (more information on the project can be found at https://www.themobilecprproject.com). One of the goals of The Mobile CPR Project is to reduce barriers to CPR education, specifically the cost of training and time commitment, by offering free on-site training, lasting less than one hour, in the community setting. Training events were conducted in locations where participants live or travel on a regular basis, such as community centers, libraries, places of worship, and other public venues, and used the American Heart Association's 'CPR Anytime Kit' (manufactured by Laerdal Medical Corporation, Wappinger Falls, NY) with video instruction and inflatable manikin for learning hands-only CPR. A mapping by location model was created from a two-factor cluster analysis comparing cardiac arrest rate and B-CPR rate for each census tract.[7] Utilizing historical registry data, cardiac arrest and bystander CPR rates were calculated using census tract populations. These rates were scaled and normalized then subjected to k-means clustering (k = 3). Comparing values for each cluster center generated the classifications as low or high rates for B-CPR and SCA rates. Members of the cluster with lower than average rates of B-CPR and higher than average rates of SCA were identified as priority training areas for The Mobile CPR Project (Fig. 1).

### *Study design and population*

We examined the association between subject characteristics, both demographic and neighborhood, and prior CPR education among individuals attending CPR training events with The Mobile CPR Project. Before each training event, participants were asked to complete a survey including: race, gender, education, time since prior CPR training (if any), AED knowledge, zip code and self-reported nearest intersection to their home address (for purposes of census tract geolocation methods). Completion of the survey was requested before participating in the educational program, but was optional. Participants 18 years of age and older who completed a survey and

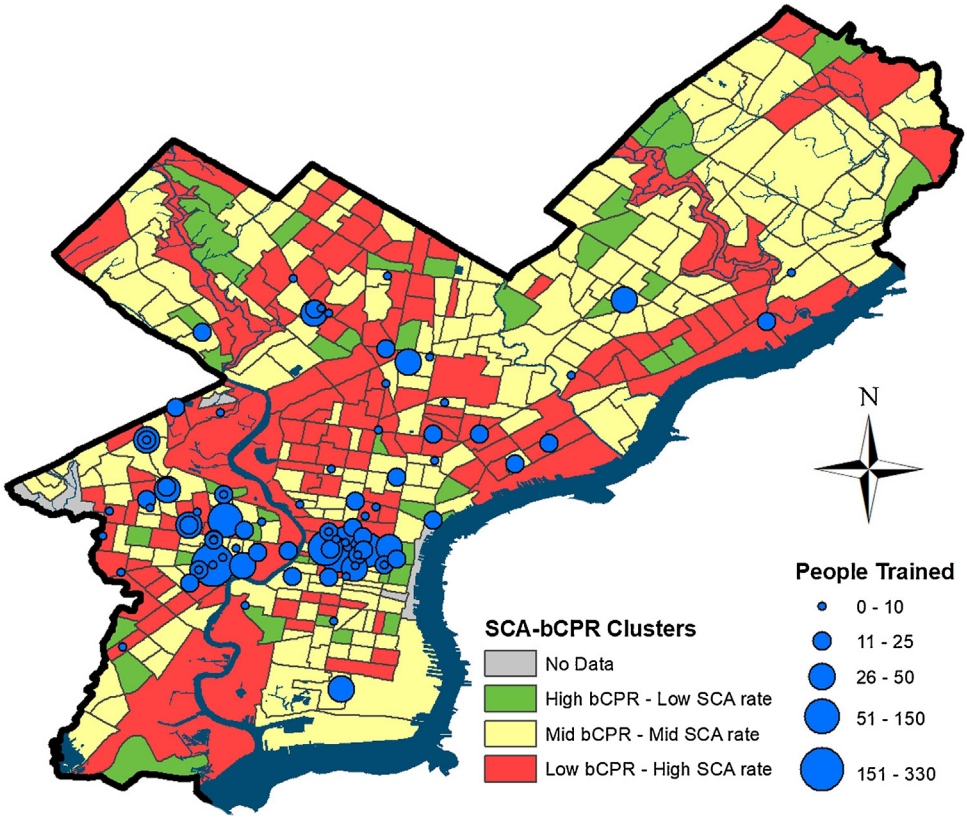


**Fig. 1 – Map of targeted neighborhoods in Philadelphia with training locations overlayed.**

provided information on the nearest intersection to their residence were included in the analysis.

MHI was obtained from publicly available U.S. census tract data based on the reported nearest intersection to their residence.[8] The cohort was divided into quartiles based on MHI. Paper survey forms were digitized and stored using a secure, web-based research database application (REDCap, Vanderbilt University, TN). Location data were geocoded using R (R Core Team, University of Auckland, New Zealand). The data were analyzed using statistical software (STATA 14, StataCorp LP, College Station, TX).

### *Statistical approach and analysis*

Descriptive statistics were calculated to assess the distribution of demographic factors including student's t-test, where appropriate. Chi-squared analysis and Wilcoxon rank sum test were used to interpret confounder effects and statistical significance. MHI was stratified into quartiles and education levels were stratified by highest level of educational attainment. The primary analysis included logistic regressions of the likelihood of prior CPR education on demographic and community variables. Prior CPR education was defined as any reported training regardless of timing or certification status. AED knowledge was assessed by a yes/no question on the survey questionnaire. Simple logistic regression for pairwise comparison of demographic variables was performed prior to multiple logistic regression. Variables were included in the final model if the p-value was below 0.2 in univariate analysis. Multiple logistic regression was used to control for confounding variables and assess the association between multiple variables and the outcome of interest.

## Results

From 7/2016 to 4/2018, 2567 layperson subjects completed surveys prior to CPR training. Of these, 1703 (66.3%) subjects provided location data and were included in this analysis. Subjects that did not meet inclusion criteria did not differ significantly from subjects included in the analysis (data not shown). The mean age was 42 ± 20 years, 70% were female, and 70% were non-white (Table 1). The overall prevalence of prior CPR training was 55.9%. MHI for this cohort was $39,318 [IQR $27,708–$60,795]. Individuals residing in Q1 were less likely to have ever received CPR training (first quartile: OR 0.646, CI 0.491–0.850, p = 0.002) and individuals residing in Q4 were nearly 1.5 times more likely to have been ever trained in CPR (fourth quartile: OR 1.55, CI 1.176–2.02, p = 0.002). Table 1 contains a side-by-side comparison of the study cohort, a weighted average of census data for the tracts where subjects reside, and city-wide data.

In multiple logistic regression, self-reported gender (male or female) was not significantly related to the likelihood of prior training (OR 1.01, CI 0.82–1.26, p = NS). Simple logistic regression showed that participants with less than a high school diploma, or equivalent, were less likely to have ever received training compared to college graduates (less than high school: OR 0.175, CI 0.089–0.344, $p < 0.001$; some high school: OR 0.452, CI 0.303–0.675, $p < 0.001$). In multiple logistic regression controlling for age, race, gender, MHI, and education, we found that higher educational attainment was associated with a higher likelihood of prior CPR training (OR 7.96 Master's or Doctoral compared to less than high school, CI 5.24–12.11, $p < 0.001$). Additionally, the average of the MHI was $4938 higher in subjects who previously received CPR training compared to those with no past training ($p < 0.001$). Fifty-two percent (52%) of individuals in the lowest MHI quartile [$11,473–$27,746] were ever trained compared to 62% percent of individuals trained in the highest MHI quartile [$60,827–$185,759] (Table 2).

## Discussion

In this study of layperson CPR training within a large U.S. city, we found that individuals living in census tracts with higher MHI were more

**Table 1 – Demographics and CPR training status, weighted neighborhood characteristics and Philadelphia-wide demographic characteristics from American Community Survey (ACS).**

| | Total | Ever trained CPR | Never trained CPR | Weighted neighborhood characteristics | Philadelphia characteristics |
|---|---|---|---|---|---|
| n = | 1703 | 950 | 753 | | 1,565,657 |
| Age (years), mean ± SD | 42 ± 20 | 39 ± 21 | 44 ± 18 | 34.7 ± 6.9 | 34.1 ± 0.1 |
| Gender, n (%) | | | | | |
| Female | 1160 (70) | 642 (67.6) | 518 (68.8) | 53.4 % | 827,245 (52.7) |
| Missing values | 48 (2.8) | 32 (3.4) | 16 (2.1) | | |
| Race, n (%) | | | | | 1,525,670 (100) |
| Black | 865 (50.8) | 468 (49.3) | 397 (52.7) | 50.02 % | 668,123 (43.8) |
| Other | 327 (19.2) | 163 (17.2) | 164 (21.8) | 14.4 % | 205,343 (13.5) |
| White | 511 (30.0) | 319 (33.5) | 192 (25.5) | 35.6 % | 652,204 (42.7) |
| Education*, n (%) | | | | | 1,166,203 (100) |
| Some college or less | 1003(58.9) | 477 (50.2) | 526 (69.8) | 74.9 % | 859,752 (73.7) |
| Bachelors | 384 (22.5) | 245 (25.8) | 139 (18.5) | 14. 9% | 188,182 (16.1) |
| Graduate | 306 (17.9) | 222 (23.4) | 84 (11.2) | 10.2 % | 118,269 (10.2) |
| Missing values | 10 (0.6) | 6 (0.6) | 4 (0.5) | | |
| Median household income | $39,318 | | | $41,740 | $40,649 |

**Table 2 – Median household income quartile bands (% trainings, % non-white, % female).**

| | Total | MHI Q1 [$11,472–$27,746] | MHI Q2 [$27,746–$39,353] | MHI Q3 [$39,353–$60,827] | MHI Q4 [$60,827–$185,759] |
|---|---|---|---|---|---|
| n (%) = | 1679 | 423 | 417 | 421 | 418 |
| Ever Trained, n (%) | 939 (55.9) | 219 (51.8) | 204 (48.9) | 255 (60.6) | 261 (62.4) |
| Female, n (%) | 1143 (68.1) | 288 (68.1) | 303 (72.7) | 299 (71.0) | 253 (60.5) |
| Race, n (%) | | | | | |
| Black | 853 (50.8) | 287 (67.9) | 262 (62.8) | 198 (47.0) | 106 (25.4) |
| Other | 339 (20.2) | 102 (24.1) | 87 (20.9) | 84 (20.0) | 66 (15.8) |
| White | 487 (29.0) | 34 (8.0) | 68 (16.3) | 139 (33.0) | 246 (58.8) |

likely to have ever received CPR training. Additionally, education was a strong predictor of the likelihood of prior CPR training. As educational attainment increased, the likelihood of prior training increased. Previous research has indicated that residents of low-SES census tracts experience lower incidence of B-CPR.[9] Our work suggests that this lower B-CPR provision rate may relate to the prevalence of B-CPR training.

In the U.S., socioeconomic disparities are associated with cardiac arrest incidence and outcomes. Prior work has suggested that communities with lower MHI have a higher risk of OHCA and lower survival.[9,10] In addition, these communities experience a lower prevalence of B-CPR intervention which has been found to be associated with lower survival rates.[9] These observations may reflect the previously described barriers to CPR education, including cost, location and time.[3] The increased incidence of OHCA and lower likelihood of CPR training in these neighborhoods compound the overall risk of death due to cardiac arrest.[11]

Several novel training modalities have been studied in an effort to increase bystander intervention. Internet-based video CPR trainings,[12] immersive Virtual Reality (VR) trainings[13] and smartphone app-based trainings[14] have all been studied in an effort to reduce barriers to CPR education. Each modality seeks to remove physical barriers from receiving CPR education, though more research needs to be conducted to better understand CPR skill retention following trainer-free CPR education. Furthermore, these methods of training need to better assess and increase the trainees willingness to provide CPR, an important barrier to performing CPR. Research has suggested that frequency of CPR education, time since previous training and multi-modal methods of training (didactic and practical) increases the willingness to perform CPR.[15] Also, the development of high-tech, novel training modalities may not address the training gaps in low-SES communities due to issues of availability and affordability.

Prior research has investigated the relationship between SES and CPR delivery.[16,17] Characteristics such as race, gender and language proficiency have been assessed in the context of pre-hospital B-CPR delivery to understand why CPR is not performed during OHCA.[18–22] A small cohort of studies have investigated the association of SES and educational attainment with layperson CPR training prevalence, including a previous study which sought to understand how SES characteristics impact AED training.[6] Studies have also utilized cross-sectional telephone surveying methods to identify significant CPR training disparities by age, education and income.[3] Futhermore, a national cross-sectional ecologic study has been performed to better understand county level rates of CPR training.[23] Our current work extends these investigations by evaluating layperson CPR training based on communities in which potential CPR providers reside.

Data pertaining to CPR training prevalence and inherent training disparities in the U.S. are limited. The first survey to assess national CPR training prevalence was published in 2017, revealing that less than 20% of U.S. adults claim currently active CPR training (i.e., within prior two years).[3] Prior research has assessed the relationship between CPR certification and community level factors, but without individual demographic and SES data. Furthermore, few efforts have been made to tailor CPR educational outreach efforts to individual neighborhoods based on community-assessed need. In this study, we utilized cost-effective, video-led training kits (American Heart Association's CPR Anytime Kit, Laerdal Medical, Wappingers Falls, NY) which remain in the community as a secondary training resource.[24] Such an approach has the potential to be generalized to other cities with similar demographic disparities.

When comparing prior CPR training across levels of educational attainment, we found that as the educational attainment increased, so did likelihood of prior training in CPR. This association may highlight a need for early introduction to CPR and AED training during secondary education. To enhance population-wide familiarity with CPR and AED education, efforts have been made to include CPR training in middle and high school curricula to ensure widespread dissemination of basic CPR knowledge.[25] This policy-level response could act as a conduit to engage the public to better understand the purpose and need for early B-CPR. A recent publication demonstrated and association between legislation requiring CPR training in schools with higher prevalence of CPR training within those states.[26] Additionally, research conducted in Denmark has shown that implementation of nationwide initiatives to provide CPR training were linked to higher rates of bystander intervention and greater overall OHCA survival rates.[27]

The current work highlights important educational and socioeconomic gaps in layperson CPR training. Historically, CPR training options have been limited by tuition costs, lack of transportation and limited time to complete training, resulting in inadequate B-CPR rates.[28,29] The concept inherent in The Mobile CPR Project is to broaden training by attenuating these barriers. Each subject voluntarily participanted in a CPR training. This highlights the opportunity for this training modality to reach those with the lowest likelihood of previous training.

We note several limitations to this study. The study population was derived from individauls attending a free and voluntary CPR training. Survey completion was encouraged, but optional, and as such are subject to selection and social desirability bias. Much of the study

population sought out training from The Mobile CPR Project because they recognized the need for CPR education. This leads to an enrichment of the population with motivated learners. Futhermore, the majority of our study participants were female, in excess of the weighted population and city-wide percentages. Though, we did not intend to survey more female participants, more women participate in The Mobile CPR Project's CPR classes, and that bias is represented in our data. Nevertheless, there is a potential for misrepresentation of male participants.

The survey questionnaire was limited in scope with regards to previous CPR training data. Participants reported years since last CPR training, however, due to analysis constraints, previous training versus never trained was the primary analysis. Futhermore, the design of the training program did not allow for follow-up surveys or a skills check to determine level of skill retention. With regards to MHI data, the income was derived from the American Community Survey (ACS) based on nearest intersection as reported in the survey response. Individually reported income would be more powerful, however, it can also lead to a reduced response rate. As a cross-sectional study, we cannot attribute causation but only association; it remains unknown whether educational attainment and SES are the crucial determinants of CPR training prevalence. Finally, as a study in one particular U.S. community, further research is required to assess if our results can be generalized to other geographic regions.

## Conclusions

In our cross-sectional evaluation of CPR training prevalence in a U.S. city, we found a strong association between neighborhood MHI and likelihood of prior CPR training. Additionally, higher educational attainment was associated with a higher likelihood of prior CPR training. These findings suggest the potential community OHCA survival benefit of targeting communities for low-cost or free CPR training with a lower MHI.

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## Conflict of interest

Dr. Abella has received research funding from the National Institutes of Health, the Patient-Centered Outcomes Research Institute, and the Medtronic Foundation. He has received speaking honoraria from Stryker and Becton Dickinson, and is an advisor to MD Ally. Marion Leary has received research support from the Medtronic Foundation, the American Heart Association, the Laerdal Foundation, and the Zoll Foundation. Ms. Leary has received in-kind support from Laerdal Medical. Ms. Leary has licensed intellectual property for software related to CPR training. The other authors do not declare any conflicts of interest.

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