Automated External Defibrillator Application Before EMS Arrival in Pediatric Cardiac Arrests

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abstract

BACKGROUND: Little is known about the predictors of pre–emergency medical service (EMS) automated external defibrillator (AED) application in pediatric out-of-hospital cardiac arrests. We sought to determine patient- and neighborhood-level characteristics associated with pre-EMS AED application in the pediatric population.

METHODS: We reviewed prospectively collected data from the Cardiac Arrest Registry to Enhance Survival on pediatric patients (age >1 to ≤18 years old) who had out-of-hospital nontraumatic arrest (2013–2015).

RESULTS: A total of 1398 patients were included in this analysis (64% boys, 45% white, and median age of 11 years old). An AED was applied in 28% of the cases. Factors associated with pre-EMS AED application in univariable analyses were older age (odds ratio [OR]: 1.9; 12–18 years old vs 2–11 years old; $P < .001$), white versus African American race (OR: 1.4; $P = .04$), public location (OR: 1.9; $P < .001$), witnessed status (OR: 1.6; $P < .001$), arrests presumed to be cardiac versus respiratory etiology (OR: 1.5; $P = .02$) or drowning etiology (OR: 2.0; $P < .001$), white-populated neighborhoods (OR: 1.2 per 20% increase in white race; $P = .01$), neighborhood median household income (OR: 1.1 per $20 000 increase; $P = .02$), and neighborhood level of education (OR: 1.3 per 20% increase in high school graduates; $P = .006$). However, only age, witnessed status, arrest location, and arrests of presumed cardiac etiology versus drowning remained significant in the multivariable model. The overall cohort survival to hospital discharge was 19%.

CONCLUSIONS: The overall pre-EMS AED application rate in pediatric patients remains low.

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WHAT'S KNOWN ON THIS SUBJECT: Automated external defibrillator (AED) use in pediatric out-of-hospital cardiac arrests improves overall survival and neurologic outcomes, with earlier application resulting in better outcomes. Predictors of pre–emergency medical service (EMS) AED application are unknown.

WHAT THIS STUDY ADDS: Pre-EMS AED application remains low, and demographic disparities persist. Younger children have lower rates of having an AED applied before EMS. Targeting interventions to these patients may help to improve outcomes of out-of-hospital cardiac arrests in children.

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Sudden cardiac arrest in young individuals has significant impact on parents, close family members, the community, and the health care system. The survival rate from pediatric out-of-hospital cardiac arrest (OHCA) has been reported to be <10%, with no significant improvement over the last decade.[1–5]

It has been demonstrated that children with OHCA who were found to have a shockable rhythm had better outcomes compared with patients who had asystole or pulseless electrical activity.[6] Furthermore, automated external defibrillator (AED) use in pediatric OHCA cases has been shown to improve overall survival and neurologic outcomes,[7] with earlier application resulting in better outcomes. The 2010 American Heart Association (AHA) resuscitation guidelines recommend AED use in cases of OHCA in all pediatric individuals regardless of age and regardless of the presence of a pediatric-specific AED or attenuator system.[8] However, there remains little contemporary data on actual AED use and its predictors in the pediatric population in the United States.

Despite the existence of multiple large population-based studies on outcomes and characteristics of pediatric OHCA, fatality rates remain high, which mandate further investigation to identify potential disparities. Neighborhood characteristics, including racial composition and median household income were shown to be associated with rates of bystander cardiopulmonary resuscitation (CPR).[9] We hypothesize that there are associations between neighborhood-level characteristics and rates of AED application before the arrival of emergency medical services (EMS) (pre-EMS in the pediatric population). Our primary objective is to identify whether subject age and neighborhood-level characteristics, such as racial composition, household income, and educational attainment, are associated with pre-EMS AED application.

METHODS

Study Design

Prospectively collected data from the Cardiac Arrest Registry to Enhance Survival (CARES) were reviewed. The design of the CARES registry is described in detail elsewhere.[9] Briefly, the CARES registry was initiated by the Emory University Department of Emergency Medicine in collaboration with the Centers for Disease Control and Prevention and the AHA in 2004 with the aim to track all cases of OHCA, identify gaps in care, and potentially improve survival. Since its initiation, the program has expanded nationally and currently includes 55 communities in 22 states; additionally, it includes 19 state-based registries and covers a catchment area of >100 million individuals (Supplemental Fig 1). The CARES registry includes OHCA cases that involved the activation of EMS. Data sources include records from 9-1-1 call centers, EMS, and hospital data. The CARES data set was geocoded on the basis of the address of the cardiac arrest by using the Centrus Desktop geocoder.[9] Census tracts were used as proxies for neighborhoods. On the basis of previous studies, we identified 3 main neighborhood variables, including white race percentage, median household income, and percentage of people who graduated from high school or had a higher level of education.[9,10] Each variable was linked to the address of the cardiac arrest by using the 2000 US Census Summary Files.[11] The neighborhood variables were studied as continuous variables as explained below.

Study Population and Definitions

For this study, we included all pediatric patients (age >1 and ≤18 years old) who sustained a nontraumatic OHCA between January 2013 and December 2015. Because of the difficulty in identifying the etiology of the arrest, all nontraumatic cases were included in this study. We excluded infants (age ≤1 year old) because cardiac arrests in infants often occur at home during nighttime, precluding the presence of an AED. In addition, we thought that including the sudden infant death syndrome population might be a confounder. The additional exclusion criteria included the following: arrest after EMS arrived, missing neighborhood characteristics, missing mortality outcome, and arrests that occurred in locations (ie, hospital, nursing home, and health care facility) where health care professionals are likely to be present (these cases are fundamentally different from cardiac cases that occurr in public or private areas). To eliminate any confounders when assessing the association between AED application and neighborhood characteristics, we excluded arrests that occurred in transport centers (ie, subway station, airport, etc) because of the high likelihood of the presence of first responders.

The primary outcome of the study was defined as AED application with or without defibrillation (depending on underlying rhythm) by either a bystander or first responder (a non–EMS-trained personnel with the equipment to provide immediate defibrillation) before EMS arrival in any setting. Individuals were divided into 2 groups: those who had an AED applied pre-EMS and those who did not. We compared baseline demographic characteristics at the patient and neighborhood levels. Variables studied included the following: age, sex, race, witnessed status, CPR use, location, rhythm type (defined as the first cardiac rhythm present when a manual defibrillator or AED was attached to the patient after cardiac arrest), presumed arrest etiology (cardiac, drowning, respiratory, or other), neighborhood racial composition, neighborhood median household income, and neighborhood educational attainment. An arrest was presumed to be of cardiac etiology unless it is known or likely to have been caused by trauma, drowning, respiratory causes, electrocution, drug overdose, presumed intoxication, asphyxia, or any other noncardiac cause as best determined by rescuers. Arrest location was considered private if an arrest occurred in a private house, private garden, private swimming pool, and private yard. A public location included occurrences in recreational places, public roadways, and buildings used by the general public. The Institutional Review Board at the Cleveland Clinic Foundation approved this study.

Statistical Analysis

Data were described by using medians and ranges for continuous variables and counts and percentages for categorical variables. By using hierarchical logistic regression models, the associations between outcomes (pre-EMS AED, survival rate to hospital discharge, and favorable neurologic outcome) and the independent variables used to describe subject and neighborhood characteristics were assessed. Individual- and neighborhood-level characteristics were added as fixed effects, and CARES sites were added as random intercepts. Univariable models were adjusted only for CARES site, and multivariable models were adjusted for CARES site and all listed effects. In the construction of the multivariable models, 2-way interaction effects and polynomial functions of continuous variables up to the third degree were assessed and included when statistically significant.

In the logistic regression models, missing values were handled through multiple imputation by using the fully conditional specification method, with 10 imputations in a model including both individual- and neighborhood-level variables. Categorical variables were imputed as categorical variables, and continuous variables were imputed within the observed range of data. Variables with missing data (number missing or percentage missing) were subject race (*N* = 337; 24%), individual who initiated CPR (*N* = 1; 0.07%), first monitored rhythm (*N* = 1; 0.07%), sustained return of spontaneous circulation (*N* = 1; 0.07%), neighborhood median household income (*N* = 15; 1%), neighborhood educational attainment (*N* = 23; 2%), and neighborhood racial composition (*N* = 22; 2%). Additional variables used in the multiple imputation process included the following: subject age, subject sex, arrest location, witnessed arrest, individual who initiated CPR, shockable rhythm, AED use, survival rate, and etiology.

SAS 9.4 software (SAS Institute, Inc, Cary, NC) was used for all analyses; multiple imputation was performed by using the multiple imputation procedure, the generalized linear mixed models procedure was used for the hierarchical logistic regression modeling, and the results of the hierarchical logistic regression analyses performed on the imputed data sets were combined by using the MIANALYZE procedure. A significance criterion of 0.05 was used for all analyses.

RESULTS

Demographics and Site Characteristics

Over the study period, a total of 1398 cases of OHCA occurred in pediatric patients (age >1 and ≤18 years). The majority of the patients were boys (*n* = 892; 64%) and were white (*n* = 476; 45%) with a median age of 11 years old. The majority of the arrests occurred in a private location (*n* = 1050; 75%) and were unwitnessed (*n* = 885; 63%). Most patients had a nonshockable rhythm (*n* = 1180; 84%). An AED was applied before EMS arrival in 385 of 1398 OHCA cases (28%), and the majority were applied by first responders (*n* = 330; 86%). The overall survival rate to hospital discharge was 19% (*n* = 270). Most cardiac arrests occurred secondary to a presumed cardiac etiology (*n* = 703; 50%) followed by a respiratory etiology (*n* = 304; 22%) and drowning (*n* = 230; 16%). Demographics and site characteristics are outlined in Table 1.

Patient- and Neighborhood-Level Characteristics and Pre-EMS AED Application

In univariable models adjusted for CARES site, an AED was more likely to be applied before EMS arrival in white versus African American (odds ratio [OR]: 1.4; 95% confidence interval [CI]:1.0–2.1) patients, older versus younger patients (12–18 years old vs 2–11 years old; OR: 1.9 [95% CI: 1.5–2.5]), witnessed versus unwitnessed arrests (OR: 1.6; 95% CI: 1.3–2.1), public versus private locations (OR: 1.9; 95% CI: 1.4–2.5), arrests presumed to be cardiac versus respiratory etiology (OR: 1.5; 95% CI: 1.06–2.1) or drowning etiology (OR: 2.0; 95% CI: 1.3–2.9), white-populated neighborhoods (OR: 1.2 [95% CI: 1.03–1.3] per 20% increase in white race as a percentage of the neighborhood population), high-income neighborhoods (OR: 1.1 [95% CI: 1.02–1.2] per $20 000 increase in median household income), and neighborhoods with a high level of education (OR: 1.3 [95% CI: 1.08–1.6] per 20% increase in percentage of residents who graduated from high school; Table 2). In terms of neighborhood-level characteristics, similar findings were observed in the univariable models for the survival to hospital discharge rate. Survival was higher in white-populated neighborhoods

TABLE 1 Subject and Neighborhood Differences in AED Application Before EMS Arrival for Pediatric Out-of-Hospital Nontraumatic Arrest

Factor	Total (*N* = 1398)	Pre-EMS AED Not Applied (*N* = 1013)	Pre-EMS AED Applied (*N* = 385)
Age, y, median (range)	11 (2–18)	10 (2–18)	13 (2–18)
Age, y, *n* (%)			
2–11	728 (52)	562 (77)	166 (23)
12–18	670 (48)	451 (67)	219 (33)
Sex, *n* (%)			
Female	506 (36)	365 (72)	141 (28)
Male	892 (64)	648 (73)	244 (27)
Race and/or ethnicity,[a] *n* (%)			
White	476 (45)	333 (70)	143 (30)
African American	361 (34)	279 (77)	82 (23)
Hispanic	171 (16)	131 (77)	40 (23)
Other	53 (5)	39 (74)	14 (26)
Arrest witnessed, *n* (%)			
Unwitnessed	885 (63)	674 (76)	211 (24)
Bystander witnessed	513 (37)	339 (66)	174 (34)
Etiology, *n* (%)			
Presumed cardiac etiology	703 (50)	497 (71)	206 (29)
Respiratory	304 (22)	230 (76)	74 (24)
Drowning	230 (16)	182 (79)	48 (21)
Other	161 (12)	104 (65)	57 (35)
Location type, *n* (%)			
Private	1050 (75)	794 (76)	256 (24)
Public	348 (25)	219 (63)	129 (36)
Individual who initiated CPR,[a] *n* (%)			
First responder	387 (28)	213 (55)	174 (45)
Lay person	720 (52)	511 (71)	209 (29)
Responding EMS personnel	290 (21)	288 (99)	2 (0.7)
Individual who first applied the AED,[a] *n* (%)			
First responder	330 (86)	—	330 (100)
Lay person	55 (14)	—	55 (100)
First monitored rhythm,[a] *n* (%)			
Nonshockable	1180 (84)	882 (75)	298 (25)
Shockable	217 (16)	130 (60)	87 (40)
Outcome, *n* (%)			
Dead	1128 (81)	830 (74)	298 (26)
Alive	270 (19)	183 (68)	87 (32)
White racial composition,[a] *n* (%)			
<20%	168 (12)	123 (73)	45 (27)
20%–40%	148 (11)	121 (82)	27 (18)
40%–60%	228 (17)	174 (76)	54 (24)
60%–80%	325 (24)	233 (72)	92 (28)
>80%	507 (37)	350 (69)	157 (31)
Median household income,[a] *n* (%)			
≤$20 000	69 (5)	44 (64)	25 (36)
$20 001–$40 000	372 (27)	293 (79)	79 (21)
$40 001–$60 000	436 (32)	322 (74)	114 (26)
$60 001–$80 000	297 (21)	211 (71)	86 (29)
>$80 000	209 (15)	133 (64)	76 (36)
High school graduates,[a] *n* (%)			
<20%	20 (1)	17 (85)	3 (15)
20%–40%	222 (16)	181 (82)	41 (18)
40%–60%	666 (48)	473 (71)	193 (29)
60%–80%	438 (32)	309 (71)	129 (29)
>80%	29 (2)	21 (72)	8 (28)

—, not applicable.

[a] Data were not available for all subjects. Missing values included the following: race and/or ethnicity (337), individual who initiated CPR (1), individual who first applied the AED (1013), first monitored rhythm (1), neurologic outcome (685), racial composition (22), median household income (15), and high school graduates (23).

(OR: 1.2 [95% CI: 1.1–1.4] per 20% increase in white race), high-income neighborhoods (OR: 1.1 [95% CI: 1.02–1.2] per $20 000 increase in median household income), and neighborhoods with a high level of education (OR: 1.2; 95% CI: 1.02–1.5; Supplemental Table 3).

In a hierarchical multivariable model, arrests of cardiac etiology were more likely to have an AED applied before EMS arrival compared with arrests due to drowning (OR: 1.9; 95% CI: 1.2–3.0; *P* = .004). Arrests that occurred in a public location were significantly more likely to have an AED applied before EMS arrival compared with arrests that occurred in other locations (OR: 1.8; 95% CI: 1.2–2.5; *P* = .001). Witnessed arrests were more likely to have an AED applied before EMS arrival (OR: 1.4; 95% CI: 1.01–1.8; *P* = .04). Furthermore, older patients were significantly more likely to have an AED applied than younger subjects (OR: 1.5; 95% CI: 1.1–2.0; *P* = .008). The effect of the other studied variables (sex, race, neighborhood racial composition, neighborhood median household income, and neighborhood high school graduates) dissipated after multiple adjustments (Table 2). The effects of neighborhood-level characteristics dissipated in the survival model after adjusting for other variables (Supplemental Table 3).

In a multivariable model, survival to hospital discharge rate was associated with drowning versus cardiac arrest (adjusted odds ratio [aOR]: 4.1; 95% CI: 2.6–6.7; *P* < .001), witnessed arrest (aOR: 4.4; 95% CI: 3.1–6.2; *P* < .001), public location of arrest (aOR: 1.6; 95% CI: 1.1–2.3; *P* = .008), and shockable rhythm (aOR: 5.7; 95% CI: 3.8–8.7; *P* < .001; Supplemental Table 3).

DISCUSSION

Since the initiation of the 2010 AHA resuscitation guidelines, this is the

TABLE 2 Univariable and Multivariable Models for Pre-EMS AED Application With Multiple Imputations

Risk Factors	Univariable		Multivariable	
	aOR (95% CI)[a]	Adjusted *P*[a]	aOR (95% CI)[b]	Adjusted *P*[b]
Sex: male versus female	1.01 (0.78–1.3)	.9	0.95 (0.72–1.3)	.7
Age: 12–18 vs 2–11 y	1.9 (1.5–2.5)	<.001	1.5 (1.1–2.0)	.008
Subject race				
White versus African American	1.4 (1.01–2.1)	.04	1.2 (0.74–1.8)	.5
Hispanic versus African American	1.2 (0.75–1.9)	.5	1.2 (0.73–2.0)	.5
Other versus African American	1.4 (0.74–2.6)	.3	1.3 (0.68–2.6)	.4
Etiology				
Respiratory versus CAE	0.67 (0.48–0.94)	.02	0.74 (0.52–1.05)	.09
Drowning versus CAE	0.51 (0.34–0.76)	<.001	0.52 (0.33–0.81)	.004
Other versus CAE	1.2 (0.78–1.7)	.5	1.3 (0.88–2.0)	.2
Arrest witnessed	1.6 (1.3–2.1)	<.001	1.4 (1.01–1.8)	.04
Public location	1.9 (1.4–2.5)	<.001	1.8 (1.2–2.5)	.001
Percentage of HS graduates per 20% increase	1.3 (1.08–1.6)[c]	.006	1.2 (0.95–1.5)[c]	.1
Median income per $20 000 increase	1.1 (1.02–1.2)[d]	.02	1.07 (0.94–1.2)[d]	.3
Percentage of white race per 20% increase	1.2 (1.03–1.3)[e]	.01	1.02 (0.88–1.2)[e]	.8

CAE, cardiac arrest etiology; HS, high school.

[a] Hierarchical univariable models for AED application with multiple imputation. ORs and *P* values are adjusted for CARES site only.

[b] Hierarchical multivariable models for AED application with multiple imputation. ORs and *P* values are adjusted for CARES site and all listed effects.

[c] OR per 20% increase in the percentage of the neighborhood reporting a completion of high school, with the percentage of high school graduates analyzed as a continuous variable.

[d] OR per $20 000 increase in neighborhood median income, with neighborhood median income analyzed as a continuous variable.

[e] OR per 20% increase in the percentage of the neighborhood reporting white race, with the percentage of white race analyzed as a continuous variable.

largest study in which researchers have examined the presence of disparities in AED application and investigated factors associated with pre-EMS AED application in the pediatric population. Using a large registry, we show that the rate of pre-EMS AED application was only 28%. Age, witnessed status, and public location of the OHCA were the most powerful predictors of AED application. We attempt to explain the mechanisms for the presence of disparities in AED application. We hypothesize that these differences are related to AED access, awareness, training, and cultural impact of bystanders.

We report that age is the most powerful predictor of AED application, independent of race, sex, location, or neighborhood characteristics. Individuals aged 12 to 18 years old had 1.4 times higher rates of having an AED applied before EMS arrival compared with children aged 2 to 11 years old. These findings are similar to those in a study in which researchers analyzed pediatric OHCAs (2005–2009) before the publication of the new AHA resuscitation guidelines and showed that younger children were less likely to receive AEDs.[12] The 2010 AHA resuscitation guidelines recommend the application of an AED in all children even in the absence of a pediatric dose-attenuator system (pediatric pads) or manual defibrillators, which was a change from the 2005 AHA guidelines in which the need for using a pediatric dose-attenuator system in children aged 1 to 8 years old was specified.[8] Unfortunately, our study design does not answer the question of why younger patients are less likely to have an AED applied before EMS arrival, but our speculation is that the lack of public knowledge is a main driver in addition to low accessibility. Our study reveals that there is an obvious lag between guideline initiation and application. The use of an AED relies on the public knowledge and their comfort level in using it. A recent questionnaire study by Brooks et al[13] revealed that there is a lack of public knowledge as well as confidence in using a defibrillator. Another theory would be that individuals may be apprehensive of applying an AED on young children; thus, it is crucial for these individuals to understand that an AED is safe to use.

In a nationwide population-based Japanese Utstein registry study in which the impact of implementing public access defibrillation program on OHCA in school-aged children was assessed, the authors showed a significant improvement in neurologic outcome, with more than half of children who received a first shock by a bystander achieving a favorable outcome.[7] Our findings and the results of this study reveal the need for an immediate public health action plan for an awareness campaign in which the importance and the safety of AED use in children is discussed because it may carry significant implications on survival rates. Perhaps raising awareness and educating the public on the importance of using AEDs as well as the safety of AEDs is equally important to making AEDs available in public and in residential locations.

Not surprisingly, public arrests were associated with higher AED application rates, which resulted in better survival. This can be attributed to multiple factors (including an earlier recognition of arrest, leading to an earlier initiation of emergency response as well as a higher likelihood of having an AED available on-site) because a delay in AED application, CPR, and EMS activation may portend poorer outcomes. For example, in cases of arrests occurring at private locations, each minute delay in treatment including advanced cardiac life support care, CPR, and defibrillation, leads to a 5.5% reduction in survival.[14] In addition, it is also important to note that AED application in the current study may be a proxy for earlier CPR use, which is supported by the observation that the AED application group was more likely to have had CPR and shockable rhythms.

In contrast to adult studies, our study suggests that there are no differences in rates of AED application on the basis of the neighborhood-level characteristics of the arrest location. Multiple adult studies from different countries have revealed the association of neighborhood socioeconomic status[9,15,16] and neighborhood racial compositions[9,17] with public interventions in OHCA. In their study, Owen et al[18] reported an association between educational attainment and likelihood of AED training. The authors also reported that significant disparities in AED training exist between different races. However, studies of AED use and its association with neighborhood-level characteristics are lacking in the pediatric population. In our univariate analysis, we found that pre-EMS AED application was significantly associated with neighborhood race, median household income, and the percentage of adults with a high level of education. These findings dissipated after making multiple adjustments in the multivariable model, suggesting that these disparities are explained by other differences, such as age, arrest etiology, or public location of arrests.

The overall survival rate in our study is higher than that of previous studies.[1–5] The higher survival rate could be attributed to differences in the underlying etiology of cardiac arrest because half of the subjects had an arrest of presumed cardiac etiology, which is associated with better outcomes compared with noncardiac etiologies.[19,20] It is important to note that the percentage of presumed arrests of cardiac etiology in our study appears to be consistent with a previous CARES study in which data from the CARES registry was analyzed between 2005 and 2013.[14] Another plausible explanation is the difference in the age inclusion criteria; we excluded infants in this study, who are known to have the worst prognosis. Atkins et al[2] reported an overall survival rate of 6.4%, with infants having the lowest survival rate (infants versus children: 3.3% vs 9.1%; infants versus adolescents: 3.3 vs 8.9%) in a population-based study that included 11 US and Canadian sites. In another nationwide population-based observation study in Japan, the overall 1-month survival rate was 11%, with elementary school and middle school groups having a survival rate of 16%.[21] Furthermore, the reported rate of public automatic defibrillator use was only 0.7% in the Japanese study, whereas in our study, we report a much higher percentage (26%). This provides another explanation of the higher survival rate in our cohort. Our study also reveals that patients with shockable rhythm at presentation were 6 times more likely to survive to hospital discharge compared with those with nonshockable rhythm (Supplemental Table 3).

Our study should be interpreted in the context of the following potential limitations. One of the limitations is data generalizability because cities included in the CARES data set are primarily moderate to large metropolitan areas, and thus, our results may not apply to rural areas. However, the CARES program currently involves 19 state-based registries and communities enrolled in 22 additional states. In addition, our study is based on a large database that was collected over 3 years, and this large cohort provides statistical power that is unlikely to be found in single or multicenter studies. Half of the subjects had an arrest of presumed cardiac etiology, which is a diagnosis of exclusion. So, it is uncertain if some cases secondary to respiratory arrest (which is the most common primary cause of cardiac arrests in children[5]) were entered as presumed cardiac etiology, which may bias our findings. Our study is also limited by a lack of granularity in details, which is encountered in all studies that are based on large databases. Furthermore, some essential data on EMS activation time, time to intervention, CPR initiation, and time to defibrillation limited our ability to study the effects of these variables on outcomes and adjust for confounding factors.

CONCLUSIONS

In this large national registry, we evaluated factors associated with AED application among pediatric patients sustaining an OHCA. After adjusting for demographic and geographic characteristics, younger patients, patients experiencing cardiac arrests in private areas or whose arrest is unwitnessed, and patients who are victims of drowning, are less likely to have an AED applied. Targeting interventions to these patients may help to improve outcomes of OHCA in children. Further studies are needed to evaluate the effect of neighborhood-level characteristics given that our results revealed no persistent disparities after adjusting for confounders.

ABBREVIATIONS

AED: automated external defibrillator
AHA: American Heart Association
aOR: adjusted odds ratio
CARES: Cardiac Arrest Registry to Enhance Survival
CI: confidence interval
CPR: cardiopulmonary resuscitation
EMS: emergency medical service
OHCA: out-of-hospital cardiac arrest
OR: odds ratio

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