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Demographics, Bystander CPR, and AED Use in Out-of-Hospital Pediatric Arrests

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Abstract

Background—In 2005 the American Heart Association released guidelines calling for routine use of automated external defibrillators during pediatric out-of-hospital arrest. The goal of this study was to determine if these guidelines are used during resuscitations.

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Contributor's Statement:

Dr. Johnson conceptualized the project, performed the data analysis, wrote and revised the manuscript, and was primarily responsible for the submission of the manuscript. Dr. Grahan conceptualized the project, aided in data analysis, and helped to write and revise the manuscript. Dr. Haukoos helped to conceptualize the project, provided aid in data analysis, and reviewed and revised the manuscript. Dr. McNally designed the CARES database, supervised collection of data within the CARES database, and revised the manuscript. Dr. Campbell provided expertise in pediatric arrests when designing the project and helped to revise the manuscript. Dr. Sasson provided aid in data analysis design and reviewed the manuscript. Dr. Slattery helped to conceptualize the project and reviewed the manuscript.

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None of the authors have a conflict of interest.

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Methods—We conducted a secondary analysis of prospectively collected data from 29 U.S. cities that participate in the Cardiac Arrest Registry to Enhance Survival (CARES). Patients were included if they were older than 1 year of age and had a documented resuscitation attempt from October 1, 2005 through December 31, 2009 from an arrest presumed to be cardiac in nature. Hierarchical multivariable logistic regression analysis was used to estimate the associations between age, demographic factors, and AED use.

Results—129 patients were 1–8 years of age (younger children), 88 patients were 9–17 years of age (older children), and 19,338 patients were ≥18 years of age (adults). When compared to adults, younger children were less likely to be found in a shockable rhythm (younger children 11.6%, adults 23.7%) and were less likely to have an AED used (younger children 16.3%, adults 28.3%). Older children had a similar prevalence of shockable rhythms as adults (31.8%) and AED use (20.5%). A multivariable analysis demonstrated that, when compared to adults, younger children had decreased odds of having an AED used (OR 0.42, 95% CI 0.26–0.69), but there was no difference in AED use among older children and adults.

Conclusions—Young children suffering from presumed out-of-hospital cardiac arrests are less likely to have a shockable rhythm when compared to adults, and are less likely to have an AED used during resuscitation.

Keywords

cardiac arrest; pediatrics; CPR; AED; automated external defibrillator; American Heart Association; guidelines

INTRODUCTION

Pediatric out-of-hospital arrests (OHA) are uncommon and have an etiology and epidemiology that are thought to be distinct from adults.^{1–3} Current attempts to define these differences have been limited by the lack of clinical data as well as inconsistencies in case definitions and reporting methods; however, it is presumed that the majority of children have primary respiratory events that lead to cardiac arrest.^{2,4} These inconsistencies have made it difficult to develop strong evidence-based resuscitation guidelines that can be applied by the lay public as well as by health care professionals.

Pediatric patients can have arrest outcomes equal to or better than those of adults^{5–7}, and although most data suggest the overall prevalence of ventricular fibrillation and pulseless ventricular tachycardia is lower among children than adults, at least one study demonstrated a higher prevalence of shockable rhythms.⁸ In an effort to improve clinical outcomes for children, in 2003 the International Liaison Committee on Resuscitation (ILCOR) suggested that any individual one year of age or older in cardiopulmonary arrest have an automated external defibrillator (AED) applied, even if it was considered an adult AED (based on pad size and joules delivered per shock). The American Heart Association (AHA), a member of ILCOR, concurred in 2005 but specified that for patients from 1 to 8 years of age, an adult AED with pediatric attenuator paddles is preferred.⁹ The 2010 update to these guidelines no longer includes age restrictions, and recommends that if a pediatric specific AED or

pediatric attenuator system for an adult AED is not available then a standard AED should be used for all patients even if less than one year of age.^{10,11}

Studies have demonstrated that pediatric patients found in shockable rhythms have improved outcomes when compared to patients found in asystole or pulseless electrical activity (PEA),^{5,8} and a recent study based in Japan has demonstrated that AED use within pediatric OHAs improves 30 day survival and neurological outcomes.¹² There remains little data on actual AED use within the pediatric population within the United States, although a single study released after the 2005 guideline updates suggests that emergency medical providers remain uninformed about current guidelines, often lack pediatric specific AEDs, and are hesitant to use adult AEDs on pediatric patients.¹³ It is important to determine whether national resuscitation recommendations have reached the front lines [bystander, first responder, and emergency medical services (EMS) response] and to identify factors that are associated with having an AED used.

Our objective was to characterize pediatric OHA events as well as layperson, first responder, and EMS response to these events. We analyzed the demographics, arrest characteristics, layperson response and first responder response to pediatric cardiac arrests entered into the Cardiac Arrest Registry to Enhance Survival (CARES) in order to describe the epidemiology of AED use in pediatric OHAs based on the 2005 AHA guidelines.

METHODS

Study Design and Setting

This was a secondary analysis of CARES, which is funded by Medtronic, Zoll, American Heart Association, and the Red Cross, and is supported by the Centers for Disease Control and Prevention and Emory University. The CARES sample includes an overall catchment area of approximately 22 million people in 29 cities across the United States. CARES is an EMS-based registry for out-of-hospital cardiac arrest, composed of a limited standard set of data elements from three sources: 911 call centers, EMS providers, and receiving hospitals in accordance with the CARES user agreement. Data from submitted reports are linked and reviewed by an independent data analyst. Detailed information on the design and development of this registry as well as the data elements included in the registry is published elsewhere.¹⁴

From October 1, 2005 through December 31, 2009, CARES captured all 911-activated cardiac arrest events in which resuscitation was attempted and the etiology was presumed to be cardiac. CARES analysts confirmed the capture of all cardiac arrests by each city's 911-center during the data review process. All data were entered using a web-based platform, and an Excel file (Microsoft Corporation, Redmond, WA) was generated with all cardiac arrest events for the specified date range.

This study was approved by the IRB for CARES research from Emory University.

Study Sample

All cases submitted to the registry during the study period were eligible for inclusion. A case was excluded if: (1) the etiology of arrest was not primarily cardiac; (2) data documenting the patient's clinical outcome were missing; or (3) the patient's age was unknown or less than 1 year. An arrest was determined to be cardiac if there was no clinically apparent alternative mechanism, such as drowning, suffocation, trauma, or known drug overdose. Arrests were considered to be secondary to respiratory causes and subsequently excluded only if the responding EMS providers were aware of a clear history of a respiratory illness leading to the arrest, such as an asthma exacerbation, all other arrests were presumed to be cardiac in nature.

Data Collection and Processing

Patient-level characteristics were obtained from the registry and included: age, sex, race/ethnicity (as coded by the EMS provider), location of the arrest (i.e., public location versus private residence), whether the arrest was witnessed (i.e., arrest witnessed by someone other than the first responder/EMS provider), and survival and neurological outcome at the time of hospital discharge. We used EMS provider-identified race/ethnicity of the patient in our analysis, as CPR provision is more plausibly influenced by how others perceive the unconscious victim rather than how a victim self-identifies himself or herself. Asian, Native Pacific and Native American races were combined into a single "other" racial class due to the small number of individuals within these groups. Bystander cardiopulmonary resuscitation (CPR) was defined as any time a person who was not part of the medical or EMS team initiated CPR. Shockable rhythms were defined as a presenting rhythm of ventricular fibrillation or pulseless ventricular tachycardia as documented by EMS providers, or when an AED was used and a shock was advised. All rhythm assessments were reported by EMS; either as the AED assessment (shockable versus non-shockable) or by the EMS personnel's own interpretation of their manual defibrillator. AED use was considered any time an AED was applied by a layperson, the first responder, or by EMS. Return of spontaneous circulation (ROSC) was defined as any time the patient regained palpable pulses during the resuscitation, and survival was defined as survival to hospital discharge. Good neurological outcome was defined as a Cerebral Performance Category (CPC) of 1 or 2, which includes all patients who were able to live and function independently at discharge.

Patients were stratified into mutually exclusive age groups based on the 2005 AHA cardiac arrest algorithms. Patients less than one year of age were excluded from analysis since the AHA guidelines did not recommend AED use for these patients. Young children were defined as between 1 year of age and 8 years of age. Older children were defined as older than 8 years of age and less than 18 years of age, and adults were defined as anyone 18 years of age or older.

Data Management and Statistical Analyses

All data were transferred into STATA version 11.0 (College Station, TX) for statistical analyses. All frequency data are presented as prevalence estimates, 95% confidence intervals (95% CI) are included in the text where appropriate. To estimate associations between individual- and site-specific characteristics and AED use, we used a hierarchical logistic

regression model to estimate the association of age (primary independent variable) on AED use (dependent variable), while adjusting for gender, race/ethnicity, witnessed by bystander, location of arrest, and whether the arrest occurred after EMS arrived, as well as regional variations in how AEDs were used. Age was included in the model as two indicator variables (age 1–8 years and 9–17 years, with 18 years of age and older used as the reference). The hierarchical approach allowed us to account for individual cardiac arrest patients nested within distinct cities. To determine the extent to which city-specific factors have effects independent of individual characteristics, we used a random intercept model to partition the variance between catchment areas and the individual-level characteristics. Individual level variables were then added as fixed effects to the model to examine their independent contributions.

To minimize bias and preserve study power, we used multiple imputation to handle missing values. We and others have previously demonstrated the validity of this method for imputing missing out-of-hospital values under a variety of conditions.^{15–17} Individual level race/ethnicity was coded as unknown in approximately 25% of our sample, whereas arrests witnessed by bystanders, and location of arrest were missing in less than 3% of the dataset. No other variable had >1% missingness. The multiple imputation model included the following variables: age, gender, race/ethnicity, witnessed arrest, initial rhythm, AED use, arrest location, regional site, prehospital disposition, and survival to hospital discharge. Ten imputed datasets were created using imputation by chained equations based on bootstrapped samples from the complete dataset, and reported results are the mean estimates from hierarchical logistic regressions performed on each of these ten datasets.

RESULTS

Population

During the study period, 20,018 patients were included in CARES and were potentially eligible for inclusion. Patients were excluded if survival to hospital discharge was unknown (n=184), if the etiology of their arrest was unknown (n=37), or if they were less than 1 year of age (n=242). A total of 19,555 patients were included in the final study sample, of which 129 were between 1–8 years of age, 88 were between 9–17 years of age, and 19,338 patients were older than 18.

Pediatric Arrests Compared to Adult Arrests

Table 1 displays demographic, clinical, and EMS results of patients stratified by age. Males account for a greater proportion of OHAs than females across all age groups. In adults, white patients accounted for a greater prevalence of arrests compared to other races/ethnicities, but black children were the most common racial/ethnic group within both pediatric OHA populations.

Patients in the 1–8 years of age group had fewer arrests in public locations (1–8 years of age 13.9%, 95% CI 8.2–20.2; 18 years of age 31.8%, 95% CI 31.1–32.4) and fewer witnessed arrests (1–8 years of age 38.8%, 95% CI 30.2–47.3; 18 years of age 47.9%, 95% CI 47.2–48.6) than those 18 years of age or older; however, there were no differences in the

prevalence of layperson CPR among any of the age groups (1–8 years of age 32.6%, 95% CI 24.4–40.8; 9–17 years of age 37.5%, 95% CI 27.2–47.8; 18 years of age 33.5%, 95% CI 32.8–34.1) (Table 1). AEDs were used less often in patients aged 1–8 years of age when compared to adults (1–8 years of age 16.3%, 95% CI 9.8–22.7; 18 years of age 28.3%, 95% CI 27.7–28.9). First responders applied AEDs the majority of the time across all age groups (Table 1), although less often in patients 9–17 years of age (38.9%, 95% CI 20.3–61.4) when compared to patients 18 years of age (71.7%, 95% CI 67.1–69.5). AEDs were applied by laypeople 9.5% of the time in patients 1–8 years of age (95% CI 0–23.3), 27.8% of the time in patients 9–17 years of age (4.8–50.7), and 11.3% of the time in patients 18 years of age (95% CI 10.5–12.2). EMS applied AEDs 14.3% of the time in patients 1–8 years of age (95% CI 5.0–34.6), 33.3% of the time in patients 9–17 years of age (95% CI 16.3–56.3) and 17.0% of the time in patients 18 years of age (95% CI 16.0–18.0).

Patients in the 1–8 years of age group had the highest prevalence of asystole as the initial recorded rhythm (Table 1) as well as the lowest prevalence of shockable rhythms (1–8 years of age: 11.6%, 95% CI 6.0–17.2; 9–17 years of age 31.8%, 95% CI 21.9–41.7; 18 years of age 23.7%, 95% CI 23.1–24.3). Patients 1–8 years of age had the lowest prevalence of ROSC (1–8 years of age: 10.1%, 95% CI 4.8–15.3; 9–17 years of age 28.4%, 95% CI 18.8–38.0; 18 years of age 33.3%, 95% CI 32.7–34.0) and the lowest prevalence of survival (1–8 years of age: 1.6%, 95% CI 0.0–3.7; 9–17 years of age 15.9%, 95% CI 8.1–23.7; 18 years of age 9.0%, 95% CI 8.6–9.4) when compared to older children and adults.

When considering only patients with witnessed arrests, there were no significant differences in who initiated CPR or in AED use (Table 2). Patients 9–17 years of age were found in a shockable rhythm more often than younger children and adult patients (1–8 years of age: 22.0%, 95% CI 10.1–33.9; 9–17 years of age: 51.2%, 95% CI 35.6–66.7; 18 years of age: 33.7%; 95% CI 32.7–34.7), and had the highest prevalence of survival (1–8 years of age: 4.0%, 95% CI 0.0–9.6; 9–17 years of age: 25.6%, 95% CI 12.0–39.2; 18 years of age: 14.7%; 95% CI 14.0–15.4).

AED use among pediatric patients

Table 3 shows demographic and response characteristics for AED use within the pediatric population. Among pediatric patients there were no significant differences in AED use between males and females, although in adult patients there was a predominance of AED use among males compared to females (male 18 years of age 29.7%, 95% CI 28.9–30.5; female 18 years of age 26.2%, 95% CI 25.2–27.2). There were also no significant differences in AED use by race/ethnicity in either pediatric age group.

In both pediatric age groups, public arrests and witnessed arrests had an increased proportion of AED use relative to arrests that occurred in private and unwitnessed arrests (Table 3). There were no differences in the prevalence of AED use among patients who received layperson CPR (1–8 years of age 23.8%, 95% CI 10.4–37.2; 9–17 years of age 27.3%, 95% CI 11.2–43.3; 18 years of age 33.9%, 95% CI 32.8–35.1), although both pediatric age groups had a decreased proportion of AED use when CPR was initiated by first responders when compared to patients 18 years of age (1–8 years of age 21.7%, 95% CI

9.4–34.1; 9–17 years of age 20.7%, 95% CI 5.0–36.4; 18 years of age 40.6%, 95% CI 39.4–41.8.)

When an AED was used, there were no significant differences in the initial presenting rhythm among all age groups (Table 4). However, when an AED was not used, patients in the youngest age group had a lower prevalence of shockable rhythms when compared to adults (1–8 years of age 7.4%, 95% CI 2.4–12.4; 18 years of age 21.9%, 95% CI 21.2–22.6), and the highest proportion of patients in asystole (1–8 years of age 75.9%, 95% CI 67.7–84.1; 18 years of age 52.9%, 95% CI 52.1–53.8). Patients aged 9–17 years of age had a similar percentage of shockable rhythms when compared to adults (9–17 years of age 27.1%, 95% CI 16.4–37.8; 18 years of age 21.9%, 95% CI 21.2–22.6) and a similar proportion of patients in asystole (9–17 years of age 48.6%, 95% CI 36.5–60.1; 18 years of age 52.9%, 95% CI 52.1–53.8). AED use had no effect on the prevalence of survival in patients 1–8 years of age and 9–17 years of age although the small total number of surviving patients limits significance. In adult patients AED use increased survival (AED use 10.4%, 95% CI 9.6–11.2; AED not used 8.4%, 95% CI 8.0–8.9) when compared to patients who did not have an AED used.

Regression of AED use among pediatric patients

Factors associated with AED use after adjusting for demographic variables are presented in Table 5. When compared to patients 18 years of age, children 1 to 8 years of age had a decreased odds of having an AED applied during an arrest (OR 0.42, 95% CI 0.26–0.69). Patients 9–17 years of age showed a similar odds of AED use when compared to patients 18 years of age (OR 0.73 95% CI 0.43–1.27). Female sex was also independently associated with a decreased odds of AED use (OR 0.90, 95% CI 0.84–0.96).

DISCUSSION

This is the first study to examine the prevalence of AED use in out-of-hospital pediatric arrest since the 2005 AHA guidelines were released. We demonstrated that patients aged 1–8 years have an AED used less often than adults, that AEDs are used less often in both pediatric age groups when CPR is initiated by first responders, and that although younger children have the highest percentage of asystole among all patients, patients 9–17 years of age (older children) with witnessed arrests have the highest prevalence of shockable initial rhythms.

The clinical benefit of an AED within a community is dependent upon the proportion of initial shockable rhythms among patients who have an OHA, the proportion of arrests that are witnessed, the availability of devices, and the proportion of people who are trained to use an AED. AED training was first included in public CPR courses in March of 1999, although AED training has been taught to first responders since the early 1990s.^{18–20} The 2005 AHA guidelines were the first to recommend AED use in pediatric patients 1–8 years of age; specifically, these guidelines recommended AED placement for patients aged 1–8 years of age but included the caveat that pediatric attenuator paddles should be used when available. In contrast, the AHA recommended that the standard adult AED and pads should be used for children 9–17 years of age, a clearer, more definitive statement. We have demonstrated that

AED use among this older age group mirrors rates in the adult population, while AED placement among the 1–8 years of age group continues to lag. Patients in both pediatric age groups who had CPR initiated by first responders continued to have a lower prevalence of AED placement, suggesting that AHA guidelines for AED use have not been optimally incorporated into arrest algorithms of first responders. As many first responders are required to take basic CPR courses and may have access to AEDs, this may represent a population who is easily targeted to improve overall AED use.

The application of an AED by a layperson during a pediatric arrest remains rare, with the majority of AEDs being placed by 1st responders. We have demonstrated a small increase in AED placement by lay persons in the 9–17 year old age group that appears to correlate with the increased incidence of public arrests within this age group (table 1). The increase in AED placement by laypersons within this age group may be a result of an increased proportion of arrests occurring within schools and public settings where AEDs are frequently available, but this does not explain the increase in AED placement by EMS personnel. Clear associations cannot be drawn from the limited data at this time, and further research with a larger cohort of pediatric arrests with AED application will be required for a thorough analysis of predictors of who applies an AED during pediatric arrests and the association of arrest location with AED application.

Our results and prior studies have demonstrated increased survival from adult out-of-hospital cardiac arrest when an AED is used^{21,22}, and recent data demonstrates a similar benefit in pediatric patients.¹² Extrapolating from adult data, pediatric patients who are found in a shockable rhythm and receive standard resuscitation with an AED should have good outcomes. The reasons why both ventricular fibrillation and pulseless ventricular tachycardia are less commonly observed in younger children in OHA are active areas of research. Prior studies have demonstrated that the etiology of pediatric OHAs are often due to non-cardiac causes^{6,12, 23–27}, which may lead to more rapid rhythm degradation. When pediatric OHAs are cardiac in origin they may be secondary to genetic channelopathies or structural abnormalities and it is unknown how these differences affect arrest rhythms. It is also important to note that the myocardium of younger children and neonates appears to be more susceptible to ischemia than adult cardiac tissue and is less likely to sustain VF even when healthy.^{28–31} As younger children have an increased proportion of unwitnessed arrests, and therefore a greater likelihood of prolonged time from arrest to initiation of resuscitation, they are more likely to have greater rhythm degradation prior to intervention.

When comparing older children to adults, we identified a non-significant increase in shockable rhythms among the older children. In order to minimize discrepancies that may be secondary to delayed recognition of arrests, we analyzed the presenting rhythm in patients who had witnessed arrests as a proxy for faster EMS response times and minimal down times. Within witnessed arrests, older children had a 17.5% increase in shockable rhythms when compared to adults (table 2), which is similar to prior studies demonstrating age dependent arrest rhythms.^{6,12,25,32} The CARES database likely includes arrests resulting from various etiologies, and the age-dependent arrest rhythms may be due to inherent differences in arrest etiology. Patients 9–17 years of age may suffer from a more benign cohort of arrest causes that produce prolonged shockable rhythms, or these patients may

have fewer comorbidities that can lead to rapid rhythm degradation in other age groups. An alternative explanation is that older children arrest in locations with easy access to AEDs (e.g. schools) more often than younger children and adults, and that the increased frequency of shockable rhythms found in older children is the result of faster response times rather than some inherent quality of the arrest. Regardless, one can infer that older children may have the greatest benefit from AED use during a resuscitation as a result of more promising initial rhythms and a relative absence of pre-existing co-morbidities.

Although survival data within this study is limited by the small sample size, we have demonstrated a trend towards improved survival with AED use in both pediatric age groups (table 4). A recent study from Japan demonstrated a similar association between AED use and survival among patients 1–18 years of age¹², although this analysis did not separate pediatric patients into younger and older children. However, the differences in arrest rhythms between pediatric age groups seen in previous studies suggest that differences in survival with AED use may exist, and that younger pediatric patients may not see similar survival benefits. AED use may complicate a resuscitation, which may slow efforts of laypersons and inexperienced first responders, and AED application requires a temporary cessation of chest compressions during rhythm analysis. Therefore, in younger pediatric groups who may derive less benefit from AED application, any increase in survival could be negated by the added complexity of the resuscitation and from stopping CPR during rhythm analysis. Future studies are needed to determine if the application of an AED increases survival within all pediatric age groups, as these findings will be important when developing evidence-based age-dependent resuscitation guidelines.

Our study has several limitations. The CARES registry was designed to study arrests of presumed cardiac etiology, and therefore does not include any arrests from known trauma, suffocation, drowning, respiratory arrest or suicide. It is thought that children are more likely to have cardiac arrests secondary to respiratory arrests, so it is uncertain if some of these cases were entered into the CARES database. The etiology of arrest is not a variable within the 2005 AHA guideline; therefore etiology should not affect AED use within this population, but it is possible that AEDs are used less often within pediatric populations because first responders and laypersons perceive pediatric arrests as respiratory in etiology. It is also possible that limiting the dataset to cardiac arrests increases the incidence of AED use, as responders may be more likely to use an AED when the etiology is presumed to be cardiac. Further research will be required to determine the incidence of AED use among all arrests and to determine the cause of the decreased use of AEDs within pediatric patients. We were unable to obtain reliable data on response times from call to EMS arrival, CPR initiation, rhythm assessment and/or AED application, which may affect initial rhythms but are unlikely to influence AED use.

There are a number of questions that need to be addressed following this study. We have demonstrated that AED use within pediatric populations lags behind AED use in adults, and future research is required to determine the factors causing this discrepancy. Since 2010 the AHA guidelines have changed, and currently for all patients regardless of age the use an adult AED is recommended when pediatric specific AEDs are not available. A repeat analysis of AED use in pediatric populations after the 2010 guidelines were released will

help determine if these discrepancies are related to the wording of the guidelines, or if there are other factors that are limiting AED use in these populations.

In summary, children 1 to 8 years of age are less likely to have a shockable rhythm when compared to adults, and are less likely to have an AED used during resuscitation. Use of AEDs in younger children with presumed cardiac OHA lags behind stated guidelines.

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Table 1

Pediatric Arrest Characteristics by Age

Characteristics	1-8 year old (n=129)		9-17 years old (n=88)		18 years old (n=19338)	
	No.	%	No.	%	No.	%
Sex						
Female	55	42.6	40	45.5	7622	39.4
Male	74	57.4	48	54.5	11708	60.5
Unknown	0	0.0	0	0.0	8	0.0
Race						
Black	44	34.1	36	40.9	5406	28.0
Caucasian	32	24.8	18	20.5	7611	39.4
Hispanic	23	17.8	11	12.5	1029	5.3
Other	3	2.3	0	0.0	488	2.5
Unknown	27	20.9	23	26.1	4804	24.8
Public Arrest	18	13.9	26	29.5	6141	31.8
Unknown	5	3.9	1	1.1	502	2.6
Witnessed	50	38.8	43	48.9	9260	47.9
Unknown	0	0.0	0	0.0	4	0.0
Who Initiated CPR						
EMS personnel	41	31.8	26	29.5	6116	31.6
First Responder	46	35.7	29	33.0	6692	34.6
Layperson	42	32.6	33	37.5	6481	33.5
Unknown	0	0.0	0	0.0	49	0.3
AED Used	21	16.3	18	20.5	5476	28.3
Unknown	0	0.0	0	0.0	5	0.0
Who Applied AED						
EMS	3	14.3	6	33.3	929	17.0
First Responder	16	76.2	7	38.9	3926	71.7
Lay Person	2	9.5	5	27.8	620	11.3
Unknown	0	0.0	0	0.0	1	0.0
Initial Rhythm						

Characteristics	1–8 year old (n=129)		9–17 years old (n=88)		18 years old (n=19338)	
	No.	%	No.	%	No.	%
Asystole	87	67.4	37	42.0	8702	45.0
PEA	17	13.2	15	17.0	3697	19.1
Unknown, unshockable	9	7.0	8	9.1	2339	12.1
VT/VF/ Unknown shockable	15	11.6	28	31.8	4586	23.7
Unknown	1	0.8	0	0.0	14	0.1
ROSC	13	10.1	25	28.4	6444	33.3
Unknown	1	0.8	0	0.0	2	0.0
Survived	2	1.6	14	15.9	1735	9.0
Good Neurological						
Outcome	2	100.0	9	64.2	1221	70.4
Unknown	0	0.0	1	7.1	205	11.8

Table 2

Characteristics of Witnessed Arrests

Characteristics	1–8 years old (n=50)		9–17 years old (n=43)		18 years old (n=9260)	
	No.	%	No.	%	No.	%
Who Initiated CPR						
EMS personnel	16	32.0	12	27.9	3215	34.7
First Responder	14	28.0	15	34.9	2781	30.0
Layperson	20	40.0	16	37.2	3238	35.0
Unknown	0	0.0	0	0.0	26	0.3
AED Used	12	24.0	10	23.3	2584	27.9
Unknown	0	0.0	0	0.0	3	0.0
Initial Rhythm						
Asystole	27	54.0	11	25.6	2855	30.8
PEA	8	16.0	6	14.0	2357	25.5
Unknown, Unshockable	4	8.0	4	9.3	924	10.0
VT/VF/Unknown shockable	11	22.0	22	51.2	3120	33.7
Unknown	0	0.0	0	0.0	4	0.0
ROSC	10	20.0	16	37.2	4077	44.0
Survived	2	4.0	11	25.6	1359	14.7
Good Neurological Function	2	4.0	7	16.3	991	10.7
Unknown	0	0.0	1	2.3	155	1.7

Table 3

AED use by age group

Characteristics	1-8 year old				9-17 year olds				18 years old*			
	AED Used (n=21)		AED Not Used (n=108)		AED used (n=18)		AED Not Used (n=70)		AED Used (n=5476)		AED Not Used (n=13857)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Sex												
Female	8	14.5	47	85.6	8	20.0	32	80.0	1996	26.2	5623	73.8
Male	13	17.6	61	82.4	10	20.8	38	79.2	3479	29.7	8227	70.3
Unknown	0	0.0	0	0.0	0	0.0	0	0.0	1	12.5	7	87.5
Race												
Black	7	15.9	37	84.1	8	22.2	28	77.8	1433	26.5	3973	73.5
Caucasian	6	18.8	26	81.2	1	5.6	17	94.4	2174	28.6	5437	71.4
Hispanic	3	13.0	20	87.0	4	36.4	7	63.6	330	32.1	699	67.9
Other	0	0.0	3	100.0	0	0.0	0	0.0	113	23.2	375	76.8
Unknown	5	18.5	22	81.5	5	21.7	18	78.3	1426	29.7	3373	70.2
Arrest Location												
Private	15	14.2	91	85.8	10	16.4	51	83.6	3268	25.7	9425	74.2
Public	6	33.3	12	66.7	8	30.8	18	69.2	2052	33.4	4086	66.5
Unknown	0	0.0	5	100.0	0	0.0	1	100.0	156	31.1	346	68.9
Arrest Witnessed												
No	9	11.4	70	88.6	8	17.8	37	82.2	2891	28.7	7181	71.3
Yes	12	24.0	38	76.0	10	23.3	33	76.7	2584	27.9	6673	72.1
Unknown	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	3	75.0
Who Initiated CPR												
EMS personnel	1	2.4	40	97.6	3	11.5	23	88.5	555	9.1	5559	90.9
First Responder	10	21.7	36	78.3	6	20.7	23	79.3	2717	40.6	3973	59.4
Layperson	10	23.8	32	76.2	9	27.3	24	72.7	2199	33.9	4281	66.1
Unknown	0	0.0	0	0.0	0	0.0	0	0.0	5	10.2	44	89.8

* In 5 cases of patients 18 years of age, AED use was unknown.

Table 4

Outcomes

Characteristics	1-8 year old				9-17 year olds				18 years old*			
	AED Used (n=21)		AED not used (n=108)		AED Used (n=18)		AED not used (n=70)		AED Used (n=5476)		AED not used (n=13857)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Initial Rhythm												
Asystole	5	23.8	82	75.9	3	16.7	34	48.6	1365	24.9	7336	52.9
PEA	0	0.0	17	15.7	0	0.0	15	21.4	460	8.4	3234	23.3
Unknown, unshockable	9	42.9	0	0.0	6	33.3	2	2.9	2104	38.4	235	1.7
VT/VF/ Unknown shockable	7	33.3	8	7.4	9	50.0	19	27.1	1547	28.3	3038	21.9
Unknown	0	0.0	1	0.9	0	0.0	0	0.0	0	0.0	14	0.1
ROSC	4	19.1	9	8.3	6	33.3	19	27.1	1975	36.1	4469	32.3
Unknown	0	0.0	1	0.9	0	0.0	0	0.0	2	0.0	0	0.0
Survived	2	9.5	0	0.0	4	22.2	10	14.3	568	10.4	1167	8.4
Good Neurological Outcome	2	100.0	0	0.0	1	25.0	8	80.0	411	72.4	810	69.4
Unknown	0	0.0	0	0.0	1	25.0	0	0.0	67	11.8	138	11.8

* In 5 cases of patients 18 years of age, AED use was unknown.

Table 5

Hierarchical multivariable logistic regression for AED use.

Characteristics	OR	95% CI
Age 1–8 years old	0.42	(0.26–0.69)
Age 9–17 years old	0.73	(0.43–1.27)
Age 18 years old		reference
Female	0.90	(0.84–0.96)
Race/ Ethnicity		
Black	0.89	(0.82–0.97)
Caucasian		reference
Hispanic	0.91	(0.78–1.06)
Other	0.87	(0.67–1.13)
Public Arrest	1.25	(1.16–1.35)
Witnessed by Bystander	1.15	(1.07–1.23)
Arrest After EMS Arrival	0.21	(0.18–0.25)