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The Association of Fire or Police First Responder Initiated Interventions with Out of Hospital Cardiac Arrest Survival

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Abstract

Objective: Fire and police first responders are often the first to arrive in medical emergencies and provide basic life support services until specialized personnel arrive. This study aims to evaluate rates of fire or police first responder-initiated cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) use, as well as their associated impact on out-of-hospital cardiac arrest (OHCA) outcomes.

Methods: We completed a secondary data analysis of the MI-CARES registry from 2014–2019. We reported rates of CPR initiation and AED use by fire or police first responders. Multilevel modeling was utilized to evaluate the relationship between fire/police first responder-initiated interventions and outcomes of interest: ROSC upon emergency department arrival, survival to hospital discharge, and good neurologic outcome.

Results: Our cohort included 25,067 OHCA incidents. We found fire or police first responders initiated CPR in 31.8% of OHCA events and AED use in 6.1% of OHCA events. Likelihood of sustained ROSC on ED arrival after CPR initiated by a fire/police first responder was not statistically different as compared to EMS initiated CPR (aOR 1.01, CI 0.93–1.11). However, fire/police first responder interventions were associated with significantly higher odds of survival to hospital discharge and survival with good neurologic outcome (aOR 1.25, 95% CI 1.08–1.45 and aOR 1.40, 95% CI 1.18–1.65, respectively). Similar associations were see when examining fire or police initiated AED use.

Conclusions: Fire or police first responders may be an underutilized, potentially powerful mechanism for improving OHCA survival. Future studies should investigate barriers and opportunities for increasing first responder interventions by these groups in OHCA.

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INTRODUCTION

It is well-established that early administration of cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) use are key interventions in the pre-hospital chain of survival for out-of-hospital cardiac arrest (OHCA).[1] Nationally, only 30 percent of OHCA patients treated by emergency medical services (EMS) survive to hospital admission and less than 10 percent survive to hospital discharge.[2–4] Additionally, there is wide geographic variability in OHCA survival.[5]

Research has shown that without bystander CPR, cardiac arrest survival decreases by up to 10% each minute until defibrillation for patients with a shockable rhythm.[6,7] As fire or police first responders are often the first to arrive on scene for OHCA events, they can play a critical role in rapid initiation of CPR and defibrillation. Indeed, studies have shown that CPR from first responders corresponds to better survival rates, although not as significantly as bystander-CPR (who often are present at the time of the arrest).[3] Though recent efforts have focused on training the public to perform CPR, approximately 50% of OHCA events are unwitnessed.[4] This increases the importance of early action by fire/police first responders, who may be first on scene.

Police dispatch is associated with shorter response time in OHCA due to strategic positioning of police in their jurisdictions, allowing them to arrive at the site of emergencies more rapidly than other reponders.[8,9] Similarly, in communities that have implemented dual dispatch protocols, fire teams arrived prior to EMS in approximately 47% of arrests – with response times being approximately 1.5 minutes faster.[10,11] Recognizing the survival benefit, fire/police first responder interventions have become increasingly common and are now considered by some to be within their scope of practice.[12,13]

Despite the significant potential for fire/police first responders as critical members of the cardiac arrest response team, knowledge gaps regarding implementation and outcomes outside of structured interventions remain. Given these gaps, juxtaposed with the high potential for benefit, this study aims to evaluate the rate of fire/police first responder-initiated CPR and AED use, as well as associated impact of these use of these services on OHCA survival and neurologic outcomes.

METHODS

Study design and setting

Data for this study was derived from the Michigan Cardiac Arrest Registry to Enhance Survival (MI-CARES), a subset of the national CARES registry, for the years 2014–2019.[14] The national CARES Registry includes over 2,000 participating EMS agencies, over 2,500 hospitals and 29 states with over 60 community sites in 13 additional states, covering a population of 167 million people with varying characteristics and broad geographic representation.[15] CARES-participating communities establish contacts at their local hospitals to provide data to the registry on OHCA patients treated at those facilities. The registry uses internationally-recognized Utstein-style definitions to ensure standardized data collection on patient-level variables and outcomes from the pre-hospital setting through

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hospital discharge.[16,17] Participating EMS agencies are required to conduct routine audits of records to ensure that all events are reported.[4] Through 2019, 151 EMS agencies, and 116 hospitals contributed data to the MI-CARES registry, which equates to a coverage of approximately 92% of the state population.[18]

Cohort Selection

Arrests were included only if they had complete data for patient- and arrest-related variables. Data from EMS agencies with less than 5 reported arrests over the study period were excluded. This resulted in the exclusion of less than 0.05% (n=11) of reported arrests in the MI-CARES registry. As they were felt to represent distinctly different from typical OCHA events, arrests that occurred in medical facilities (including nursing homes) or were witnessed by first responders (e.g., occurring after arrival on scene) were also excluded. This resulted in the inclusion of 25,067 arrests (71.8% of the MI-CARES registry). As there is significant geographic variability in cardiac arrest outcomes, we also include community level variables using American Community Survey for the years under study. Data sets were linked at the level of the census tract of arrest location.

Exposure

The primary independent variables of interest were who initiated CPR or applied the AED. Variables were analyzed in the manner they were collected as part of the registry. Notably, the exposure variables of interest are collected differently when comparing CPR initiation and AED application. CPR initiation was classified as either fire/police first responder (non-transport firefighters or police, either local or state), lay person (further broken down into bystanders, family members, and lay medical providers), or EMS. Data detailing AED application was defined as: police, another first responder (this includes EMS and fire), layperson sub-groups, or no AED was applied.

Outcomes

The primary outcomes of interest include sustained return of spontaneous circulation (ROSC) with pulse upon emergency department arrival (i.e. end of EMS care), survival to hospital discharge, and survival with good neurological outcomes at the time of hospital discharge. Good neurologic outcome was defined as a Cerebral Performance Category (CPC) score of 1 or 2 (good or moderate cerebral performance, respectively) at the time of discharge.[16]

Analysis

To assess the impact of the fire/police interventions on our prespecified outcomes, we used multivariable hierarchical logistic regression with EMS-agency level intercepts to account for variation across agencies. All models included patient, arrest, and community-level covariates for risk adjustment. To adjust for temporal trends in cardiac arrest survival, a calendar-year covariate was also included as a linear predictor. Further, as the CARES database has annual growing coverage, sensitivity analyses including only the three most recent years of data were analyzed.

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Patient- and arrest-related covariates included age, gender, race/ethnicity, location of the OHCA (home/residence, nursing home/health care facility, or other location), witnessed arrest status, and the first documented rhythm (shockable rhythm defined as ventricular fibrillation, ventricular tachycardia, or unknown shockable; or unshockable rhythm defined as asystole, idioventricular/pulseless electrical activity, or unknown unshockable). Given the time-sensitivity of cardiac arrest intervention, utlization of arrival timestamps and dispatcher-assisted CPR were explored. Timestamps were not available for police arrival and missing for fire arrival in 82% of cases while completion of dispatcher-assisted CPR was missing/unknown in 63.2% of cases, limiting their ultilization in the presented analysis. Community-level variables included aggreate measures of sex, non-white residents, over the age of 25, and had at least a high school education, expressed as proportions of the total population. Median age, average household size, percent of the population below the poverty line, population density per-square mile, and land area were also included.

All data analyses were completed using using standard statistical software (SAS v9.4, SAS Institute, Cary, NC).[19] Approval was obtained from the CARES national office to use data from MI, and the study was approved by the University of Michigan Institutional Review Board.

RESULTS

A total of 25,067 OHCA incidents met the inclusion criteria. Among those who sustained ROSC, the average age was 60.9 (SD 18.7) and 61.3% male (Table 1). Under a quarter (23.0%) of patients sustained ROSC upon ED arrival. Those who sustained ROSC were more likely to arrest in a non-residential location (20.1% vs 12.6%) and have an initial shockable rhythm (31.0% vs 16.1%) than those who did not sustain ROSC. Of the patients who sustained ROSC, 37.4% (n=2,152) had targeted temperature management initiated, 20% (n=1, 150) underwent coronary angiography, and 9.3% (n=537) received a cardiac stent. Overall, 8.3% of pateints survived to hospital discharge and 6.9% survived with good neurological outcome.

Fire/police first responder interventions occurred in less than half of arrests. CPR was initiated by a lay person 33.1% of the time. Of the remaining cases that did not have CPR initiated by a lay person, fewer than half had CPR initiated by fire/police first responders (49.8% of those without layperson initiated CPR; 31.8% of total population). Among those who both did and did not sustain ROSC, no AED was applied in the majority of arrests (62.1% and 68.9%, respectively). Police accounted for AED application in 6.1% of all arrests, while non-police (EMS and fire) first responders accounted for application in 24.4% of all arrests.The likelihood of sustained ROSC on ED arrival after CPR initiated by a fire/police first responder was not statistically different as compared to EMS initiated CPR (OR 1.01, CI 0.93–1.11; Table 2). In contrast, the likelihood of survival to hospital discharge and survial to discharge with good neurologic outcome was significantly greater after fire/police first responder CPR as compared to EMS initiated CPR. Lay person-and lay medical provider-initiated CPR was also associated with a significantly greater likelihood of survival to hospital discharge and discharge with good neurologic outcome compared with

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EMS-initiated CPR. Results including only the three most recent years of cases showed equivalent trends to those completed with the complete cohort.

When examining the relationship between AED application and the prespecified outcomes, we found a statistically significant association between good neurological outcome and AEDs applied by all groups, including police (Table 3). AED application by lay people was positively associated with all outcomes (sustained ROSC, survival to discharge, and good neurologic outcome) when compared to no AED application. Results for AED application including only the three most recent years of cases showed equivalent trends to those completed with the complete cohort.

DISCUSSION

Since 1993, the American Heart Association has recommended that “basic CPR should be started immediately after cardiac arrest is recognized” and that “with rare exceptions, initiation of CPR by emergency personnel is too late”.[20] Indeed, suggested benchmarks indicate that CPR should be initiated within six minutes and defibrillation within eight minutes at the latest.[21,22] Our data show that CPR is initiated by fire/police in one-third of arrests, with police applying an AED in approximately 6% of arrests. This is despite data that police are often the first to arrive to OHCAs and other medical emergencies in most communities.[23,24]

Further, we demonstrated that interventions initiated by bystanders and fire/police, groups that have potential to arrive more quickly on scene, were associated with improved outcomes as compared to EMS-initiated CPR and no AED application, respectively. Given the significant time dependence of cardiac interventions, the improvement in outcomes associated with fire or police first responder interventions is not surprising. Moreover, it is consistent with a broad body of previously published literature that has served as the foundation for early CPR and defibrillation as chief mechanisms to improve outcomes for patients.[25,26] Prior literature has demonstrated decreased time to defibrillation and increased OHCA survival following the implementation of police AED programs.[13,27] We believe the finding of better outcomes with survival to hospital discharge is particularly important. It suggests that while interventions by these first responders may not increase immediate survival, they are associated with better downstream outcomes (potentially by limiting neurological injury from prolonged down times).

While fire/police interventions were not directly compared to bystander interventions, our data did show trends toward persistent but attenuated improvements in outomes benefits. This is likely driven in large part by the temporal sequence of events after an arrest occurs, a bystander’s potential to respond most rapidly followed by the arrival of fire/police. This trend is consistent with prior literature demonstrating the arrival of fire and police prior to EMS.[8–11] Other contributing factors to this trend may be due, in part, in the wide variation to training requirements and AED access for fire/police first responders.

Prior studies have demonstrated wide variation nationally in minimum training requirements, with little guidance around medical training for police.[12] At present in the

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State of Michigan, while CPR and AED use are covered as a component of initial police academy training there are not standardized guidelines or requirements on the acquisition or maintenance for basic life support (BLS) training such as that provided through the American Heart Association.

AED access and utilization are also critical components of early prehospital response, not only with respect to early defibrillation but also as it may be correlated with fire/police viewing their role as initial medical providers. Prior studies demonstrate that police initiate medical intervention in the minority of arrests,[12] though surveys of law enforcement agencies demonstrate that those agencies who carry AEDs are more likely to view their role as initial medical providers than those who do not (83% vs 46%).[23]

Further underscoring the role of fire/police as initial providers, both domestically and abroad, dual-dispatch systems have repeatedly shown to reduce the time to defibrillation and improve survival rates.[10,28–31] In each study, earlier response times were speculated to be the primary mechanism driving improved survival outcomes.[10,28–31] Notably, each of these studies also included widespread access to AEDs and (for prospective studies) annual training.

We demonstrate here that interventions initiated by fire/police first responders have potential to improve outcomes, particularly survival to discharge and discharge with good neurological outcomes. Their role may be particularly in unwitnessed arrests where bystanders are not available to intervene earlier. Our findings have important implications for many stakeholders in the OHCA chain of survival, including CARES registry state coordinators, leaders in EMS agencies, first responders, emergency medicine providers, and patients. Future work should focus on the characterization of resources and practices among fire/police prehospital providers, with a focus on the acceptability and feasibility of interventions to enhance their role in OHCA interventions.

LIMITATIONS

Our study does have important limitations. Evaluation of temporal events were limited due to characterization of related variables as supplemental rather than required, resulting in high rates of missing time-related variables (e.g., the estimated time of the arrest, the time of the first defibrillation, and the time of CPR initiation).[16] Due to the nature of our study as a secondary data analysis, we were unable to parse out granular response details. In particular, we were not able to distinguish fire and police in CPR initiation nor were we able to characterize details around CPR quality. Further, limitations exist in our ability to distinguish which responder may have been first on scene. Collected data describes which responder group was dispatched but not the on-scene arrival order.

An additional limitation may result from regional variation in fire/police access to AEDs or hospital resources and practices. Given that patient outcomes in the emergency department and at hospital discharge are highly impacted by both prehospital and hospital-based resources, it is difficult to differentiate the role of individual components of care.

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CONCLUSIONS

Our study found associations with improved outcomes for interventions initiated by both fire/police first responders as well as by lay persons. While time data were not available for analysis, this is likely driven by their ability to intervene with CPR and AED utilization earlier in the OHCA. Other components, which may be more amenable to modification, include training and access to AEDs. Future work should focus on further clarifying the role of fire/police prehospital providers in OHCA.

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DECLARATION OF CONFLICTS OF INTEREST:

Dr. Robert Neumar reports being Co-Chair, International Liaison Committee on Resuscitation, and President and Board Chair, SaveMiHeart. All other authors confirm the absence of the potential conflicts of interest listed in the ICMJE guidelines including: grants, consulting fees or honoraria, support for meeting travel, fees for participation in review activities such as data monitoring boards or statistical analysis, payment for writing or reviewing the manuscript, and/or provision of writing assistance, medicines, equipment, or administrative support.

DATA AVAILABILITY:

Data is available for access upon request through the CARES National Office (https://mycares.net).

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Table 1.

Characteristics of cardiac arrests in Michigan, 2014–2019.

	No Sustained ROSC (Frequency, %) (N = 19318)	Sustained ROSC (Frequency, %) (N = 5749)
Patient Characteristics		
Age (Mean, SD)	59.73 (20.42)	60.94 (18.65)
Male	12283 (63.58)	3524 (61.30)
White	10251 (53.06)	3802 (66.13)
Black/African American	5265 (27.25)	820 (14.26)
Other Race	3802 (19.68)	1127 (19.60)
Arrest Characteristics		
Location of Arrest		
Home	16884 (87.40)	4593 (79.89)
Public	2434 (12.60)	1156 (20.11)
Initial Rhythm		
Shockable	3108 (16.09)	1782 (31.00)
Unshockable	16210 (83.91)	3967 (69.00)
Year		
2014	1704 (8.82)	452 (7.86)
2015	2621 (13.57)	757 (13.17)
2016	3041 (15.74)	917 (15.95)
2017	3722 (19.27)	1089 (18.94)
2018	3956 (20.48)	1213 (21.10)
2019	4274 (22.12)	1321 (22.98)
Exposure Variables		
Who Initiated CPR *		
Fire/Police	6192 (32.05)	1785 (31.05)
Lay Person	6091 (31.53)	2205 (38.35)
Lay Medical Provider	536 (2.77)	229 (3.98)
EMS Personnel	6499 (33.64)	1530 (26.61)
Who First Applied AED *		
Not Applied	13312 (68.91)	3571 (62.12)
Non-Police First Responder	4587 (23.74)	1536 (26.72)
Lay Person	153 (0.79)	152 (2.64)
Lay Medical Provider	143 (0.74)	79 (1.37)
Police	1123 (5.81)	411 (7.15)

*As collected in the registry, police & fire first responders are combined for reporting CPR initiation, while fire & EMS first responders are combined for reporting AED initiation

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Table 2.

Adjusted effects of CPR initiation by responding group, as compared to EMS-initiated CPR.[*]

	CPR Initiation[**] (All years)	CPR Initiation[**] (2017–2019)
Outcome	**Odds Ratio (95% CI)**	
Sustained ROSC		
Fire/Police First Responder[***]	1.01 (0.93, 1.11)	1.01 (0.90, 1.13)
Lay Person	1.07 (0.98, 1.17)	1.07 (0.96, 1.19)
Lay Medical Provider	1.13 (0.95, 1.35)	1.15 (0.92, 1.45)
Survival to Discharge		
Fire/Police First Responder	1.25 (1.08, 1.45)[†]	1.43 (1.18, 1.73)
Lay Person	1.56 (1.36, 1.79)[†]	1.78 (1.50, 2.13)
Lay Medical Provider	1.77 (1.37, 2.28)[†]	1.97 (1.41, 2.73)
Discharged with Good Neurological Outcome		
Fire/Police First Responder	1.40 (1.18, 1.65)[†]	1.65 (1.33, 2.05)
Lay Person	1.71 (1.46, 1.99)[†]	2.08 (1.70, 2.55)
Lay Medical Provider	2.00 (1.52, 2.64)[†]	2.47 (1.74, 3.52)

[*] Estimates derived using multilevel logistic regression models adjusted for: age, gender, race/ethnicity, location, first documented rhythm, calendar year, and community level variables as defined in the methods

[**] Odds ratio reference category: EMS

[***] As collected in the registry, “First Responder” here refers to (Fire or Police)

[†] P-value<0.01

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Table 3.

Adjusted effects of AED application by responding group, as compared to no AED application.*

	AED Application** (All Years)	AED Application** (2017–2019)
	Odds Ratio (95% CI)	
Sustained ROSC		
*First Responder****	1.08 (1.00, 1.18)‡	1.08 (0.98, 1.19)
Lay Person and Lay Family Member	1.74 (1.35, 2.23)†	1.52 (1.10, 2.09)
Lay Medical Provider	1.40 (1.03, 1.90)‡	1.75 (1.19, 2.57)
Police	0.99 (0.87, 1.13)	1.06 (0.90, 1.24)
Survival to Discharge		
First Responder	1.13 (1.00, 1.28)	1.17 (1.00, 1.36)
Lay Person and Lay Family Member	1.95 (1.47, 2.59)†	1.59 (1.10, 2.30)
Lay Medical Provider	1.91 (1.31, 2.78)†	2.21 (1.38, 3.53)
Police	1.40 (1–17, 1.69)†	1.50 (1.19, 1.88)
Discharged with Good Neurological Outcome		
First Responder	1.17 (1.02, 1.34)‡	1.18 (1.00, 1.40)
Lay Person and Lay Family Member	2.06 (1.54, 2.77)†	1.75 (1.20, 2.57)
Lay Medical Provider	2.23 (1.51, 3.30)†	2.48 (1.52, 4.04)
Police	1.47 (1.21, 1.79)†	1.58 (1.24, 2.01)

*Estimates derived using multilevel logistic regression models adjusted for: age, gender, race/ethnicity, location, first documented rhythm, calendar year, and community level variables as defined in the methods

**Odds ratio reference category: No AED applied

***As collected in the registry, “First Responder” here refers to (EMS or firefighters)

‡P-value<0.05;

†P-value<0.01