



## Clinical paper

## Adult out-of-hospital cardiac arrest in Philadelphia from 2008–2012: An epidemiological study



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## ABSTRACT

**Background:** Wide variation in out-of-hospital cardiac arrest (OHCA) survival has been reported, with low survival in urban settings. We sought to describe the epidemiology of OHCA in Philadelphia, Pennsylvania, the fifth largest U.S. city, and identify potential areas for targeted interventions to improve survival.

**Methods and results:** Retrospective chart review of adult, non-traumatic, OHCA occurring in Philadelphia between 2008 and 2012. We determined incidence and epidemiological factors including: demographics, initial cardiac rhythm, bystander cardiopulmonary resuscitation, automated external defibrillator use, return of spontaneous circulation and 30-day survival. 5198 cases of adult, non-traumatic OHCA were identified. The incidence was 81.5/100,000. The majority of cases occurred in a residence (76.2%); 30.4% were witnessed events; the initial cardiac rhythm was pulseless ventricular tachycardia or ventricular fibrillation in 6.2% of cases, pulseless electrical activity in 21.0%, asystole in 38.3% and was unknown or undocumented in the remaining 34.5%. Multivariate logistic regression analysis demonstrated increased 30-day survival with younger age, shockable cardiac rhythms, and daytime arrest. 30-day survival was 8.1% for EMS-assessed patients and 8.6% for EMS-transported patients.

**Conclusions:** Philadelphia's reported incidence is consistent with urban settings although the survival rate is higher than other urban centers.

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## Introduction

Cardiovascular disease has remained a leading cause of death for over 15 years in the United States [1] and is a major contributor to sudden cardiac arrest. Approximately 360,000 episodes of out-of-hospital cardiac arrest (OHCA) [1,2] occur annually in the United States. Wide variation in 30-day survival rates has been reported for emergency medical services (EMS)-assessed OHCA, ranging from 1.1% in Alabama to 8.2% in Seattle [3], and EMS-treated OHCA, rang-

ing from 0.2% in Detroit, to a mid-range of 3% in New York City, to as high as 16.3% in Seattle [3–9].

The American Heart Association (AHA)'s "chain of survival" describes essential actions in the attempt to achieve return of spontaneous circulation (ROSC) after OHCA, with each link contributing to survival [1,2,10,11]. Variations in the delivery of these interventions may contribute to the wide range of OHCA survival. Despite large public health interventions focused on the initial links in the "chain of survival", the national OHCA mortality remained unchanged for several decades at 7.6% [4,6,12,13]. More recent data from the Cardiac Arrest Registry to Enhance Survival, covering the years 2005–2012, suggests an increase in survival from 5.7% to 8.3% over that time [13]. A recent Institute of Medicine report suggests the need for an immediate change in the national approach to OHCA: "A national responsibility exists to improve the likeli-

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hood of survival and favorable neurologic outcomes following a cardiac arrest. This will require immediate changes in cardiac arrest reporting, research, training, and treatment [14].”

The epidemiology of OHCA in Philadelphia, the nation's fifth largest city [15], has not been systematically reported. We sought to describe the epidemiology of OHCA in Philadelphia and examine the impact of different factors on survival, including initial cardiac rhythm, witnessed arrest, bystander CPR, and use of automated external defibrillators (AEDs) [16–19].

## Methods

### Study design

We conducted a retrospective, observational study of OHCA patients treated by the Philadelphia Fire Department (PFD), the city's sole provider of emergency, prehospital care and transport, which responds to approximately 270,000 medical dispatches annually. Philadelphia had a population of 1,540,351 on January 1, 2008, the start of the study period. Study design and data acquisition methods have been described previously for this dataset and are summarized below [20]. The Institutional Review Boards of the University of Pennsylvania and the City of Philadelphia Department of Public Health approved this study. The PFD operates a tiered system with 14 basic life support (BLS) and 36 advanced life support (ALS) ambulances. The PFD uses 59 engine companies and 29 ladder companies as BLS first responders, staffed with emergency medical technicians equipped with AEDs, oxygen, and other BLS equipment. All transported EMS calls are taken to one of 23 receiving hospitals, including five adult Level I trauma centers, one Level II trauma center, and two pediatric Level I trauma centers. Philadelphia is a diverse city that is 44% African American, 13% Hispanic, and had a population of 1,553,165 in 2013 [15].

### Study sample

The study population, in accordance with Utstein criteria, included adult patients ( $\geq 18$  years of age) who suffered a non-traumatic OHCA between January 1, 2008, and February 20, 2012. Exclusion criteria included patients with do-not-resuscitate orders, patients who were found to be unsalvageable, with substantial rigor mortis or decapitation on EMS arrival, and those whose name and date of birth were unknown making survival status impossible to determine.

Data were derived from EMS reports, summarizing the events and treatments provided, and extracted using uniform data collection forms. Additional cases were extracted based upon reporting “cardiac arrest” or “code blue” as part of the care report. Multiple verification steps were performed to validate this identification algorithm and to evaluate for missed cases of OHCA. To assess for false negatives, an exploratory set of 7815 excluded cases in which the EMS personnel impression of the patient was unconscious/unresponsive, hypotension, or cardiac rhythm disturbance was reviewed. Of these, 32 possible false negatives were found, with only 12 of these being true OHCA where cardiac arrest occurred prior to EMS arrival. To assess for false positives, 500 randomly selected cases meeting the extraction criteria were examined. No cases were found in this sample where cardiac arrest did not occur. Based on these analyses of the data, the sensitivity of the identification algorithm was 99.3% and the specificity was 100%. Verified case narratives were also individually reviewed by the research team.

### Outcome measurements

Prospectively selected primary outcome measures were: pre-hospital ROSC and 30-day survival confirmed by chart review by two investigators, defined as survival  $\geq 30$  calendar days after the cardiac arrest event date. The PFD database has no outcomes data included; therefore, survival was confirmed by a multistep process utilizing publically available resources. The following criteria needed to be met in order to be considered alive at 30 days: 1) they were not found in the US Social Security Death Index (SSDI) database; 2) they were not in the Pennsylvania Department of Health death records; 3) they were listed as having a current address in LexisNexis (LexisNexis Group, Dayton, OH) during a public records search and not listed as deceased; and 4) a search did not turn up an obituary. As an additional check for accuracy, we compared survival for patients in the PFD database transported to 2 specific hospitals with the survival for the same patients in an independent database (Penn Alliance for Therapeutic Hypothermia [PATH]), which contains hard survival outcomes from follow up visits at the same hospitals and phone interviews.

### Statistical analysis

Raw data were downloaded into Stata (Stata 13; StataCorp LP, College Station, TX) for analysis. Descriptive statistics were used to characterize the study population across an array of continuous and categorical variables, including demographic, prehospital care, and hospital care characteristics. We tested for significant differences in the mortality and survival groups using 2-sample *t* tests for numerical variables. Categorical variables that were dichotomous (yes/no) were analyzed using odds ratios and 95% confidence intervals, while continuous variables were analyzed using means, medians, and *t*-tests.

Logistic regressions on survival were estimated for the full sample as well as select subgroups of patients. In the preferred specification, a broad range of controls as well as fixed effects for hospital destination, month, and year of incident were included. However, findings were robust to models with no fixed effects and a reduced number of covariates. A remaining concern was the potential for EMS-treated and transported patients without documented 30-day survival data (908/4625; 19.6%) to confound results through selection bias if the sample used for analysis differed from the broader population. Review of independent variable summary statistics comparing the matched and unmatched samples indicated that this was in fact the case; patients matched to 30-day mortality records were statistically significantly more likely to be older and less likely to receive bystander CPR or have an AED used. Pre-hospital epinephrine administration was included as a control variable within the multivariable analysis; however related results are not presented as we can neither observe nor control for inpatient administration [12,21,22]. A Heckman two-step model was estimated as an additional robustness check to control for cases lost to follow-up [23–25]. In the first stage, the independent variables were used to predict observation of 30-day mortality. Results from this specification were used in the second stage regression on 30-day mortality. Because indicators for incident location do not significantly affect survival but did predict observation of survival, these variables were only included as identifying variables in the first stage selection equation. Core results and the selection model demonstrated very similar findings.

## Results

Over the study period, there were 5198 adult, non-traumatic EMS-assessed OHCA, giving an incidence of 81.5/100,000. After

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