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# Survival, expenditure and disposition in patients following out-of-hospital cardiac arrest: 1995–2013☆

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ABSTRACT

*Aims:* To investigate trends in survival to hospital discharge, in-hospital expenditures, and post-acute-care disposition following out-of-hospital cardiac arrest (OHCA) in the United States.
*Methods:* We performed this nationwide serial cross-sectional study using data from the National Inpatient Sample on all patients (age >18 years) hospitalized with OHCA between January 1, 1995, and December 31, 2013. Our main outcome measure was survival to hospital discharge. We fitted multivariable regression models with survival, in-hospital expenditures, and post-acute-care disposition as our dependent variables.
*Results:* Of 247,684 patients included in this study, 58.8% were men; mean age was 67 years. Overall trend of survival to discharge was unchanged ($P_{trend}$ = 0.56) but a non-significant linear trend increase (49.9% [95% CI, 39.8%–60.0%] in 1995 to 54.0% [95% CI 46.3%–61.8%] in 2013) was noted. Survival improved for patients with VF arrest rhythm but not for those with non-VF arrest rhythm. Increasing age, female gender, non-Caucasian race, high comorbidity burden, non-private primary insurance, non-VF-arrest rhythm and weekend arrest were all negatively associated with neurologically-intact survival. The cost of hospitalization increased from $18,287 ($683) in 2001 to $21,092 ($514) in 2013 at an average annual rate of $261 ($P_{trend}$ < 0.001). No change in post-acute discharge disposition was observed except for transfer to a short-term hospital ($P_{trend}$ < 0.01).
*Conclusions:* Overall survival to discharge following out-of-hospital cardiac arrest remained static between 1995 and 2013. Renewed national efforts are needed to warrant better knowledge translation and wider implementation of the best available science in order to improve outcomes.


## Introduction

In the United States, cardiovascular mortality and disease burden is lower than other highly populated countries[1]; however, cardiovascular disease continues to be the leading cause of mortality with heart disease accounting for one of every seven deaths in the country (~370,000 deaths/year).[2] The estimated U.S. annual incidence of sudden cardiac death has been reported to range from 180,000 in 1980 to more than 450,000 in 2007.[3] Using 2015 census data, extrapolation of the incidence and case fatality rate of EMS-assessed out-of-hospital cardiac arrest by the Resuscitation Outcomes Consortium (ROC) investigators suggest that each year in the United States, around 347,000 adults (quasi CI, 341,000–353,000) experience EMS-assessed out-of-hospital cardiac arrests (OHCA).[2]

Studies from quality improvement registries investigating trends in OHCA survival in participating United States communities have shown increased survival over time.[4,5] However, a recent meta-analysis concluded that survival rates have been stable for almost 30 years.[6] Although there is ample reason to believe that adoption of high quality practices and other performance improvement activities should lead to higher rates of OHCA survival in the United States, this has not been consistently demonstrated.

Therefore, in order to better understand whether results from quality improvement registries may be generalizable to the entire nation particularly to communities not participating in such registries and also assess the impact of post-arrest care on national healthcare expenditure, we used the Nationwide Inpatient Sample (NIS) database to assess trends in survival to hospital discharge, in-

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hospital expenditures, and post-acute-care disposition following OHCA in the United States. In addition, we sought to examine which patient- and hospital-level factors are associated with survival with good neurologic outcome.

## Materials and methods

### *Data source*

Data were obtained from the Agency for Healthcare Research and Quality's (AHRQ's) Healthcare Cost and Utilization Project-Nationwide Inpatient Sample (NIS) files yearly from 1995 through 2013. The NIS is the largest publicly available all-payer inpatient health care database in the United States. The database contains data from 7 to 8 million hospital stays each year.[7,8]

The NIS contains de-identified clinical and resource utilization information. The database results have been shown to correlate well with other national databases in the United States (American Hospital Association Annual (AHA) Survey Database, National Hospital Discharge Survey (NHDS) and Medicare Provider Analysis and Review (MedPAR) data).[9] The NIS has also been widely used for national analyses on cardiac arrest and other acute illnesses and to evaluate the utilization and safety of various procedures.[10–13] Approval for the use of the NIS patient-level data in this study was obtained from the Institutional Review Board of Johns Hopkins University and from the Healthcare Cost and Utilization Project.

### *Study population*

We used the *International Classification of Diseases, Ninth Edition, Clinical Modification* (*ICD-9-CM*) codes 427.5 (cardiac arrest) and 427.41 (ventricular fibrillation) to identify adult patients ≥18 years of age with a principal diagnosis of out-of-hospital cardiac arrest (OHCA) from 1995 to 2013 (Supplementary eFig. 1).[14] Previous studies using state-wide databases as well as Medicare/Medicaid claims data have shown ICD-9-CM codes, at the principal diagnosis position, to be reliable in accurately identifying patients with OHCA.[15–17] We excluded patients with traumatic OHCA (injury *ICD-9-CM* diagnosis codes 800–999 or E800–E900). We also excluded patients with missing data on survival and patients transferred from other acute care hospitals to avoid duplication of cases.

### *Definition of variables*

We used NIS variables to identify patients' age, sex, race, median household income for patient's zip code, primary expected payer, weekday versus weekend admission, arrest rhythm (VF versus non-VF), and comorbidities.[18] Other clinically relevant comorbidities (acute myocardial infarction, atrial fibrillation, carotid artery disease, known coronary artery disease, dyslipidemia, previous cardiac arrest, prior coronary artery bypass grafting, prior myocardial infarction, prior percutaneous coronary intervention, and smoking status) were identified using ICD-9-CM codes (Supplementary eTable 1). Comorbidity burden was assessed using Deyo's modification of Charlson's co-morbidity index (CCI).[19] NIS hospital variables included geographical region, bed size, location and teaching status. We divided the study years into four sub-groups: 1995–1999, 2000–2004, 2005–2009 and 2010–2013.

### *Study outcomes*

The primary outcome in this study was survival to discharge, defined as the proportion of hospitalized OHCA patients who were discharged alive. Both state-specific (every 5 years) as well as yearly (1995–2013) rates were calculated. Using the direct method of standardization, survival rates were age- and sex-standardized using the 2010 U.S. Census Bureau data as reference population.[20] Secondary outcomes included post-acute care discharge disposition, total hospitalization cost and charges, and survival with good neurologic outcome defined as the proportion of OHCA patients alive upon discharge who (1) were not comatose (*ICD-9-CM* code 780.01), (2) did not sustain a permanent anoxic brain injury (*ICD-9-CM* code 348.1 & 997.01), and (3) were not discharged alive in a persistent vegetative state (*ICD-9-CM* code 780.03).

We classified post-acute discharge disposition for all OHCA patients who survived to hospital discharge as discharge to home (self-care), short-term hospital, skilled nursing facility, home health care, or other.[18] Total hospital charges represent the amount hospitals billed for the entire hospital stay but does not reflect the actual cost. The HCUP provides data that contain hospital-specific cost-to-charge ratios based on all-payer inpatient cost. This cost information is obtained from the hospital accounting reports collected by the Centers for Medicare and Medicaid Services (CMS).[21] Using this information, total hospital costs were calculated as total hospital charges multiplied by the corresponding cost-to-charge ratio. Charges and Costs were adjusted for inflation using the year-specific Consumer Price Index provided by the US Bureau of Labor Statistics, with 2015 as the index base.[22]

### *Statistical analysis*

Analyses were performed using Stata/MP version 13.0 (StataCorp Inc., College Station, TX). All *p*-values were 2 sided with a significance threshold of $P < 0.05$. Weighting of patient-level observations was implemented to obtain estimates for the entire U.S. population of hospitalized OHCA patients. Patient- and hospital-level characteristics were compared among the year-specific subgroups using the Pearson $\chi^2$ test for categorical variables and univariate linear regression (1-way ANOVA) for continuous variables.

Odds ratios (ORs) with 95% confidence intervals were calculated by logistic regression analyses to examine association between baseline patient/hospital characteristics and survival to discharge with good neurologic outcome for the entire study period. Analysis models were adjusted for age, sex, race, comorbidities, primary payer, patient' income, weekend versus weekday arrest, arrest rhythm, and hospital characteristics (region, size, location and teaching status).

To assess whether survival to discharge has changed over time, multivariable logistic regression models were constructed for the overall cohort and by rhythm type while accounting for hospital strata and clustering of patients within hospitals. In these models, our independent variable, calendar year, was included as a continuous variable (1995–2013) alongside age and sex. To examine temporal trends in post-acute discharge disposition, multinomial regression models were constructed to examine the change in proportion of patients discharged to each specific destination with calendar year added to the model as an independent continuous variable. Similarly, linear regression models were used to examine temporal trends in inflation-adjusted hospitalization charges and costs.

To test whether missing data could introduce bias into the study, we made the assumption that data was missing at random (MAR) and applied the MICE (multivariate imputation by chained equations) method estimated from sequential multivariable models with fully conditional specifications.[23,24] Overall, 25 imputed data sets were constructed using information from all covariates used in regression models as well as other covariates in the database without missing information. Results with and without imputation were not meaningfully different. Thus, the former are reported except in Table 2 where regression results for complete case analyses are also presented.