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# Unchanged pediatric out-of-hospital cardiac arrest incidence and survival rates with regional variation in North America☆

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ABSTRACT

*Aim:* Outcomes for pediatric out-of-hospital cardiac arrest (OHCA) are poor. Our objective was to determine temporal trends in incidence and mortality for pediatric OHCA.
*Methods:* Adjusted incidence and hospital mortality rates of pediatric non-traumatic OHCA patients from 2007–2012 were analyzed using the 9 region Resuscitation Outcomes Consortium—Epidemiological Registry (ROC-Epistry) database. Children were divided into 4 age groups: perinatal (<3 days), infants (3 days–1 year), children (1–11 years), and adolescents (12–19 years). ROC regions were analyzed post-hoc.
*Results:* We studied 1738 children with OHCA. The age- and sex-adjusted incidence rate of OHCA was 8.3 per 100,000 person-years (75.3 for infants vs. 3.7 for children and 6.3 for adolescents, per 100,000 person-years, $p < 0.001$). Incidence rates differed by year ($p < 0.001$) without overall linear trend. Annual survival rates ranged from 6.7–10.2%. Survival was highest in the perinatal (25%) and adolescent (17.3%) groups. Stratified by age group, survival rates over time were unchanged (all $p > 0.05$) but there was a non-significant linear trend (1.3% increase) in infants. In the multivariable logistic regression analysis, infants, unwitnessed event, initial rhythm of asystole, and region were associated with worse survival, all $p < 0.001$. Survival by region ranged from 2.6–14.7%. Regions with the highest survival had more cases of EMS-witnessed OHCA, bystander CPR, and increased EMS-defibrillation (all $p < 0.05$).
*Conclusions:* Overall incidence and survival of children with OHCA in ROC regions did not significantly change over a recent 5 year period. Regional variation represents an opportunity for further study to improve outcomes.



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## Introduction

While the incidence of pediatric out-of-hospital cardiac arrest (OHCA) is low (8 per 100,000 person-years), survival to hospital discharge is only 6%.[1] Poor outcomes after pediatric OHCA have been related to patient, event, resuscitation, and post-resuscitation care factors. These include a high frequency of unwitnessed arrests, asphyxial events, unfavorable presenting rhythms, long duration of pulselessness, and lack of effective post-resuscitation care therapies.[2–5]

Multiple efforts have led to improved pediatric in-hospital cardiac arrest (IHCA) survival (14–43% over a 10-year study period) without an increase in the frequency of severe disability among survivors.[6,7] Data from the Resuscitation Outcomes Consortium (ROC) have also shown increased survival over time for adult OHCA victims but regional variation exists.[8,9] Data from Australia/New Zealand and Denmark have not demonstrated improvements in survival after pediatric OHCA but recent data from Sweden in children aged 0–21 years showed that 30-day survival increased from 6% in 1992–1998 to 14% in 2007–2012.[10,11]

Little is known about regional trends in the incidence and outcomes after pediatric OHCA in North America. The purpose of this study was to determine temporal trends in incidence and mortality for pediatric OHCA using the prospective ROC Epidemiological Registry (ROC-Epistry) database. We hypothesized that the incidence and survival to hospital discharge following pediatric OHCA have improved over time.

## Methods

### *Design and setting*

This is a prospective cohort of consecutive pediatric OHCA cases. The ROC is a collaboration of 10 regional sites in the United States and Canada managed through a single Data Coordinating Center. Formed in 2004, the ROC's primary goal is to conduct out-of-hospital randomized controlled trials in patients with life threatening trauma and cardiac arrest. The regional sites consist of the participating Emergency Medical Support (EMS) agencies and receiving hospitals serving a combined population of approximately 24 million individuals.[12]

The primary data source for this analysis was the ROC-Epistry database.[13] This prospective observational population based registry collects data on all OHCA cases responded to by participating EMS agencies. The present study included 9 regions (3 Canadian and 6 American) that continuously participated in ROC-Epistry during a five-year period between July 1, 2007 and June 30, 2012. We excluded one region and the initial registry start-up years (2005–2006) because of incomplete case capture. Because EMS agency participation varied over the period, only cases in which the first responding agency participated in the registry for the full 5 year study period were included for internal consistency.

### *Study population*

Subjects included children ages 0–19 years of age and excluded children with traumatic causes of cardiac arrest and those participating in ongoing clinical trials (age 18 years and older). Treated cases were defined as children who received EMS treatment, including cardiopulmonary resuscitation (CPR) or defibrillation at any time. Non-treated cases were those children who did not receive EMS treatment, presumably due to do-not-resuscitate status or obvious signs of death such as rigor mortis or dependent livid appearance. We divided subjects a priori into 4 age groups: perinatal (less than 3 days), infants (4 days up to 1 year), children (1–11 years), and adolescents (12–19 years).[1] This observational study met the requirements for waiver of informed consent for minimal risk research in the United States and Canada, and was approved by 74 Institutional Review boards and 34 Research Ethics boards.[1]

### *Data collection, management, quality and outcome measures*

Data from EMS records were transferred to ROC data collection forms by trained research coordinators. Details of ROC data management and quality assurance have been reported previously.[9] Clinical variables included patient demographics, Advanced and Basic Life Support team response, median time to EMS response; cardiac arrest and resuscitation interventions, and outcomes which included return of spontaneous circulation (ROSC) and survival to hospital discharge. We did not analyze functional outcome, etiology of arrest, and race/ethnicity, because information about these variables was incomplete or not available.

The primary outcomes were trends in incidence of pediatric OHCA and survival to hospital discharge over the study period controlling for year, age, sex, and region. The secondary outcomes were incidence and survival by region and variables associated with survival. Regions were defined by the 9 ROC geographic regions, each comprised of participating EMS agencies within the region.[13]

### *Statistical analysis*

We examined subject characteristics, cardiac arrest event and treatment factors, treatment status, EMS response characteristics, as well as outcomes by age group, region, and year using descriptive statistics. Complete variables were available only for EMS-treated cardiac arrest episodes and not for non-treated cases.

To calculate incidence rates, we first identified catchment areas by determining the location of all cardiac arrests by census tract, as defined according to the United States 2010 or the 2011 Canada census. We converted locations recorded using the geographical coordinate systems of Universal Transverse Mercator (UTM) or latitude and longitude to the corresponding census tract. Cases entered with a census tract designation from previous versions of the censuses were updated to the most recent tract designation using conversion tables provided by the census bureaus. With the collection of identified tracts, we defined the catchment area of a region to include all tracts with two or more cases or an adjacent tract with one case. We used the reported pediatric population in a specific catchment area from the 2010/2011 censuses as the denominator for our incidence calculations. The numerator was the number of pediatric cases occurring in the area. We reported incidence rates for three age groups: perinatal/infants, children, and adolescents, where the first two age groups were combined to match available census age group data. Canadian episodes that occurred outside of a census tract were not included in our incidence calculations. When reporting incidence rates we standardized to a population that had a uniform distribution of age and gender.

We tested for difference in incidence rates by age group, year, and region using a chi-squared test with 0.05 as the criterion for significance. We estimated linear differences in incidence rates using linear regression with Wald tests. We evaluated differences in survival to hospital discharge in treated cardiac arrest subjects using adjusted logistic regression models and the likelihood ratio test to jointly test factorized forms of age group, year period (from July to June), and region. We a priori selected covariates to include in the multiple regression models, as listed in the table footnotes. Statistical analyses were performed in SAS, version 9.3 and R, version 2.15.2, with the packages Maps, Maptools and US Census 2010.