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The association between neighborhood effects and out-of-hospital cardiac arrest outcomes[☆],[☆☆]

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A R T I C L E   I N F O

A B S T R A C T

Background: To date, 72% of variability in survival following out-of-hospital cardiac arrest (OHCA) is explained by the Utstein variables. Whether neighborhood factors further influence a return of spontaneous circulation or survival after OHCA is poorly understood.

Methods: We completed a retrospective cohort study of all paramedic-treated OHCA within the City of Toronto's 531 census tracts between 2006 and 2014. Neighborhood variables included the Ontario Marginalization Index – a measure of poverty, ethnicity and instability – crime rate and the density of family physicians. Hierarchical logistic regression analysis explored the association between a patient's census tract (neighborhood) characteristics and survival to hospital discharge and a prehospital return of spontaneous circulation (ROSC). Receiver operator characteristics curves measured how the Utstein variables and neighborhood factors discriminate OHCA outcomes.

Results: There were 23,067 OHCA during the study period, with 10,097 cases excluded due to obvious death, 896 from an obvious etiology and 2589 cases for other reasons, leaving 9485 patients for analysis. Of the neighborhood variables, only census tracts with a moderate ethnic concentration had an increased likelihood of survival-to-hospital discharge. The Utstein variables accounted for 89.2% of survival and 39.8% of prehospital ROSC. Adding all neighborhood factors to the Utstein model increased discrimination for survival to discharge to 89.8% ($p = 0.005$) and of a prehospital ROSC to 40.8% ($p = 0.006$).

Conclusions: Residential neighborhood factors marginally improve discrimination for outcomes after an OHCA, beyond the Utstein variables. Further research should explore the influence of other currently unmeasured neighborhood factors on OHCA outcomes.

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Introduction

Each year an estimated 300,000 people suffer an out-of-hospital cardiac arrest (OHCA) in North America.[1] Unfortunately, only 10% of patients survive to hospital discharge.[1] Data from the Resuscitation Outcome Consortium indicate that doubling survival from 7.9% to 16.3% could lead to an additional 14,785 premature deaths being prevented in Canada and the United States.[2,3]

The Utstein variables are currently the accepted "best standard" set of variables used to adjust for in OHCA research, as they are most

closely associated with favorable outcomes. Formulated in 1990 and modified in 2004, these variables were collectively referred to as the Utstein template, and are used to enable both universal and consistent reporting of data elements across countries and generalizability of study findings.[4]

Despite the evidence supporting the associations between the Utstein variables and survival,[5] few studies have investigated their ability to discriminate OHCA outcomes.[3] Recently Rea et al. studied more than 10,000 EMS-treated OHCA from the Resuscitation Outcomes Consortium database. They demonstrated that the Utstein variables predicted 72% of all non-traumatic EMS-treated survival, with initial cardiac rhythm explaining 66% of survival among treated cases.[3] Thus, while the Utstein variables are a worthwhile foundation to guide care, unknown factors may explain up to 28% of the reported variability in OHCA survival.

Evidence from other disciplines suggests that neighborhood level factors influence health outcomes. Numerous studies have evaluated socioeconomic status (SES)[6–9] and race/ethnicity[7,10–16] and their association with OHCA survival, but their results have been inconsistent, and none have considered those factors account for survival in addition to the Utstein variables. Moreover, none evaluated geographic, environmental, social and cultural factors collectively as determinants of OHCA outcomes.

The objectives were to investigate whether a patient's residential neighborhood factors improve the discrimination for survival to hospital discharge or a return of spontaneous circulation (ROSC) at emergency department (ED) arrival, in addition the conventional Utstein variables.

Methods

Study design

This was a retrospective cohort study investigating the role of neighborhood factors as determinants of OHCA outcomes. The Research Ethic Boards of St. Michael's Hospital and the University of Toronto approved the study. The full methods of this study have been published elsewhere,[17] but are summarized briefly below.

Setting and study participants

All patients who experienced an OHCA between January 1st, 2006 and December 31st, 2014 were included. This was a retrospective population-based cohort study using data from the Toronto Regional RescuNET cardiac arrest database; Rescu Epistry, which is compliant with the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest and based on the Strategies for Post Arrest Care methodologies that are described elsewhere.[18,19] Briefly, Rescu Epistry includes consecutive OHCA patients assessed by prehospital care providers. Data is entered into Rescu Epistry after each OHCA, and includes patient identifiers, call characteristics, prehospital interventions and outcomes.[19]

We included all adult patients aged ≥20 years, who sustained a non-traumatic OHCA, were treated by Toronto Paramedic Service, and whose home postal code was within the City of Toronto. Any patient who met the criteria for obvious death (i.e., presence of rigor mortis, levidity, decapitation, hemi-section, or decomposition), who had a valid "Do Not Resuscitate" (DNR) advanced directive, who had an arrest of known etiology (ex. trauma or asphyxiation), or whose arrest was witnessed by paramedics were also excluded. We also excluded any patient who lacked sufficient residential information necessary for geocoding.

Geocoding and neighborhood variables

A patient's residential postal code was abstracted from both prehospital and in-hospital data, and then linked to one of the 531 nine-digit census tracts using the Statistics Canada Postal Code Conversion File program.[20] A census tract is a limited geographical area that contains about 2500–6000 people, who, based on their proximity to each other tend to share similar demographics, such as education level and income.[21] Each cardiac arrest patient was then assigned the characteristic of the census tract corresponding to his/her residential postal code.

Six neighborhood level measures were collected across all 531 census tracts: (1) the four measures (domains) of the Ontario Marginalization Index, (2) violent crime rate and (3) the density of family physicians. The Ontario Marginalization Index is a geographically derived index used to study social and economic marginalization, and to highlight inequalities in various measures of health and social well being.[22] Its four domains are residential instability, dependency, material deprivation, and ethnic concentration.[22] Crime rate was expressed as a number of violent crimes per 100,000 people at risk.[23] The density of family physicians was expressed as the number of family physicians per 100,000 inhabitants.[24]

Each of the six neighborhood variables was converted from its continuous form into quintiles, where quintile 1 (Q1) represents a disadvantaged neighborhood and quintile 5 (Q5) represents an advantaged neighborhood.

Statistical analysis

Descriptive statistics were used to assess the distribution of all variables. Continuous variables were summarized as means and standard deviations, while categorical variables were summarized as counts and percentages.

Unadjusted bivariate analyses were performed to assess for differences between the independent variables and the outcome measures. t-Tests were applied for all continuous variables and Chi-square tests for discrete or categorical variables. Model diagnostics were performed, and multicollinearity was assessed using tolerance statistics and the variance inflation factor (VIF). Upon assessing all Utstein and neighborhood variables included in all models, none showed evidence of multicollinearity (VIF >2.5 in all instances).

Multivariable logistic regression analysis was used to assess the relation between the neighborhood factors (in addition to the traditional Utstein variables) and the outcomes of survival to hospital discharge and a ROSC at ED arrival. The logistic regression models used a hierarchical modeling approach using a binomial distribution and generalized estimating equations to capture variation within neighborhoods using an independent correlation structure. Patients were clustered by census tracts. A total of eight models were run. Model #1 contained only the Utstein variables. Models #2 to #7 included the Utstein variables and each one of the six neighborhood factors, respectively. Model #8 included the Utstein variables and all six neighborhood factors together.[17] A post hoc analysis was conducted to evaluate the effects of the neighborhood variables alone and collectively on discrimination. Odds ratios and 95% confidence intervals (CI) were used to estimate the associated risk between one or more independent variables and each study outcome.

Receiver operating characteristics (ROC) curves were used to measure each model's discriminative ability, as described by the area under the curve (AUC). The AUC, as measured by the c-statistic, measures the discriminative ability of the model. Values between 0.7 and 0.8 indicate acceptable discrimination, while values 0.8–0.9 indicate excellent discrimination, and calculated as