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Derivation and initial application of a standard population for out-of-hospital cardiac arrest (SPOHCA)☆

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ABSTRACT

Aim: While adjusting data for age, sex, race and/or socio-economic status is well established in out-of-hospital cardiac arrest (OHCA) research, there are shortcomings to reporting and comparing population-based OHCA outcomes. The purpose of this study was to derive a case-based standard population specific to EMS treated adult OHCA (SPOHCA) in the U.S., and demonstrate its application.
Methods: The proposed SPOHCA was developed from three sources of multi-site OHCA data: the Cardiac Arrest Registry to Enhance Survival (CARES); the National EMS Information System (NEMSIS); and a published report from the Resuscitation Outcomes Consortium (ROC). OHCA data from a single EMS system were then used to demonstrate the application of SPOHCA. We report raw survival, population-based survival adjusted to the U.S. population, and the new SPOHCA-adjusted survival.
Results: Observed raw survival was 12.3%. Adjustment to the demographic make-up of the adult U.S. population produced an adjusted incidence of 94.2 OHCA per 100,000 p-y, with a survival rate of 9.8 per 100,000 p-y. Using the proposed SPOHCA to adjust survival data produced an adjusted survival rate of 12.4%.
Conclusion: A case-based standard population provides for more practical interpretation of reported OHCA outcomes. We encourage a more widespread effort involving multiple stakeholders to further explore the effects of adjusting OHCA outcomes using the proposed SPOHCA instead of population-based demographics.

1. Introduction

Improving survival from out-of-hospital cardiac arrest (OHCA) is a leading priority for public health officials and emergency medical services (EMS). Roughly 300,000 people in the United States (U.S.) suffer OHCA each year, with current resuscitation rates hovering between 4% and 8%.[1,2] Considerable resources have been allocated to studying interventions aimed at improving OHCA survival[3–5] and establishing standardized approaches to measuring and reporting resuscitation rates.[1,6] Utstein survival rates, stratified by whether OHCA is witnessed and the presenting cardiac rhythm,[6] have become a *de facto* performance measure for EMS systems striving to improve OHCA resuscitation rates.[7,8]

Whether OHCA is witnessed and the presenting rhythm, however, are not the sole determinants of OHCA survival. Age, race, socioeconomic status, comorbidities, arrest etiology, type of location and bystander CPR—and the interactions between these variables—are associated with both incidence of and survival from EMS-treated OHCA.[2,9–12] For EMS systems interested in benchmarking OHCA resuscitation rates, comparing their raw or Utstein OHCA survival rates to those of other systems is problematic.

Adjusting incidence or outcome data for age, sex, race and/or socioeconomic status is well established in OHCA research.[2,9–11] In comparative studies, statistical adjustment for these potential confounders can be performed within the study data, (e.g., by performing multi-variable regression modeling). One option for descriptive analyses reporting single system data is to report population-based incidence or outcome data, which can be adjusted by normalizing locality demographic characteristics to an established standard population such as the U.S. Standard

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Population or the World Standard Population.[13,14] If the same standard population is used to generate these adjusted survival rates, then reported OHCA resuscitation rates from different locations can be directly compared.

One shortcoming of reporting population-based OHCA outcomes is that geographic differences exist in the incidence of OHCA that cannot be completely explained by the demographics of the local population.[2] Another problem is that localities with a higher incidence of EMS-treated OHCA can simultaneously have higher population-based survival rates *and* higher population-based mortality rates. This paradox, which occurs because the reported outcomes relate to the population at risk for OHCA rather than specifically to patients who suffer OHCA, has appeared in actual cardiac arrest data: in a report describing regional variations in OHCA survival among Resuscitation Outcomes Consortium (ROC) sites, Seattle had both the highest adjusted OHCA survival rate (12.2 per 100,000 population) and the second worst adjusted OHCA mortality rate (131.8 per 100,000 population).[2] Additionally, population-based outcomes for multi-year data must be reported in units of 'person-years,' which is a less-than-intuitive concept.

While researchers, epidemiologist and statisticians might be facile enough to extract practical meaning from adjusted population-based OHCA data, clinicians, policy-makers and the lay public can struggle with their interpretation. A realistic, case-based standard population for OHCA (SPOHCA) could provide for more practical interpretation and comparison of reported outcomes data by non-scientist medical professionals, health system administrators, community leaders and lay people. The goals of this preliminary study were to derive a case-based SPOHCA specific to EMS-treated adult OHCA in the U.S., and demonstrate its application using resuscitation data from a single U.S. EMS system.

2. Methods

2.1. Development of SPOHCA

Three publicly available sources of multisite OHCA data were used in the derivation of the SPOHCA: (a) the Cardiac Arrest Registry to Enhance Survival (CARES), (b) the National EMS Information System (NEMSIS), and (c) the Resuscitation Outcomes Consortium (ROC).

CARES collects and analyzes data from communities in 23 states in an effort to improve the quality of care and outcomes for OHCA patients.[1] CARES utilizes Utstein-style definitions and reporting templates. In 2011, CARES published its first report, which included 5 years of surveillance data and summarized more than 31,000 OHCA events reported by 46 EMS systems in 20 states.[1]

NEMSIS is an effort to establish a national EMS database for the U.S. NEMSIS data are publicly available through a web-based interface. Of the more than 42 million records included in NEMSIS for 2011 through mid-2014, 300,456 represented OHCA of presumed cardiac etiology attended by a transport-capable EMS agency.[15]

ROC is a North American network comprised of 11 sites and 260 EMS agencies serving a population of nearly 24 million. The ROC Epistry is a multicenter, observational registry that collects uniform data on OHCA.[5] In 2008, ROC published a report describing more than 20,000 OHCA occurring at 10 ROC sites over a 12-month period.[2]

These data sources are not representative of all OHCA cases in the U.S., and overlap exists among the OHCA events they report. Thus, the derived SPOHCA could not be uniformly calculated from these data; rather, it is better described as being "informed" by the approximate mid-points, based on the weighted average, of the data available from these three sources.

Table 1
Derivation of age standardized OHCA population.

CARES[1]		NEMSIS[15]		Proposed SPOHCA	
Ages	%	Ages	%	Ages	%
0–17	1.9	0–1	0.6	0–17	N/A
		1–9	1.4		
		10–17[a]	2.2		
18–34	3.7	18–19[a]	0.6	18–39	10.0
		20–29	4.6		
35–39[b]	4.4	30–39	4.7		
40–49[b]	8.7	40–49	8.4	40–64	33.0
50–64	30.2	50–59	14.8		
		60–64[c]	8.7		
65–79	28.8	65–69[c]	8.7	65+	57.0
		70–79	17.8		
80+	22.3	80–89	17.9		
		90–99	6.1		
		100+	0.3		
Unknown	0.3	Unknown	3.4	N/A	N/A

[a] Calculated from NEMSIS 10–19 age group data (2.8%).
[b] Calculated from CARES 35–49 age group data (4.7).
[c] Calculated from NEMSIS 60–69 age group data (17.4%).

2.1.1. Age standardization

Table 1 shows the derivation of the age groups for the proposed SPOHCA. CARES reports ages of OHCA patients in six groups,[1] while NEMSIS reports ages in 12 groups (plus an "Unknown" category) that do not entirely correspond to the CARES age categories.[15] We excluded children under the age of 18, because arrests in children are rare and typically represent a different disease process. We then collapsed the remaining age categories into three groups: (1) 18–39; (2) 40–64, and (3) 65 and older. Where the CARES or NEMSIS age categories spanned break-points in the SPOHCA age groups, the observed frequencies in that CARES or NEMSIS age category were pro-rated equally among the included ages. The ROC paper reported only median age: 67 years.[2]

2.1.2. Sex standardization

Table 2 shows the derivation of the sex distribution for the proposed SPOHCA. After recalculating the sex distribution in each source dataset ignoring the missing or unknown data, the weighted average of the proportions of male and female OHCA patients was calculated and rounded to the nearest whole number.

2.1.3. Race/ethnicity standardization

Table 3 shows the derivation of the race/ethnicity groupings for the proposed SPOHCA. Amalgamating the race/ethnicity data presented several difficulties. CARES reports race/ethnicity as a single data point, with Hispanic included as a distinct category.[1] NEMSIS reports race separately from Hispanic ethnicity, including the categories Other and Unknown in addition to the five U.S. Census racial designations.[15,16] While the ROC Epistry allows simultaneous entry of multiple race and ethnicity categories for any case,[5] those data were not included in the source article for this analysis (and to our knowledge have not been published elsewhere). Hispanic ethnicity is the only ethnic subgroup reported in any of these sources.

We cross-tabulated the NEMSIS race/ethnicity data to determine the percentage of White, Black and other race patients who

Table 2
Derivation of sex standardized OHCA population.

	CARES%[1]	NEMSIS%[15]	ROC%[2]	Proposed SPOHCA%
Male	61.1	52.6	61.0	57.0
Female	38.9	44.4	38.2	43.0
Unknown	<0.1%	3.0	0.8%	N/A