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Clinical paper

International variation in survival after out-of-hospital cardiac arrest: A validation study of the Utstein template

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Abstract

Introduction: Out-of-hospital cardiac arrest (OHCA) survival varies greatly between communities. The Utstein template was developed and promulgated to improve the comparability of OHCA outcome reports, but it has undergone limited empiric validation. We sought to assess how much of the variation in OHCA survival between emergency medical services (EMS) across the globe is explained by differences in the Utstein factors. We also assessed how accurately the Utstein factors predict OHCA survival.

Methods: We performed a retrospective analysis of patient-level prospectively collected data from 12 OHCA registries from 12 countries for the period 1 Jan 2006 through 31 Dec 2011. We used generalized linear mixed models to examine the variation in survival between EMS agencies (n = 232).

Results: Twelve registries contributed 86,759 cases. Patient arrest characteristics, EMS treatment and patient outcomes varied across registries. Overall survival to hospital discharge was 10% (range, 6% to 22%). Overall survival with Cerebral Performance Category of 1 or 2 (available for 8/12 registries) was 8% (range, 2% to 20%). The area-under-the-curve for the Utstein model was 0.85 (Wald CI: 0.85–0.85). The Utstein factors explained 51% of the EMS agency variation in OHCA survival.

Conclusions: The Utstein factors explained 51% of the variation in survival to hospital discharge among multiple large geographically separate EMS agencies. This suggests that quality improvement and public health efforts should continue to target modifiable Utstein factors to improve OHCA survival. Further study is required to identify the reasons for the variation that is incompletely understood.

Keywords: Out-of-hospital cardiac arrest, Utstein, Emergency Medical Services, Outcomes, Survival

Introduction

Out-of-hospital cardiac arrest (OHCA) survival is often poor (<10%),[1] however, there is large variation in survival after OHCA between communities.[2,3] Some of these differences reflect differences in the structure and function of emergency medical services (EMS); others reflect differences in the method of measuring process and outcome. The Utstein template, which includes patient and EMS factors, was developed and promulgated to improve the comparability of intra- and inter-site reports of outcomes after OHCA.[4] Its components have been selected and refined through expert consensus but the template has undergone limited empiric validation. Therefore it is incompletely understood how accurately and completely the Utstein factors explain the variation in survival between communities.

A North American study revealed that the Utstein factors poorly predicted survival after OHCA, especially among patients who had a first recorded rhythm that was shockable.[5] Another study comparing OHCA survival between Sweden and Ireland found the Utstein factors accounted for only 17% of the variation in survival among bystander witnessed OHCA who had a first recorded rhythm that was shockable.[6] Both these studies did not take into account variation between EMS agencies, and did not consider all patients treated.[5,6] EMS agency may be a more natural unit for monitoring and reporting of outcome compared to country or administrative site. There has been no analysis of the Utstein factors at the EMS agency level nor an assessment of the validity of the Utstein factors among multiple international communities.

A better understanding of which factors contribute to improved survival in OHCA will help these factors to be implemented more broadly. It is also useful to understand which factors explain the biggest proportion of survival improvement to enable prioritisation, particularly in resource poor settings. Empiric evidence of whether the Utstein template explains international variation in survival would inform this discussion. Thus, our objective was to measure how much the Utstein factors explain the variation in OHCA survival between EMS agencies across the globe. Our secondary aim was to assess how accurately the Utstein factors predict OHCA survival.

Methods

We performed a retrospective analysis of prospectively collected patient-level data from 12 OHCA registries. Using this registry data, we measured how much of the variation in survival after OHCA between EMS agencies was explained by the Utstein factors. The study period was between 1 January 2006 and 31 December 2011, however not all registries provided data for the whole study period. The University of Washington Human Subjects Division determined that this study of previously de-identified data was exempt from human subjects research regulations.

Data sources

Twelve OHCA registries representing four continents, 12 countries and 232 EMS agencies provided data for this study. This study builds on our earlier work describing the international variation in the structure and function of OHCA registries.[7] All of the registries that participated in our previous study[7] provided data for this study, but data from the Utstein Osaka Project were excluded due to difficulty translating and verifying the data. The registries and their structure and function were previously described. We included registries that could provide patient-level data and had existing population-based cohorts of OHCA with at least one peer-reviewed publication and collected data during at least one year since 2005. De-identified patient-level data for all core Utstein factors was provided by each registry and coded to facilitate pooling.

The data for this study was collected (and the registries designed) before the publication of the 2015 update to Utstein template[8], therefore the definitions used in this study are based on the 2004 version of the template.[9] We examined the 21 core factors and six core time events in the Utstein template. The 21 core Utstein factors include: witnessed status, arrest witnessed by bystander, arrest witnessed by EMS personnel, assisted ventilation, attempted defibrillation, bystander cardiopulmonary resuscitation (CPR), cardiac arrest, cause of arrest (aetiology), chest compressions, date of arrest, age (in years), defibrillation attempt before EMS arrival, drugs (epinephrine and other drugs), first monitored rhythm, location of arrest, neurological outcome at discharge from hospital,

Table 1a – Baseline characteristics of all cases.

	Total N = 86,759	Survived to hospital discharge N = 8433	Died before discharge N = 78,326	Total with Known CPC N = 27,239	Survived with CPC 1 or 2 N = 2378	Death or survived with CPC 3 or 4 N = 24,861
Age (years), mean (SD) [N = 86,089]	64.8 (19.0)	59.7 (16.9)	65.3 (19.1)	64.2 (18.4)	59.7 (15.5)	64.7 (18.6)
Sex,%						
Female	34%	27%	35%	33%	24%	33%
Male	66%	73%	65%	67%	76%	67%
Missing or unknown	0.2%	0.1%	0.2%	0.4%	0.2%	0.4%
Location of arrest, %						
Home	71.0%	54.1%	72.9%	67.5%	46.9%	69.5%
Public	18.4%	36.6%	16.4%	23.5%	45.6%	21.3%
Other	10.6%	9.3%	10.7%	9.1%	7.5%	9.2%
Missing or unknown	0.8%	0.6%	0.8%	2.3%	0.8%	2.4%
Arrest witnessed, %						
EMS witnessed	11.2%	23.0%	9.9%	8.5%	20.5%	7.3%
Bystander witnessed	43.7%	59.6%	42.0%	49.4%	66.1%	47.8%
Other witnessed	1.1%	1.9%	1.0%	1.7%	3.6%	1.6%
Unwitnessed	43.9%	15.5%	47.1%	40.3%	9.8%	43.4%
Missing or unknown	6.6%	3.8%	6.9%	6.0%	2.1%	6.4%
Cause of arrest (aetiology), %						
Presumed cardiac	84.5%	88.7%	84.0%	79.3%	89.6%	78.2%
Trauma	2.9%	1.0%	3.1%	5.9%	0.9%	6.4%
Respiratory	3.3%	3.1%	3.3%	6.9%	3.2%	7.3%
Drowning	0.7%	0.8%	0.7%	1.1%	1.1%	1.1%
Other non-cardiac	8.6%	6.5%	8.9%	6.9%	5.2%	7.0%
Missing or unknown	4.6%	3.0%	4.8%	10.9%	3.1%	11.7%
Bystander CPR, non-EMS witnessed arrest, %						
Yes	35.8%	55.1%	34.0%	33.3%	68.7%	30.4%
No	64.2%	44.9%	66.0%	66.7%	31.3%	69.6%
Missing or unknown	19.1%	18.2%	19.2%	1.7%	2.1%	1.7%
Bystander shocks given, non-EMS witnessed arrest, %						
Yes	2.9%	8.9%	2.3%	2.5%	12.4%	1.6%
No	97.1%	91.1%	97.7%	97.5%	87.6%	98.4%
Missing or unknown	21.2%	12.8%	22.0%	17.7%	7.2%	18.5%
Initial rhythm, %						
VF or VT	24.9%	70.6%	20.0%	24.5%	74.5%	19.6%
PEA	20.3%	15.5%	20.8%	18.8%	17.0%	18.9%
Asystole	49.1%	10.9%	53.2%	54.9%	5.9%	59.8%
Other non-shockable	5.7%	3.0%	6.0%	1.8%	2.5%	1.7%
Missing or unknown	6.7%	8.3%	6.5%	10.8%	7.6%	11.1%
Continent, %						
Asia	13.0%	8.9%	13.5%	41.4%	9.8%	44.5%
Australia	12.6%	15.2%	12.4%	–	–	–
Europe	28.6%	38.7%	27.5%	58.6%	90.2%	55.5%
North America	45.7%	37.2%	46.6%	–	–	–

Table 1b – Baseline characteristics of all cases by registry.

	Arrest N = 6782	German resuscitation registry N = 3776	Helsinki cardiac arrest registry N = 1367	Irish OHCAR N = 1976	Oslo and Akershus registry N = 775	SJA-WA Cardiac arrest registry N = 2316	ROC N = 39,637	CAVAS project N = 8522	Swedish Register of CPR N = 8711	Taipei OHCA Registry N = 2791	VACAR N = 8658	VICAR N = 1,448
EMS agencies	N = 5	N = 8	N = 1	N = 1	N = 1	N = 1	N = 210	N = 1	N = 1	N = 1	N = 1	N = 1
Age (years), mean (SD)	N = 6725	N = 3776	N = 1367	N = 1935	N = 762	N = 2316	N = 39,450	N = 8522	N = 8402	N = 2789	N = 8613	N = 1,432
	64.1 (17.3)	68.0 (16.9)	62.6 (16.8)	63.2 (19.5)	64.4 (18.1)	59.8 (22.2)	65.2 (18.8)	60.8 (19.4)	67.6 (18.0)	70.4 (18.5)	63.3 (20.8)	65.8 (16.5)
Sex,%												
Female	29%	34%	30%	33%	32%	29%	36%	34%	33%	36%	32%	37%
Male	71%	66%	70%	67%	68%	71%	64%	66%	67%	64%	68%	63%
Missing or unknown	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%
Location of arrest, %												
Home	66.0%	68.4%	53.5%	67.3%	55.5%	68.7%	74.9%	69.9%	69.3%	73.4%	67.3%	64.6%
Public	28.9%	18.1%	37.5%	18.3%	28.7%	26.4%	14.5%	23.4%	17.5%	14.6%	19.0%	21.9%
Other	5.1%	13.5%	8.9%	14.4%	15.8%	5.0%	10.6%	6.7%	13.2%	12.1%	13.8%	13.6%
Missing or unknown	0.6%	1.3%	0.0%	0.4%	0.3%	0.0%	0.1%	5.9%	0.0%	0.4%	0.0%	0.8%
Arrest witnessed, %												
EMS witnessed	9.6%	13.9%	18.4%	8.2%	11.3%	11.4%	10.8%	2.6%	17.2%	9.4%	16.4%	8.7%
Bystander witnessed	63.3%	43.6%	66.9%	48.7%	57.1%	42.2%	40.1%	47.4%	37.7%	18.9%	47.4%	48.5%
Other witnessed	3.3%	–	–	8.7%	–	–	–	–	6.5%	3.0%	–	–
Unwitnessed	23.8%	42.5%	14.7%	34.4%	31.6%	46.4%	49.1%	50.0%	38.6%	68.6%	36.3%	42.7%
Missing or unknown	2.0%	–	–	13.3%	0.6%	0.5%	5.3%	12.8%	22.3%	5.6%	0.4%	–
Cause of arrest (aetiology), %												
Presumed cardiac	84.4%	74.7%	67.6%	85.4%	66.7%	79.7%	94.6%	78.7%	60.9%	55.7%	76.2%	87.3%
Trauma	2.9%	3.6%	2.4%	7.4%	–	10.7%	0.2%	9.3%	2.7%	16.0%	4.7%	1.8%
Respiratory	4.3%	11.4%	4.6%	2.9%	–	3.4%	0.2%	9.0%	4.4%	16.4%	5.6%	3.7%
Drowning	1.0%	0.6%	2.1%	0.7%	–	–	0.4%	1.6%	0.9%	1.3%	0.6%	0.5%
Other non-cardiac	7.4%	9.6%	23.2%	3.6%	33.3%	6.2%	4.5%	1.4%	31.1%	10.7%	12.9%	6.7%
Missing or unknown	0.0%	24.2%	17.6%	0.0%	0.0%	0.0%	0.1%	1.0%	10.7%	61.7%	0.0%	2.9%
Bystander CPR, non-EMS witnessed arrest, %												
Yes	70.5%	16.8%	56.7%	49.4%	64.2%	49.7%	20.1%	5.5%	97.9%	21.8%	54.0%	45.2%
No	29.5%	83.2%	43.3%	50.6%	35.8%	50.3%	79.9%	94.5%	2.1%	78.2%	46.0%	54.8%
Missing or unknown	2.4%	5.3%	0.9%	3.5%	0.6%	0.0%	31.3%	0.0%	38.9%	1.7%	4.3%	0.0%
Bystander shocks given, non-EMS witnessed arrest, %												
Yes	5.0%	0.5%	0.7%	4.3%	10.9%	–	2.7%	–	7.5%	–	2.8%	3.5%
No	95.0%	99.5%	99.3%	95.7%	10.9%	–	97.3%	100.0%	92.5%	–	97.2%	96.5%
Missing or unknown	0.1%	56.2%	0.0%	4.6%	0.3%	100.0%	7.7%	–	42.7%	100.0%	54.9%	0.0%
Initial rhythm, %												
VF or VT	39.6%	24.5%	38.5%	25.3%	32.9%	31.3%	23.3%	9.9%	26.2%	11.4%	29.9%	36.4%
PEA	31.1%	12.5%	35.2%	10.5%	20.7%	30.8%	20.8%	8.1%	13.8%	21.2%	24.8%	26.0%
Asystole	29.3%	58.5%	26.3%	58.0%	46.4%	37.9%	45.0%	80.1%	60.0%	66.3%	45.0%	37.6%
Other non-shockable	–	4.6%	–	6.2%	–	–	10.9%	2.0%	–	1.1%	0.3%	–
Missing or unknown	6.8%	4.8%	0.7%	12.9%	0.3%	0.4%	3.9%	16.4%	12.4%	16.1%	1.8%	15.4%

(continued on next page)

Table 1b (continued)

	Arrest N = 6782	German resuscitation registry N = 3776	Helsinki cardiac arrest registry N = 1367	Irish OHCAR N = 1976	Oslo and Akershus registry N = 775	SJA-WA Cardiac arrest registry N = 2316	ROC N = 39,637	CAVAS project N = 8522	Swedish Register of CPR N = 8711	Taipei OHCA Registry N = 2791	VACAR N = 8658	VICAR N = 1,448
Continent, %												
Asia	–	–	–	–	–	–	–	100.0%	–	100.0%	–	–
Australia	–	–	–	–	–	100.0%	–	–	–	–	100.0%	–
Europe	100.0%	100.0%	100.0%	100.0%	100.0%	–	–	–	100.0%	–	–	100.0%
North America	–	–	–	–	–	–	100.0%	–	–	–	–	–

SD, Standard deviation; EMS, Emergency Medical Service; CPR, Cardiopulmonary Resuscitation; VF, Ventricular Fibrillation; VT, Ventricular Tachycardia; PEA, Pulseless Electrical Activity.

resuscitation attempt by EMS personnel, return of spontaneous circulation (ROSC), sex, survived event and survival to hospital discharge. The location data element was simplified to three categories: home, public, or other because detailed location information was not available for all of the participating registries. The six core time events include: date of discharge/death, time of witness/monitored arrest, time when call received, time of first rhythm analysis/assessment of need for CPR, time of first CPR attempts, time of first defibrillation attempt if shockable rhythm. We also collected the year of the event because of the possibility of temporal changes in the process and outcome of care for OHCA.

Study population

We included all OHCA cases captured by the participating registries where resuscitation was attempted by EMS. Although the Utstein template recommends inclusion of patients assessed but not treated by EMS providers for OHCA, such data were not collated for this study because these patients have a poor prognosis and our ultimate objective was to assess whether the Utstein factors explain differences in survival among patients who were actively treated. Patients of all ages and OHCAs of all aetiologies were included. OHCA was defined as the cessation of cardiac mechanical activities as confirmed by the absence of signs of circulation.[8] Operationally, this was defined as chest compressions provided by EMS or defibrillation by lay or EMS. Patients who had an in-hospital cardiac arrest and patients who were not treated by EMS were excluded. An initial 'shockable' rhythm was defined as the patient presenting to EMS in ventricular fibrillation or pulseless ventricular tachycardia or where a bystander placed automated external defibrillator (AED) advised shock before EMS arrival. OHCAs were grouped by EMS agency (defined below) for the purposes of this study. The EMS agencies varied by region from single tiered to two-tiered and fire-based and third service.

Study setting

An EMS agency was defined a priori a single EMS agency or group of agencies that is under a single medical direction. For example, two EMS agencies that provide advanced life support (ALS) response to the same geographic area with separate medical direction will be considered separate agencies. Conversely, EMS providers that serve a large geographic area under a single medical direction will be considered a single agency. As well, if multiple agencies provide first response to a geographic area followed by an ALS service which has a single medical direction that may or may not include the first responding agencies, the region was considered a single geographic region under the ALS service. For the purpose of this analysis, ALS was defined as ability to insert an advanced airway (including endotracheal tube or supraglottic airway) and the ability to administer intravenous medications, regardless of whether the providers' professional background is that of paramedicine, nursing or physician as well as regardless of what treatment was actually administered to individual patients included in the analysis.

Outcomes

The primary outcome measure of this study was survival to hospital discharge. Return of spontaneous circulation upon hospital arrival and survival to hospital discharge with a cerebral

Table 2a – Characteristics of EMS treatment and patient outcomes for all cases.

	Total N = 86,759	Survived to hospital discharge N = 8433	Died before discharge N = 78,326	Total with Known CPC N = 27,239	Survived with CPC 1 or 2 N = 2378	Death or survived with CPC 3 or 4 N=24,861
Call to EMS assessment, mean (SD)	10.5 (22.6)	8.6 (13.5)	10.7 (23.3)	13.7 (44.1)	9.1 (20.8)	14.3 (46.2)
EMS chest compressions	97.1%	93.8%	97.5%	90.8%	97.3%	90.5%
Missing or unknown	14.8%	25.1%	13.7%	46.4%	74.6%	43.7%
Shocks given, %	36.0%	73.2%	32.0%	34.3%	82.7%	29.7%
Missing or unknown	0.7%	0.5%	0.8%	0.7%	0.4%	0.7%
Assisted ventilation, %	93.6%	90.6%	93.9%	80.4%	78.6%	80.5%
Missing or unknown	14.0%	24.1%	12.9%	43.8%	71.4%	41.2%
Drugs, %						
Epinephrine	63.5%	39.5%	65.9%	34.9%	43.3%	34.4%
Other drugs	2.0%	11.3%	1.1%	2.0%	5.6%	1.8%
No drugs	34.5%	49.1%	33.1%	63.1%	51.0%	63.8%
Missing or unknown	8.1%	16.6%	7.2%	24.7%	52.4%	22.0%
ROSC before ED, %	30.0%	91.5%	23.0%	29.6%	91.3%	21.3%
Missing or unknown	20.1%	15.7%	20.6%	31.9%	7.3%	34.3%
ROSC at ED arrival, %	21.3%	84.7%	15.2%	13.2%	87.7%	8.7%
Missing or unknown	26.8%	33.4%	26.1%	40.7%	61.7%	38.7%
Hospital admission, %	25.0%	99.5%	16.6%	28.7%	99.6%	21.7%
Missing or unknown	43.4%	40.5%	43.7%	12.6%	10.0%	12.9%
Survival to hospital discharge, %	9.7%	100.0%	0%	11.6%	100.0%	3.1%
Survival to discharge with CPC 1 or 2, %	8.3%	72.3%	–	8.7%	100.0%	0.0%
Missing or unknown	51.5%	42.5%	–	–	–	

EMS, Emergency Medical Service; SD, Standard deviation; ED, Emergency Department; CPC, Cerebral Performance Category.

performance category (CPC) of 1 or 2 were measured as secondary outcomes.

Statistical analysis

We used generalized linear mixed models (GLMM) with a logistic link to examine the variation in survival between EMS agencies as well as the relationship between the Utstein factors and outcomes. We tested the null hypothesis that survival was equally distributed between EMS agencies by using the Wald test for variance components in GLMM. The fixed effects included in the model were witnessed status (i.e., arrest witnessed by bystander, EMS personnel, other, or neither), attempted defibrillation, bystander CPR, cause of arrest (aetiology), chest compressions, year of arrest, age (0–18 years, 19–39, 40–49, 50–59, 60–69, 70–79, 80–89, or 90+), defibrillation attempt before EMS arrival, first monitored rhythm (shockable, PEA, asystole, or other non-shockable), location of arrest (home, public, or other), sex and time from call to EMS assessment. The random effects included in the model were EMS agency and interaction term between time and EMS agency. Cases with missing covariate data were included in the model, and coded as a missing category for that variable. A ROC curve was produced to assess the predictive ability of the model, and summarized with the area under the curve (AUC).

In addition to the full model, we repeated the analysis in subgroups defined a priori by aetiology (Non-traumatic/Presumed cardiac/Non-Cardiac), initial rhythm (shockable/non-shockable), witness status (EMS witnessed/Not EMS witnessed), bystander (Lay) witnessed with a shockable initial rhythm, and age group (Adult >18 years/Child 1 ≤ 18 years). Due to the low number of survivors, we excluded infant OHCAs (<1 year of age) from the model.

We performed a sensitivity analysis to assess whether including an interaction between bystander CPR and the call to EMS assessment interval in the model improved the fit of the primary model. In addition, we performed a sensitivity analysis including medication administration and assisted ventilation as fixed effects, limiting the analysis to those registries that collect that information (10/12).

Statistical analysis was performed using SAS v9.4 (SAS Institute Inc., Cary, NC, USA). All

p-values less than 0.05 were considered significant.

Results

Patient and event characteristics

During the six year study period, twelve registries contributed 86,759 OHCA cases. The mean age of OHCA patients was 65 years (SD 19), and most were male (66%, Table 1a). Patient arrest characteristics, EMS treatment and patient outcomes varied across registries. Less than half of OHCAs were bystander witnessed (44%). The proportion of patients presenting with an initial 'shockable' rhythm varied from 10% to 40% and was lowest in the two Asian registries (Table 1b). There was also variation in the proportion of cardiac arrests of presumed cardiac aetiology, ranging from 56% to 95%. The proportion of non-EMS witnessed patients receiving bystander CPR varied greatly across registries (range 6%–98%). The mean call to

Table 2b – Characteristics of EMS treatment and patient outcomes for all cases by registry.

	Arrest N = 6782	German resuscitation registry N = 3776	Helsinki cardiac arrest registry N = 1367	Irish OHCAR N = 1976	Oslo and Akershus Registry N = 775	SJA-WA cardiac arrest registry N = 2316	ROC N = 39,637	CAVAS Project N = 8522	Swedish Register of CPR N = 8711	Taipei OHCA registry N = 2,791	VACAR N = 8658	VICAR N=1448
Call to EMS assessment, mean (SD)	10.1 (5.0)	10.1 (12.5)	10.9 (4.6)	16.6 (48.8)	10.5 (4.7)	–	9.0 (11.0)	–	10.9 (10.5)	22.3 (84.3)	11.3 (7.1)	17.7 (66.2)
EMS chest compressions	0.0%	0.0%	100.0%	99.6%	0.0%	95.6%	99.6%	84.9%	99.3%	98.0%	94.6%	0.0%
Missing or unknown	100.0%	100.0%	0.0%	0.4%	100.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	100.0%
Shocks given, %	52.6%	45.4%	49.0%	38.5%	40.8%	36.4%	34.9%	8.6%	38.4%	11.7%	43.5%	92.6%
Missing or unknown	0.8%	0.0%	0.4%	4.5%	0.4%	0.0%	0.1%	0.0%	4.8%	1.4%	0.0%	0.0%
Assisted ventilation, %	–	–	96.6%	96.7%	78.1%	97.1%	97.9%	68.2%	97.0%	99.7%	92.9%	0.0%
Missing or unknown	100.0%	100.0%	1.8%	3.2%	0.3%	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%	100.0%
Drugs, %												
Epinephrine	–	83.6%	78.7%	52.3%	44.7%	6.0%	77.6%	0.0%	76.9%	19.1%	69.2%	75.7%
Other drugs	–	8.6%	1.0%	0.0%	4.7%	0.0%	2.3%	0.0%	0.6%	0.1%	2.5%	2.1%
No drugs	–	7.8%	20.3%	47.7%	50.6%	94.0%	20.1%	100.0%	22.5%	80.8%	28.2%	22.2%
Missing or unknown	100.0%	0.2%	0.1%	1.3%	1.3%	0.0%	0.4%	0.0%	0.6%	0.0%	0.1%	0.0%
ROSC before ED, %	34.7%	32.4%	49.2%	19.2%	35.1%	15.2%	29.0%	–	–	12.2%	38.4%	30.0%
Missing or unknown	0.3%	1.1%	0.0%	6.3%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%
ROSC at ED arrival, %	–	26.1%	42.7%	13.8%	29.2%	13.9%	22.6%	1.8%	–	–	32.9%	–
Missing or unknown	100.0%	1.0%	0.0%	7.5%	0.0%	0.0%	8.3%	0.0%	100.0%	100.0%	0.8%	100.0%
Hospital admission, %	39.9%	26.1%	43.0%	–	27.7%	18.0%	23.7%	20.4%	18.3%	26.6%	–	–
Missing or unknown	1.0%	1.0%	0.0%	100.0%	0.0%	0.0%	64.2%	0.0%	0.0%	0.0%	100.0%	100.0%
Survival to hospital discharge, %	20.0%	12.7%	22.1%	6.0%	12.8%	9.0%	7.9%	6.6%	8.5%	6.8%	12.4%	11.4%
Survival to discharge with CPC 1 or 2, %	18.6%	8.4%	19.6%	5.3%	11.6%	–	4.3%	1.8%	94.3%	2.8%	–	8.8%
Missing or unknown	1.5%	1.5%	0.0%	0.8%	0.0%	100.0%	64.0%	0.0%	93.6%	0.9%	100.0%	0.0%

EMS, Emergency Medical Service; SD, Standard deviation; ED, Emergency Department; CPC, Cerebral Performance Category.

Table 3 – Association between the Utstein data elements and outcomes for all cases.

	Survival to discharge N = 86,759 OR (95% CI)	Pulses at ED arrival N = 57,030 OR (95% CI)	Survived with CPC 1 or 2[1] N = 27,239 OR (95% CI)
Age Category			
≤18	1.27 (1.04, 1.54)	0.71 (0.58, 0.86)	1.02 (0.65, 1.63)
19–39	Reference	Reference	Reference
40-49	0.93 (0.82, 1.04)	0.95 (0.85, 1.06)	0.99 (0.79, 1.25)
50–59	0.82 (0.74, 0.92)	0.94 (0.85, 1.04)	0.85 (0.68, 1.05)
60–69	0.68 (0.61, 0.75)	0.87 (0.79, 0.97)	0.65 (0.52, 0.80)
70–79	0.48 (0.43, 0.54)	0.95 (0.86, 1.05)	0.47 (0.38, 0.58)
80–89	0.30 (0.26, 0.34)	0.83 (0.75, 0.92)	0.24 (0.19, 0.31)
≥90	0.17 (0.14, 0.22)	0.72 (0.62, 0.82)	0.17 (0.10, 0.30)
Missing or unknown	0.24 (0.15, 0.37)	0.38 (0.24, 0.61)	0.06 (0.01, 0.45)
Sex			
Female	1.13 (1.07, 1.20)	1.36 (1.30, 1.43)	1.08 (0.96, 1.21)
Male	Reference	Reference	Reference
Missing or unknown	0.44 (0.20, 0.96)	0.46 (0.26, 0.82)	0.49 (0.17, 1.46)
Location of arrest			
Home	Reference	Reference	Reference
Public	1.73 (1.63, 1.83)	1.19 (1.12, 1.26)	1.81 (1.62, 2.02)
Other	1.10 (1.00, 1.21)	0.96 (0.89, 1.04)	1.03 (0.85, 1.25)
Missing or unknown	0.99 (0.71, 1.37)	0.72 (0.44, 1.18)	1.11 (0.66, 1.88)
Arrest witnessed			
Bystander witnessed	2.15 (2.00, 2.31)	1.89 (1.79, 1.99)	2.25 (1.92, 2.63)
EMS witnessed	5.92 (5.38, 6.51)	2.73 (2.51, 2.96)	8.02 (6.54, 9.84)
Witnessed by other	3.65 (2.94, 4.54)	2.54 (1.65, 3.91)	4.03 (2.88, 5.64)
Witnessed, unknown by whom	1.48 (1.19, 1.84)	1.02 (0.60, 1.74)	1.89 (1.16, 3.11)
Unwitnessed	Reference	Reference	Reference
Missing or unknown	1.54 (1.30, 1.82)	1.27 (1.04, 1.56)	2.01 (1.28, 3.18)
Cause of arrest (aetiology)			
Presumed cardiac	Reference	Reference	Reference
Trauma	0.26 (0.21, 0.33)	0.48 (0.39, 0.59)	0.24 (0.15, 0.39)
Respiratory	1.54 (1.32, 1.78)	1.80 (1.57, 2.06)	1.18 (0.90, 1.56)
Drowning	1.68 (1.25, 2.27)	1.53 (1.10, 2.12)	2.73 (1.66, 4.50)
Other non-cardiac	1.04 (0.94, 1.17)	1.23 (1.12, 1.35)	0.81 (0.65, 1.02)
Missing or unknown	0.73 (0.62, 0.86)	0.45 (0.37, 0.55)	0.41 (0.31, 0.55)
Bystander CPR, non-EMS witnessed arrest			
Yes	1.09 (1.02, 1.17)	1.16 (1.10, 1.23)	1.23 (1.08, 1.39)
No	Reference	Reference	Reference
Missing or unknown	1.06 (0.97, 1.15)	1.04 (0.97, 1.11)	1.24 (0.85, 1.82)
Bystander defibrillation attempted			
Yes	1.67 (1.47, 1.90)	1.02 (0.87, 1.20)	1.86 (1.48, 2.34)
No	Reference	Reference	Reference
Unknown	1.03 (0.93, 1.14)	0.89 (0.82, 0.96)	2.22 (1.66, 2.98)
Initial rhythm			
Shockable rhythm (VF, VT, AED advised shock)	8.75 (7.92, 9.66)	3.72 (3.45, 4.02)	9.51 (7.67, 11.80)
PEA	2.51 (2.28, 2.76)	2.06 (1.93, 2.19)	3.85 (3.08, 4.80)
Asystole	Reference	Reference	Reference
Other non-shockable	2.62 (2.23, 3.07)	1.50 (1.35, 1.65)	7.69 (5.19, 11.39)
Missing or unknown	4.84 (4.31, 5.42)	2.66 (2.34, 3.02)	4.62 (3.58, 5.95)
Call to EMS assessment			
<5 min	Reference	Reference	Reference
5-<10 min	0.85 (0.74, 0.97)	1.01 (0.83, 1.22)	0.75 (0.61, 0.91)
10-<15 min	0.61 (0.53, 0.71)	0.92 (0.76, 1.12)	0.52 (0.43, 0.65)
15-<20 min	0.52 (0.43, 0.62)	0.67 (0.54, 0.84)	0.53 (0.40, 0.69)
≥20 min	0.70 (0.59, 0.82)	0.75 (0.61, 0.92)	0.61 (0.46, 0.81)
Missing or unknown	0.75 (0.64, 0.88)	0.80 (0.65, 0.98)	0.77 (0.61, 0.97)
EMS chest compressions			
Yes	Reference	Reference	Reference
No	2.44 (2.11, 2.83)	1.36 (1.15, 1.62)	0.48 (0.28, 0.83)
Missing or unknown	2.21 (1.73, 2.80)	2.58 (1.62, 4.09)	1.78 (0.95, 3.31)
EMS defibrillation attempted			
Yes	1.55 (1.42, 1.69)	1.13 (1.06, 1.21)	2.81 (2.36, 3.34)
No	Reference	Reference	Reference
Missing or unknown	1.25 (0.88, 1.79)	0.80 (0.41, 1.59)	1.02 (0.51, 2.05)

(continued on next page)

Table 3 *(continued)*

	Survival to discharge N = 86,759 OR (95% CI)	Pulses at ED arrival N = 57,030 OR (95% CI)	Survived with CPC 1 or 2[1] N = 27,239 OR (95% CI)
Year of arrest	1.09 (1.07, 1.11)	1.11 (1.08, 1.16)	1.06 (1.00, 1.11)
P-value from test for variation of agency effects	<0.001	<0.001	0.02
P-value from test for variation of agency by year effects	0.18	0.01	0.14

Note: models include random terms for agency and agency by year effects.
OR, Odds Ratio; CI, Confidence Interval; ED, Emergency Department; CPC, Cerebral Performance Category; EMS, Emergency Medical Service; CPR, Cardiopulmonary Resuscitation; VF, Ventricular Fibrillation; VT, Ventricular Tachycardia; AED, Automated External Defibrillator; PEA, Pulseless Electrical Activity.
[1] Model includes the eight registries that collected this outcome and had >50% non-missing data.

EMS assessment interval was 11 min (SD 23) and varied between 9 and 22 min (Tables 2a and 2b). Overall, the majority of patients were administered epinephrine by EMS (64%) and 36% were administered a shock.

Patient outcomes

Overall survival to hospital discharge was 10% (range, 6%–22%) (Tables 2a and 2b). Overall survival to hospital discharge with CPC of 1 or 2 was 8% for the eight registries that collected this data and where the majority of data was not missing (range 2%–20%).

Association between the Utstein factors and outcomes

The adjusted association between the Utstein factors and patient outcomes are outlined in Table 3. An initial 'shockable' rhythm had the strongest association with survival to hospital discharge (AOR 8.75 95% CI: 7.92–9.66) and survival to hospital discharge with a CPC of 1 or 2 (AOR 9.51 95% CI: 7.67–11.80). The strength of the association between Utstein factors and survival to hospital discharge varied among the predefined subgroups (Table 4), however several factors revealed a consistent effect. Increasing patient age and time to EMS assessment were consistently associated with poorer survival. In addition, public location, witnessed event (bystander, EMS, other witness and unknown witness) and bystander defibrillation were consistently associated with improved odds of survival.

The interaction between bystander CPR and the call to EMS assessment interval was significant ($p < 0.001$, Supplementary Table 1) but it did not improve model fit. This analysis revealed there was a trend to lower odds of survival for shorter EMS assessment interval categories in patients not receiving bystander CPR when compared to those receiving bystander CPR. Supplementary Table 2 outlines the association between the Utstein factors and patient survival to hospital discharge including additional EMS treatment variables collected by 10 registries.

Extent of survival predicted by the Utstein factors

Supplementary Figure 1 presents the receiver operating characteristic curve generated from the GLMM model of survival. The AUC for the Utstein model was 0.850 (Wald CI: 0.845−0.854) indicating that the model provides good discrimination between those who do and do not survive their OHCA.

Extent of survival variation explained by the Utstein factors

In the full model which adjusted for the Utstein factors, the variance of the EMS agency effects was estimated to be 0.14. In a null model that contained no fixed effects, the variance of the EMS agency effects was estimated to be 0.29. Using the null model as the baseline, the Utstein factors accounted for 51% of the variability across EMS agencies (0.51 = 1-0.1424/0.2883).

Discussion

Utstein factors explained only half of the variation in OHCA survival to hospital discharge across EMS agencies. There is a large portion of the variation in OHCA survival that remains incompletely understood.

A North American study revealed that the Utstein factors explained a slightly lower proportion (44%) of the between site variation in OHCA survival within the Resuscitation Outcomes Consortium (ROC).[5] In addition, the ROC study revealed that much of the variation in OHCA survival was explained by a single variable, initial rhythm. When the ROC study[5] and a study comparing Sweden and Ireland[6] examined the variation in survival among bystander witnessed ventricular fibrillation OHCAs, much less of the between agency or country variation was explained by the Utstein factors (17–22%). Nonetheless, the Utstein template encourages consistent reporting and has contributed a greater understanding of the elements of effective resuscitation practice.

The 49% of the variation in OHCA survival that we reported remains incompletely understood may be explained through the supplementary (non-core) Utstein factors or additional factors that are not part of the Utstein template. The supplementary Utstein factors include factors that could pose a significant burden for registries to accurately collect or factors where the association with outcomes is still being investigated, such as: patient comorbidities and airway management. In addition information about hospital-based care may be difficult for EMS-based registries to access but may be explanatory.[10] Aspects of care including hospital type and volume, attempted coronary reperfusion and targeted temperature management may account for some of the variability across registries.

The Utstein template includes a system description which defines the characteristics of the population served and the EMS response.[8] This includes a description of the organisational structure of the EMS being provided, such as provider skill level, and the size of the population and the geographical area served. However, these factors are difficult to account for when comparing outcomes between

Table 4 – Association between the Utstein data elements and survival to hospital discharge by subgroups.

	Etiology[1]			Initial rhythm		Witnessed status		Age group		Bystander (Lay) Witnessed, Shockable
	Non-traumatic arrest N = 84,349 OR (95% CI)	Presumed cardiac N = 69,933 OR (95% CI)	Non-cardiac N = 16,826 OR (95% CI)	Shockable N = 20,138 OR (95% CI)	Non-shockable N = 66,621 OR (95% CI)	EMS witnessed N = 9,111 OR (95% CI)	Not EMS witnessed N = 77,648 OR (95% CI)	Adult (≥18 years) N = 84,119 OR (95% CI)	Child (1 to <18 years) N = 1225 OR (95% CI)	N=12,550 OR (95% CI)
Age category										
≤18	1.27 (1.04, 1.56)	1.19 (0.90, 1.56)	1.27 (0.96, 1.69)	1.39 (0.94, 2.05)	1.21 (0.97, 1.53)	1.61 (0.91, 2.84)	1.19 (0.97, 1.47)	–	–	1.18 (0.72, 1.93)
19–39	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	–	Reference
40–49	0.92 (0.82, 1.04)	0.98 (0.85, 1.12)	0.77 (0.61, 0.97)	0.99 (0.84, 1.18)	0.84 (0.71, 0.99)	1.36 (0.99, 1.86)	0.86 (0.76, 0.98)	0.92 (0.82, 1.04)	–	0.88 (0.71, 1.08)
50–59	0.82 (0.73, 0.91)	0.86 (0.76, 0.98)	0.68 (0.54, 0.85)	0.86 (0.73, 1.00)	0.75 (0.64, 0.88)	1.25 (0.93, 1.67)	0.76 (0.68, 0.86)	0.82 (0.73, 0.91)	–	0.74 (0.62, 0.90)
60–69	0.67 (0.60, 0.75)	0.70 (0.61, 0.79)	0.67 (0.54, 0.83)	0.66 (0.57, 0.78)	0.66 (0.57, 0.77)	0.94 (0.71, 1.26)	0.64 (0.57, 0.72)	0.67 (0.60, 0.75)	–	0.60 (0.49, 0.72)
70–79	0.48 (0.43, 0.54)	0.48 (0.42, 0.55)	0.60 (0.48, 0.75)	0.47 (0.40, 0.55)	0.48 (0.41, 0.56)	0.79 (0.59, 1.06)	0.44 (0.39, 0.49)	0.48 (0.43, 0.54)	–	0.41 (0.34, 0.50)
80–89	0.29 (0.26, 0.33)	0.29 (0.25, 0.33)	0.39 (0.30, 0.50)	0.25 (0.21, 0.30)	0.34 (0.29, 0.40)	0.48 (0.35, 0.65)	0.26 (0.23, 0.30)	0.29 (0.26, 0.33)	–	0.21 (0.17, 0.26)
≥90	0.17 (0.13, 0.21)	0.15 (0.12, 0.20)	0.30 (0.19, 0.47)	0.11 (0.07, 0.16)	0.22 (0.16, 0.29)	0.29 (0.19, 0.44)	0.15 (0.11, 0.20)	0.17 (0.14, 0.22)	–	0.10 (0.06, 0.18)
Missing or unknown	0.22 (0.14, 0.35)	0.21 (0.12, 0.39)	0.29 (0.15, 0.56)	0.22 (0.12, 0.39)	0.28 (0.14, 0.55)	0.46 (0.15, 1.40)	0.21 (0.13, 0.34)	–	–	0.18 (0.09, 0.38)
Sex										
Female	1.14 (1.07, 1.20)	1.15 (1.08, 1.23)	1.07 (0.94, 1.23)	1.18 (1.09, 1.29)	1.10 (1.02, 1.20)	0.96 (0.84, 1.08)	1.18 (1.11, 1.26)	1.13 (1.07, 1.20)	1.06 (0.67, 1.67)	1.20 (1.08, 1.34)
Male	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Missing or unknown	0.39 (0.17, 0.88)	0.42 (0.17, 1.04)	0.55 (0.12, 2.40)	0.70 (0.26, 1.90)	0.23 (0.06, 0.97)	0.99 (0.26, 3.83)	0.27 (0.09, 0.77)	0.34 (0.14, 0.82)	64.82 (2.84, 1480.74)	0.32 (0.07, 1.43)
Location of arrest										
Home	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Public	1.74 (1.64, 1.85)	1.74 (1.63, 1.85)	1.75 (1.48, 2.06)	1.68 (1.56, 1.81)	1.73 (1.57, 1.92)	1.12 (0.94, 1.34)	1.85 (1.73, 1.97)	1.74 (1.64, 1.85)	1.54 (0.93, 2.55)	1.76 (1.61, 1.92)
Other	1.09 (0.99, 1.20)	1.09 (0.98, 1.22)	1.18 (0.97, 1.44)	1.05 (0.91, 1.21)	1.10 (0.97, 1.24)	0.87 (0.74, 1.03)	1.19 (1.06, 1.33)	1.11 (1.01, 1.22)	0.57 (0.20, 1.64)	1.10 (0.90, 1.35)
Missing or unknown	0.99 (0.71, 1.37)	0.85 (0.57, 1.27)	1.55 (0.87, 2.77)	1.25 (0.71, 2.20)	0.87 (0.57, 1.31)	0.56 (0.15, 2.15)	1.05 (0.75, 1.47)	0.94 (0.67, 1.32)	2.13 (0.34, 13.35)	0.92 (0.41, 2.08)
Arrest witnessed										
Bystander witnessed	2.17 (2.02, 2.33)	2.14 (1.98, 2.32)	2.25 (1.90, 2.65)	1.89 (1.71, 2.08)	2.48 (2.23, 2.75)	–	2.20 (2.05, 2.36)	2.13 (1.98, 2.29)	2.32 (1.40, 3.84)	–
EMS witnessed	5.97 (5.42, 6.57)	7.19 (6.45, 8.02)	3.07 (2.49, 3.79)	9.75 (8.31, 11.43)	5.03 (4.42, 5.72)	–	–	5.96 (5.41, 6.57)	3.13 (1.31, 7.45)	–
Witnessed by other	3.72 (2.98, 4.64)	3.90 (3.02, 5.03)	2.81 (1.84, 4.31)	3.37 (2.50, 4.56)	3.64 (2.60, 5.09)	–	3.71 (2.98, 4.63)	3.58 (2.86, 4.47)	8.31 (1.13, 61.39)	–
Witnessed, unknown by whom	1.44 (1.15, 1.81)	1.51 (1.15, 1.98)	1.41 (0.97, 2.05)	1.52 (1.13, 2.06)	1.48 (1.05, 2.07)	–	1.50 (1.19, 1.88)	1.44 (1.14, 1.80)	3.77 (0.99, 14.37)	–
Unwitnessed	Reference	Reference	Reference	Reference	Reference	–	Reference	Reference	Reference	–
Missing or unknown	1.57 (1.32, 1.86)	1.35 (1.10, 1.66)	2.24 (1.64, 3.07)	1.11 (0.83, 1.48)	1.86 (1.50, 2.30)	–	1.49 (1.25, 1.77)	1.53 (1.29, 1.82)	1.49 (0.56, 3.95)	–
Cause of arrest (aetiology)										
Presumed cardiac	Reference	–	–	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Trauma	–	–	0.32 (0.23, 0.43)	0.31 (0.18, 0.53)	0.27 (0.20, 0.35)	0.26 (0.16, 0.44)	0.27 (0.21, 0.36)	0.26 (0.20, 0.34)	0.25 (0.09, 0.67)	0.23 (0.10, 0.54)
Respiratory	1.53 (1.32, 1.78)	–	1.79 (1.43, 2.25)	0.40 (0.23, 0.71)	1.82 (1.56, 2.13)	0.95 (0.71, 1.27)	1.82 (1.53, 2.16)	1.55 (1.33, 1.81)	0.94 (0.33, 2.67)	0.59 (0.25, 1.39)

(continued on next page)

Table 4 *(continued)*

	Etiology[1]			Initial rhythm		Witnessed status		Age group		Bystander (Lay) Witnessed, Shockable
	Non-traumatic arrest N = 84,349 OR (95% CI)	Presumed cardiac N = 69,933 OR (95% CI)	Non-cardiac N = 16,826 OR (95% CI)	Shockable N = 20,138 OR (95% CI)	Non-shockable N = 66,621 OR (95% CI)	EMS witnessed N = 9,111 OR (95% CI)	Not EMS witnessed N = 77,648 OR (95% CI)	Adult (≥18 years) N = 84,119 OR (95% CI)	Child (1 to <18 years) N = 1225 OR (95% CI)	N=12,550 OR (95% CI)
Drowning	1.67 (1.24, 2.26)	–	1.77 (1.25, 2.52)	1.24 (0.54, 2.85)	1.84 (1.33, 2.54)	1.66 (0.27, 10.18)	1.64 (1.21, 2.23)	1.19 (0.82, 1.74)	3.77 (1.91, 7.41)	1.63 (0.47, 5.73)
Other non-cardiac	1.04 (0.93, 1.16)	–	1.31 (1.07, 1.60)	0.57 (0.45, 0.70)	1.40 (1.23, 1.60)	0.71 (0.57, 0.89)	1.17 (1.04, 1.33)	1.04 (0.93, 1.16)	1.23 (0.70, 2.16)	0.73 (0.54, 0.98)
Missing or unknown	0.72 (0.61, 0.85)	–	Reference	0.57 (0.44, 0.74)	0.90 (0.72, 1.11)	0.43 (0.28, 0.66)	0.80 (0.67, 0.96)	0.73 (0.61, 0.86)	0.55 (0.09, 3.24)	0.49 (0.34, 0.70)
Bystander CPR, non-EMS witnessed arrest										
Yes	1.08 (1.01, 1.16)	1.10 (1.02, 1.19)	1.02 (0.86, 1.21)	1.28 (1.17, 1.40)	0.94 (0.84, 1.05)	–	1.22 (1.13, 1.31)	1.08 (1.01, 1.16)	1.79 (1.00, 3.21)	1.41 (1.26, 1.57)
No	Reference	Reference	Reference	Reference	Reference	–	Reference	Reference	Reference	Reference
Missing or unknown	1.05 (0.96, 1.15)	1.10 (1.02, 1.19)	0.83 (0.65, 1.06)	1.30 (1.15, 1.46)	0.82 (0.71, 0.94)	–	1.13 (1.02, 1.24)	1.05 (0.96, 1.14)	1.63 (0.88, 3.01)	1.35 (1.17, 1.55)
Bystander defibrillation attempted										
Yes	1.67 (1.46, 1.89)	1.61 (1.40, 1.85)	2.07 (1.41, 3.04)	1.44 (1.23, 1.69)	2.01 (1.57, 2.58)	–	1.71 (1.50, 1.95)	1.66 (1.46, 1.90)	2.89 (0.88, 9.45)	1.42 (1.17, 1.71)
No	Reference	Reference	Reference	Reference	Reference	–	Reference	Reference	Reference	Reference
Unknown	1.03 (0.94, 1.14)	0.93 (0.83, 1.04)	1.21 (0.99, 1.48)	0.84 (0.71, 0.99)	1.24 (1.07, 1.43)	–	1.04 (0.93, 1.18)	1.03 (0.93, 1.13)	1.22 (0.70, 2.13)	0.72 (0.55, 0.95)
Initial rhythm										
Shockable rhythm (VF, VT, AED advised shock)	8.77 (7.93, 9.69)	8.52 (7.62, 9.52)	7.59 (5.90, 9.77)	–	–	5.61 (4.51, 6.98)	10.08 (9.00, 11.29)	8.61 (7.79, 9.52)	9.70 (4.29, 21.96)	–
PEA	2.53 (2.30, 2.79)	2.33 (2.07, 2.61)	3.16 (2.64, 3.78)	–	2.62 (2.37, 2.90)	1.05 (0.87, 1.28)	3.25 (2.90, 3.63)	2.42 (2.20, 2.68)	3.93 (2.14, 7.24)	–
Asystole	Reference	Reference	Reference	–	Reference	Reference	Reference	Reference	Reference	–
Other non-shockable	2.64 (2.25, 3.10)	2.66 (2.23, 3.17)	2.58 (1.72, 3.85)	–	2.91 (2.46, 3.45)	1.66 (1.19, 2.33)	2.82 (2.35, 3.39)	2.57 (2.18, 3.02)	3.16 (1.02, 9.79)	–
Missing or unknown	4.85 (4.33, 5.45)	4.49 (3.91, 5.16)	5.44 (4.45, 6.63)	–	5.02 (4.46, 5.65)	2.17 (1.70, 2.77)	5.93 (5.22, 6.75)	4.80 (4.27, 5.40)	4.74 (2.45, 9.17)	–
Call to EMS assessment										
<5 min	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
5-<10 min	0.85 (0.74, 0.97)	0.81 (0.69, 0.94)	1.03 (0.76, 1.39)	0.94 (0.78, 1.13)	1.08 (0.82, 1.42)	1.11 (0.64, 1.94)	0.84 (0.73, 0.97)	0.84 (0.73, 0.96)	4.09 (0.72, 23.09)	0.88 (0.70, 1.10)
10-<15 min	0.61 (0.53, 0.70)	0.56 (0.48, 0.66)	0.86 (0.62, 1.17)	0.82 (0.67, 1.01)	0.99 (0.75, 1.31)	1.45 (0.84, 2.53)	0.56 (0.48, 0.65)	0.60 (0.52, 0.70)	4.02 (0.69, 23.27)	0.78 (0.61, 0.99)
15-<20 min	0.52 (0.44, 0.63)	0.52 (0.42, 0.63)	0.50 (0.33, 0.76)	0.84 (0.64, 1.10)	0.82 (0.59, 1.12)	1.38 (0.78, 2.43)	0.38 (0.30, 0.47)	0.52 (0.43, 0.62)	1.70 (0.20, 14.43)	0.78 (0.54, 1.11)
≥20 min	0.70 (0.59, 0.83)	0.70 (0.58, 0.85)	0.73 (0.51, 1.04)	0.98 (0.76, 1.28)	0.89 (0.66, 1.20)	1.39 (0.81, 2.38)	0.39 (0.30, 0.50)	0.67 (0.56, 0.79)	4.64 (0.68, 31.67)	0.77 (0.47, 1.25)
Missing or unknown	0.76 (0.65, 0.90)	0.80 (0.66, 0.97)	0.83 (0.60, 1.15)	1.25 (0.96, 1.62)	0.89 (0.67, 1.18)	1.18 (0.68, 2.05)	0.77 (0.65, 0.92)	0.74 (0.63, 0.87)	4.87 (0.84, 28.19)	0.98 (0.70, 1.36)

Table 4 *(continued)*

	Etiology[1]			Initial rhythm		Witnessed status		Age group		Bystander (Lay) Witnessed, Shockable
	Non-traumatic arrest N = 84,349 OR (95% CI)	Presumed cardiac N = 69,933 OR (95% CI)	Non-cardiac N = 16,826 OR (95% CI)	Shockable N = 20,138 OR (95% CI)	Non-shockable N = 66,621 OR (95% CI)	EMS witnessed N = 9,111 OR (95% CI)	Not EMS witnessed N = 77,648 OR (95% CI)	Adult (≥18 years) N = 84,119 OR (95% CI)	Child (1 to <18 years) N = 1225 OR (95% CI)	N=12,550 OR (95% CI)
EMS chest compressions										
Yes	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
No	2.58 (2.22, 2.99)	2.64 (2.24, 3.11)	1.51 (1.04, 2.20)	4.08 (3.26, 5.11)	1.34 (1.07, 1.70)	4.57 (3.43, 6.08)	1.67 (1.38, 2.01)	2.45 (2.12, 2.85)	2.48 (0.87, 7.10)	3.09 (2.20, 4.36)
Missing or unknown	2.15 (1.69, 2.73)	2.09 (1.62, 2.70)	1.52 (1.18, 1.95)	1.80 (1.42, 2.30)	2.08 (1.54, 2.81)	2.08 (1.53, 2.84)	2.04 (1.56, 2.66)	2.17 (1.71, 2.75)	1.03 (0.52, 2.04)	1.81 (1.37, 2.40)
EMS defibrillation attempted										
Yes	1.55 (1.43, 1.69)	1.76 (1.60, 1.94)	0.95 (0.77, 1.18)	2.07 (1.63, 2.63)	1.52 (1.37, 1.68)	1.72 (1.46, 2.03)	1.39 (1.25, 1.53)	1.55 (1.42, 1.69)	1.51 (0.75, 3.07)	1.86 (1.33, 2.58)
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Missing or unknown	1.26 (0.88, 1.81)	1.02 (0.58, 1.78)	1.17 (0.73, 1.87)	1.55 (0.36, 6.63)	1.30 (0.89, 1.89)	0.99 (0.37, 2.62)	1.17 (0.80, 1.73)	1.26 (0.88, 1.83)	2.13 (0.38, 11.91)	1.95 (0.41, 9.30)
Call to defibrillation										
<5 min	–	–	–	Reference	–	–	–	–	–	Reference
5-<10 min	–	–	–	0.69 (0.56, 0.85)	–	–	–	–	–	0.69 (0.54, 0.90)
10-<15 min	–	–	–	0.43 (0.34, 0.53)	–	–	–	–	–	0.42 (0.32, 0.55)
15-<20 min	–	–	–	0.26 (0.20, 0.33)	–	–	–	–	–	0.22 (0.16, 0.30)
≥20 min	–	–	–	0.31 (0.24, 0.40)	–	–	–	–	–	0.15 (0.10, 0.22)
Missing or unknown	–	–	–	0.43 (0.34, 0.55)	–	–	–	–	–	0.45 (0.33, 0.60)
Year of arrest	1.09 (1.07, 1.11)	1.09 (1.07, 1.12)	1.05 (1.00, 1.10)	1.11 (1.08, 1.14)	1.07 (1.04, 1.10)	1.05 (1.01, 1.10)	1.10 (1.08, 1.12)	1.09 (1.07, 1.11)	0.97 (0.85, 1.11)	1.12 (1.08, 1.15)
P-value from test for variation of agency effects	<0.001	<0.001	0.05	<0.001	<0.001	0.002	<0.001	<0.001	0.39	<0.001

Note: models include random terms for agency, but not agency by year effects.

[1] Not mutually exclusive categories.

communities. There are many factors in a community such as socioeconomic status,[11,12] ethnicity[13,14] and population density[15] that have been associated with OHCA outcome.

Other than a brief description of the structure of the EMS agency, the Utstein template does not capture many of the strategies that EMS agencies implement to improve OHCA outcomes in their community. These include initiatives such as law enforcement defibrillation or community first responder programs. Other factors such as EMS personnel training, CPR quality and the cultivation of a 'culture of excellence' within the EMS agency could also lead to more favourable outcomes but are very difficult to capture objectively.[16]

In addition to the characteristics of the community and the EMS agency, post-resuscitation care in the hospital may also contribute to varied outcomes. Several aspects of in-hospital care are included in the supplementary in-hospital Utstein factors, however, cultural practices and guidelines on deferred prognosis assessment and withdrawal of care for OHCA patients are not. Many OHCA deaths that occur in hospital are due to active withdrawal of life sustaining treatment based on prognostication of a poor neurological outcome.[17] The processes of neurologic prognostication, withdrawal of treatment and OHCA outcomes are closely correlated, but practices vary between countries, regions and even individual hospitals.[18,19] Early or premature withdrawal of treatment may lead to variation in OHCA survival.

An inconsistent application of the Utstein definitions, incomplete case capture or missing data that are not missing at random may be a source of noise that obscures the 'Utstein signal' and may partly explain the variation in OHCA survival that remains incompletely understood. In our previous study we observed differences in coding and missingness between registries participating in the current study.[7] Methods to reduce these issues would lead to more valid comparisons between communities.

Lastly, many of the Utstein factors are not independent of each other. We observed an interaction between the call to EMS assessment interval and bystander CPR. Therefore it may not be appropriate to code some variables as binary because their influence is dependent on other factors.

Limitations

This study required translation of data from existing registries to uniform definitions therefore classification errors may have occurred. Mistranslation and missing data may affect the reliability of the results. Also, not all registries were able to submit data for the entire study period, however, we adjusted for the year of arrest. We included all registry data that were available for the study period. However, this may have resulted in a disproportionate representation of North American EMS agencies since 46% of included cases were from the ROC Epistry. A post hoc secondary analysis that excluded ROC data suggested that the Utstein factors explained a qualitatively similar proportion of the variability across EMS agencies (Appendix 1). Some of the ROC data included in our study overlapped with a previous study that examined the role of the Utstein factors in explaining variation of survival after OHCA between large geographic sites in North America.[5] A recent analysis of ROC data to assess variation in outcomes classified EMS agency by first arriving unit reported similar findings to the present study.[20] We included data from 11 other registries from 10 other countries and grouped cases by EMS agency as determined by medical direction, rather than by administrative site or by first arriving unit. Although the proportion of variation explained by each method is similar, we believe that our method of classifying EMS agency is more robust.

Additional factors added to the 2015 Utstein template[8] may explain more of the variation in OHCA survival than was explained in the present study. For example, the core dispatcher factors that ascertain whether the cardiac arrest was identified and whether telephone CPR instructions were administered, could clarify the beginning of the chain of survival, which impacts more patients and has the potential for a greater effect on survival than subsequent links in the chain.[21] The 2015 template[8] also includes specific information on whether a bystander applied an AED and whether they administered defibrillation. However, at the time that our study was initiated, participating EMS agencies had varying adoption of the use of and recording of telecommunicator CPR instructions or lay use of AED. Such variation limited our ability to use the 2015 data template.

Conclusion

Our study identified that the Utstein factors explain 51% of the international EMS agency variation in OHCA survival. These findings suggest that EMS agencies should continue to target modifiable Utstein factors to improve OHCA survival in their communities. In addition, further study is required to identify the reasons for the variation that is not currently understood.

Conflicts of interest

Several authors are employed by the EMS agencies included in this study. All authors have no financial or personal conflicts of interest that could influence their work to disclose.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.03.018.

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