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Clinical paper

Regional variation in the characteristics, incidence and outcomes of out-of-hospital cardiac arrest in Australia and New Zealand: Results from the Aus-ROC Epistry☆

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ABSTRACT

Introduction: The aim of this study was to investigate regional variation in the characteristics, incidence and outcomes of out-of-hospital cardiac arrest (OHCA) in Australia and New Zealand.

Methods: This was a population-based cohort study of OHCA using data from the Aus-ROC Australian and New Zealand OHCA Epistry over the period of 01 January 2015–31 December 2015. Seven ambulance services contributed data to the Epistry with a capture population of 19.8 million people. All OHCA attended by ambulance, regardless of aetiology or patient age, were included.

Results: In 2015, there were 19,722 OHCA cases recorded in the Aus-ROC Epistry with an overall crude incidence of 102.5 cases per 100,000 population (range: 51.0–107.7 per 100,000 population). Of all OHCA cases attended by EMS (excluding EMS-witnessed cases), bystander CPR was performed in 41% of cases (range: 36%–50%). Resuscitation was attempted (by EMS) in 48% of cases (range: 40%–68%). The crude incidence for attempted resuscitation cases was 47.6 per 100,000 population (range: 34.7–54.1 per 100,000 population). Of cases with attempted resuscitation, 28% survived the event (range: 21%–36%) and 12% survived to hospital discharge or 30 days (range: 9%–17%; data provided by five ambulance services).

Conclusion: In the first results of the Aus-ROC Australian and New Zealand OHCA Epistry, significant regional variation in the incidence, characteristics and outcomes was observed. Understanding the system-level and public health drivers of this variation will assist in optimisation of the chain of survival provided to OHCA patients with the aim of improving outcomes.

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Introduction

Out-of-hospital cardiac arrest (OHCA) is a global public health problem, with significant regional variation reported in the incidence and outcomes internationally [1–7]. The development of multi-centre OHCA registries has enhanced our understanding of these regional differences, by highlighting the influence of different ambulance service structures; and the patient, ambulance service and clinical factors associated with survival [8–10]. These national/international registries also contribute to quantifying the burden of OHCA [1].

In Australia and New Zealand, many regional OHCA registries have been established, based on geographical boundaries [11–14]. However, until now, there has not been the infrastructure to combine and compare these data; and therefore little attempt to ensure a consensus of definitions and standardisation of data elements. This has prevented understanding of variation in practice and outcomes within our region. Understanding such factors may provide an opportunity to improve the systems of care provided to OHCA patients. In this study, we aim to investigate regional variations in the characteristics, incidence and outcomes of OHCA in Australia and New Zealand.

Methods

Study design

This is a population-based cohort study of OHCA occurring between 01 January 2015 and 31 December 2015. Data were collected from seven ambulance services who participate in the Aus-ROC Australia and New Zealand OHCA Epistry.

Aus-ROC Australian and New Zealand OHCA Epistry

The Aus-ROC Australian and New Zealand OHCA Epistry was established with the aim of understanding regional, ambulance service and treatment factors associated with improved OHCA survival and outcomes [15]. In this study, seven ambulance services in Australia (Ambulance Victoria (AV), SA Ambulance Service (SAAS), St John Ambulance Western Australia (SJAWA), Queensland Ambulance Service (QAS) and St John Ambulance Northern Territory (SJANT)) and New Zealand (St John New Zealand (SJNZ) and Wellington Free Ambulance (WFA)) contributed data to the Epistry. Each participating ambulance service in Australia covers a whole state/territory, while SJNZ and WFA collectively cover New Zealand (WFA covers the metropolitan region of Wellington, and Wairarapa, and SJNZ cover the remainder of New Zealand) (Fig. 1). The total catchment population was approximately 19.8 million persons, representing 64% of the Australian population and 100% of the New Zealand population. We are actively engaging with the three non-participating ambulance services (NSW Ambulance, Ambulance Tasmania and the ACT Ambulance Service) with respect to future participation in the Aus-ROC Epistry. Ethics approval was independently sought by each of the contributing registries. Over-arching ethics for the Epistry was provided by Monash University HREC (Approval No. CF12/3938-2012001888).

Description of emergency medical services (EMS)

The ambulance services participating in the Aus-ROC Epistry have been described previously [16]. Clinical management of OHCA was noted to be similar across ambulance services, and follow the 2015 Australian and New Zealand Committee on Resuscitation (ANZCOR) resuscitation guidelines which are co-badged by both the Australian Resuscitation Council (ARC) and the New Zealand Resuscitation Council (NZRC) [17,18]. Differences were noted in the proportion of paramedics with BLS, ALS or intensive care skills training, the geographical areas serviced (Table 1) and criteria for withholding or terminating resuscitation attempts.

Inclusion criteria

All OHCA cases attended by ambulance, regardless of aetiology or patient age, were included in this study. There were 54 cases where the patient was defibrillated and achieved a return of spontaneous circulation (ROSC) prior to the arrival of EMS, which were excluded from this analysis (AV: n = 21; SAAS: n = 3; SJAWA: n = 8; QAS: n = 11; SJANT: n = 1; SJNZ: n = 10; WFA: n = 0). All deaths attended by ambulance are classified as OHCA and thus included in the Epistry. One ambulance service (Wellington Free Ambulance) provided data on only those patients that received attempted resuscitation.

Data collection

Data across all participating sites were collected in accordance with Utstein definitions [19], although some variation in the coding of these items existed. Recoding of each variable was conducted to improve uniformity in the data collected. The primary outcome measure was 'survived event' (defined as ROSC on arrival at hospital) with 'ROSC in the prehospital setting' and 'survival to hospital discharge' or 'survival to 30 days' as key secondary outcomes. The secondary outcome of survival to hospital discharge was provided by four of the seven participating ambulance services. One ambulance service (St John New Zealand) collected survival to 30 days as their primary outcome. In this study, survival is reported as either survival to hospital discharge or survival to 30 days. The Utstein comparator group was defined as those cases that had attempted resuscitation, were bystander-witnessed and had a first recorded rhythm that was shockable [19].

Definition of attempted resuscitation

Across six of the seven participating ambulance services, 'attempted resuscitation' was defined as any chest compressions and/or any defibrillation by EMS. One ambulance service (Wellington Free Ambulance) defined 'attempted resuscitation' as 'any purposeful initiation of CPR by paramedics' [16].

Data analysis

Annual crude and age-standardised incidence rates (ASIRs) of all attended cases of OHCA, and annual crude incidence rates for cases of attempted resuscitation, were calculated. Annual rates were calculated using population data from the Australian Bureau of Statistics or Statistics New Zealand. ASIRs were calculated using the direct method [20] whereby annual age-specific incidence rates were calculated across 5-year age-groups using the number of OHCAs for each age-group as numerators. Rates were standardised by 5-year age groups using the 2011 Australian standard population [21]. Age and/or sex were missing in 339 cases (1.7%). These data were assumed to be missing at random and an inflation factor (calculated as the percentage of missing data; see Supplementary material) was calculated for each ambulance service and applied to both the crude and age-standardised incidence rates. Uninflated incidence rates are provided in the Supplementary material.

Comparisons of data between ambulance services were made using the χ^2 test and the Kruskal–Wallis test as appropriate. A summary of missing data is provided in the Supplementary Material. Data analysis was performed using Stata (Version 14.2, StataCorp, College Station, TX). A p-value < 0.05 was considered statistically significant.

Results

Overall

In 2015, there were 19,722 OHCA cases recorded in the Aus-ROC Epistry; 15,129 in Australia (77%) and 4593 in New Zealand (23%).

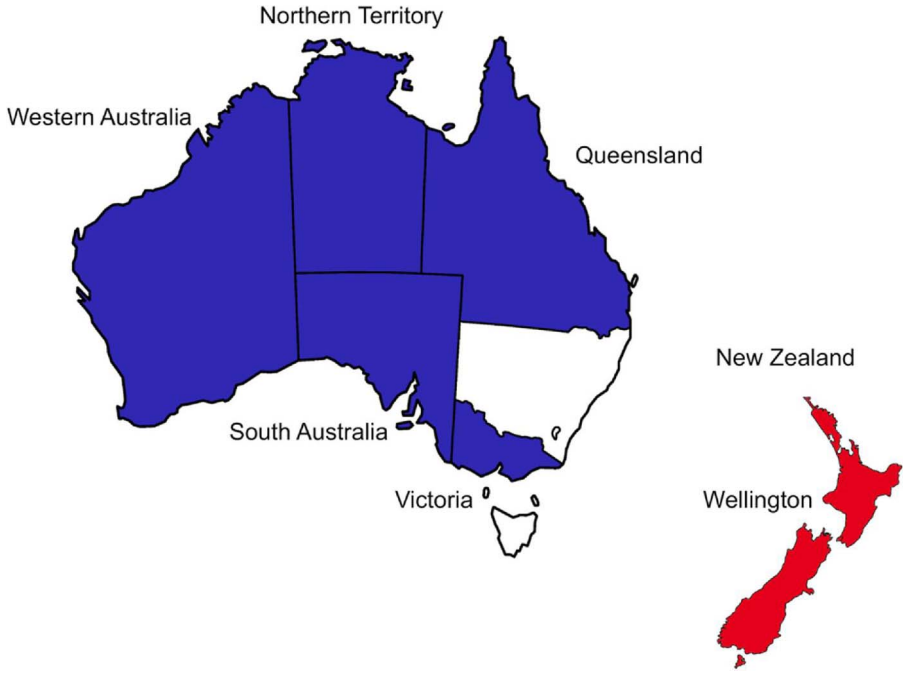

Fig. 1. Map of ambulance services contributing to the Aus-ROC Australian and New Zealand OHCA Epistry in 2015.

Table 1
Summary of ambulance services contributing to the Aus-ROC Australian and New Zealand OHCA Epistry in 2015.

	Overall	Australia					New Zealand	
		Victoria (AV)	South Australia (SAAS)	Western Australia (SJAWA)	Queensland (QAS)	Northern Territory (SJANT) [a]	St John New Zealand (SJNZ)	Wellington Free Ambulance (WFA) [b]
Number of EMS agencies	7	1	1	1	1	1	1	1
Service area population (2015)	19,811,078	5,937,481	1,698,660	2,590,259	4,778,854	210,104	4,098,840	496,880
Geographical area (km^2)		227,496	984,180	2,526,418	1,725,826	1,353,164	261,522	8130
Population density (persons per km^2)		26.1	1.7	1.0	2.8	0.18	15.7	61.1
Number of OHCA cases attended by EMS	19,722	5740	1829	2451	5002	107	4324	269
Crude incidence (per 100,000 population) [c]	102.5 [d]	96.6	107.7	94.4	104.6	51.0	105.5	-
Age standardised incidence (per 100,000 population) [c]	99.2	92.8	93.6	99.0	105.6	71.9	103.8	-
Attempted resuscitation								
Yes	9425 (47.8%)	2708 (47.2%)	737 (40.3%)	1265 (51.6%)	2337 (46.7%)	73 (68.2%)	2036 (47.1%)	269 (100%)
Crude incidence for attempted resuscitation cases (per 100,000 population)	47.6	45.6	43.4	48.8	48.9	34.7	49.7	54.1
Transported to hospital (of those cases that had attempted resuscitation)								
Yes	3686 (39.1%)	974 (36.0%)	209 (28.4%)	816 (64.5%)	870 (37.2%)	38 (52.0%)	673 (33.1%)	106 (39.4%)
No	5726 (60.8%)	1734 (64.0%)	528 (71.6%)	438 (34.6%)	1467 (62.8%)	35 (48.0%)	1361 (66.8%)	163 (60.6%)
Missing	13 (0.1%)	0	0	11 (0.9%)	0	0	2 (0.1%)	0

A) Note: SJANT do not service the entire Northern Territory (NT); some ambulance coverage is provided by the Department of Health. Given this, the exact geographical area that SJANT service could not be accurately quantified; the geographical area and population density reflect that of the entire region of the NT. B) Note: Wellington Free Ambulance provided data only on cases that received attempted resuscitation. C) Note: incidence calculations include an inflation factors that accounts for missing age and sex data (see Methods and Supplementary Material). D) Note: the overall crude incidence reflects all contributing regions, with the exception of Wellington Free Ambulance who provided data only on cases that received attempted resuscitation. Missing data (see Supplementary Material) was subtracted from denominators.

Table 2
Summary table of OHCA cases that received attempted resuscitation in the Aus-ROC Epistry in 2015. P-values reflect comparisons across all ambulance services.

	Overall (n = 9425)	Australia					New Zealand		
		Victoria (AV) (n = 2708)	South Australia (SAAS) (n = 737)	Western Australia (SJAWA) (n = 1265)	Queensland (QAS) (n = 2337)	Northern Territory (SJANT) (n = 73)	St John New Zealand (SJNZ) (n = 2036)	Wellington Free Ambulance (WFA) [a] (n = 269)	P-value
Demographics									
Age (years) (median, IQR)	65 (49–78)	66 (50–79)	69 (55–81)	63 (45–79)	64 (47–77)	49 (35–63)	65 (52–77)	68 (52–77)	< 0.001
Sex									0.070
Male	6403 (68.0%)	1896 (70.0%)	491 (66.6%)	845 (66.8%)	1582 (67.7%)	49 (67.1%)	1347 (66.2%)	193 (71.8%)	
Female	3021 (32.0%)	811 (30.0%)	246 (33.4%)	420 (33.2%)	755 (32.3%)	24 (32.9%)	689 (33.8%)	76 (28.2%)	
Location									0.001
Public	1601 (17.6%)	511 (18.9%)	68 (17.1%)	233 (18.4%)	381 (16.3%)	15 (20.6%)	324 (16.0%)	69 (25.7%)	
Other	7478 (82.4%)	2197 (81.1%)	329 (82.9%)	1032 (81.6%)	1955 (83.7%)	58 (79.4%)	1707 (84.0%)	200 (74.3%)	
Arrest features									
Witnessed by									< 0.001
EMS	1435 (15.4%)	439 (16.3%)	103 (14.3%)	139 (11.0%)	396 (17.4%)	4 (6.4%)	327 (16.1%)	27 (10.0%)	
Bystander	3866 (41.5%)	1150 (42.7%)	323 (44.7%)	328 (26.0%)	856 (37.6%)	30 (47.6%)	1038 (51.0%)	141 (52.4%)	
Unwitnessed	4022 (43.1%)	1104 (41.0%)	296 (41.0%)	796 (63.0%)	1025 (45.0%)	29 (46.0%)	671 (32.9%)	101 (37.6%)	
Bystander CPR for bystander–witnessed cases	2932 (76.9%)	886 (79.3%)	242 (75.2%)	239 (72.9%)	635 (75.3%)	21 (70.0%)	808 (78.1%)	101 (71.6%)	0.056
First monitored cardiac arrest rhythm									< 0.001
Shockable (VF/FT)	2591 (27.9%)	750 (27.9%)	187 (26.3%)	247 (19.5%)	557 (24.5%)	16 (25.8%)	738 (36.5%)	96 (36.4%)	
Pulseless electrical activity	2277 (24.5%)	730 (27.2%)	199 (28.0%)	277 (21.9%)	571 (25.1%)	13 (21.0%)	435 (21.5%)	52 (19.7%)	
Asystole	4369 (47.0%)	1202 (44.7%)	324 (45.7%)	740 (58.6%)	1148 (50.4%)	33 (53.2%)	808 (40.0%)	114 (43.1%)	
Unknown – non-shockable	48 (0.5%)	5 (0.2%)	0	0	0	0	41 (2.0%)	2 (0.8%)	
Aetiology									< 0.001
Presumed cardiac	6854 (73.9%)	1967 (72.6%)	550 (74.6%)	1008 (79.7%)	1506 (66.9%)	27 (50.9%)	1558 (76.7%)	232 (86.3%)	
Non-cardiac	2417 (26.1%)	741 (27.4%)	187 (25.4%)	257 (20.3%)	744 (33.1%)	26 (49.1%)	473 (23.3%)	47 (13.7%)	
Response time for non-EMS witnessed cases, mins (median, IQR)	8.0 (6.0–11.0)	7.5 (5.9–10.0)	8.4 (6.1–11.4)	8.9 (6.6–12.1)	8.0 (6.0–11.0)	8.0 (7.0–13.0)	9.0 (7.0–12.0)	9.6 (7.0–13.2)	< 0.001

Note: Missing data is provided in the Supplementary Material. Missing data was subtracted from denominators.

The overall crude incidence was 102.5 per 100,000 population (range: 51.0–107.7 per 100,000 population) and the overall age-standardised incidence was 99.2 per 100,000 population (range: 71.9–105.6 per 100,000 population) (Table 1). The crude incidence for Australia was 99.4 per 100,000 population and the crude incidence for New Zealand (SJNZ only) was 105.5 per 100,000 population. The median age of all OHCA cases was 66 years (interquartile range (IQR): 50–80 years), and most were male (66%) (see Supplementary material). Arrests attended by SJANT were typically younger (median age 50 years; IQR: 36–66 years), reflecting the underlying population, compared to other regions. Of all OHCA cases attended by EMS (excluding EMS-witnessed cases), 41% received bystander CPR (range: 36%–50%). However, of those cases that were witnessed by a bystander, 67% received bystander CPR. Bystander CPR rates for bystander-witnessed cases were highest in areas serviced by SJNZ (71%) and SJANT (70%).

Attempted resuscitation

Overall, resuscitation was attempted in 48% (n = 9,425) (range: 40%–68%) of all OHCA cases. The overall crude incidence of attempted resuscitation cases was 47.6 per 100,000 population (range: 34.7–54.1 per 100,000 population). Among cases with attempted resuscitation, 15% were witnessed by EMS (range: 6%–17%) and 42% were witnessed by a bystander (range: 26%–52%) (Table 2). A shockable rhythm was present in 28% of cases with attempted resuscitation (range: 20%–37%) and most OHCA were of a presumed cardiac aetiology (74%; range: 51%–86%). Response times for non-EMS witnessed cases varied between a median of 7.5 and 9.6 min (Table 2).

Outcomes

For those who received attempted resuscitation, 33% achieved ROSC in the prehospital setting, 39% were transported to hospital and 28% survived the event (had ROSC on arrival at hospital) (Table 3). Significant variation in these outcomes was noted between services in this patient group; ROSC in the prehospital setting varied from 24% to 38% ($p < 0.001$), the proportion of patients transported to hospital varied from 28% to 65% ($p < 0.001$) and the proportion who survived the event varied from 21% to 36% ($p < 0.001$) (Fig. 2). Of those ambulance services that collected survival to hospital discharge or survival to 30 days (n = 5), overall survival (for those patients where resuscitation was attempted) was 12%, which varied from 9% to 17% ($p = 0.002$) (Table 3).

In sub-group analyses, survival to hospital discharge or survival to 30 days (five services only) in the EMS-witnessed group was 25% (range: 19%–44%; $p = 0.126$) and 12% for non-EMS witnessed cases with a presumed cardiac aetiology (range: 8%–15%; $p = 0.004$) (Table 4). Survival to hospital discharge in the Utstein comparator group was 31%, which varied from 29% to 40% ($p = 0.530$).

Discussion

This is the first study to report regional variation in the incidence, characteristics and outcomes of OHCA in Australia and New Zealand. In 2015, there were 19,722 OHCA cases recorded in the Aus-ROC Epistry with an overall crude incidence of 102.5 cases per 100,000 population. For all OHCA cases (excluding EMS-witnessed cases), bystander CPR was performed in 41% of cases and this ranged from 36% to 50% between regions. Overall, 48% of cases received attempted resuscitation and of these, 33% achieved ROSC in the prehospital setting, 28% survived the event and survival to hospital discharge or 30 days was 12%. Regional variation was observed in the incidence, demographics, arrest characteristics and outcomes. Specifically, ROSC in the prehospital setting varied from 24% to 38% and survival to hospital discharge varied from 9% to 17%.

Other multi-centre OHCA registries have provided significant insights into regional variation in OHCA, including the North-American Resuscitation Outcomes Consortium (ROC) [2], the Cardiac Arrest Registry to Enhance Survival (CARES) [7], the European Registry of Cardiac Arrest (EuReCa ONE) [6], the Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) project in England [4], and the Pan Asian Resuscitation Outcomes Study (PAROS) [3]. However, this is the first time that regional variation in OHCA has been quantified in our region of Australia and New Zealand.

We observed a crude incidence rate for Australian OHCA cases of 99.4 per 100,000 population and a crude incidence rate for New Zealand OHCA cases of 105.5 per 100,000 population. This equates to an estimated 24,373 cases of OHCA in Australia annually (using the 2017 Australian population of 24,511,800 persons) [22] and 5048 cases of OHCA in New Zealand annually (using the 2017 New Zealand population of 4,785,100) [23]. This incidence is higher than that previously reported for Europe (84.0 per 100,000 population) [6] and Japan (70.3 per 100,000 population) [5], but similar to North America (95.7 per 100,000 population) [2]. Variation within our region was also observed with age-standardised incidence rates ranging between 71.9 and 105.6 per 100,000 population. Some of this variation may be explained by case capture and accuracies in defining the serviced population. Specifically, SJANT do not service the entire Northern Territory region, with ambulance coverage in the remaining region provided by the state's Department of Health. As a result, defining the exact population that is captured by SJANT is challenging. The lower incidence in the area serviced by SJANT is particularly surprising given that the Northern Territory has the largest proportion of Indigenous people [15] and it is known that the incidence of cardiovascular disease in Indigenous people is substantially higher than that of non-Indigenous people [24]. This regional variation may also be explained by an accompanying variation in underlying risk of OHCA; studies have demonstrated that a large proportion of regional variation in incidence can be explained through socioeconomic factors and health characteristics of the underlying population [25,26].

Bystander CPR is a crucial component of the 'chain of survival'; patients who receive bystander CPR are more than two times more likely to survive than those who do not receive bystander CPR [27]. In our study, 41% of all OHCA cases attended by EMS (excluding EMS-witnessed cases) received bystander CPR. This is greater than the United States (34%) [7], but less than the 47% reported in Europe [6]. This difference may be explained by higher rates of bystander-witnessed arrests in Europe (54% vs 26%) or rates of CPR training in the populations [28]. In our study, 33% of cases that were witnessed to collapse by a bystander did not receive bystander CPR, which varied between 29% and 37%. This is despite all services using a similar dispatch system (Medical Priority Dispatch System; MPDS) and all provide pre-arrival instructions for bystander CPR over the telephone if the arrest is recognised at the point of call [16]. This demonstrates a significant area where improvements may be achieved and a number of studies are underway in some regions to understand the associated barriers and implement strategies to improve rates of bystander CPR.

Overall, 48% of OHCA cases received attempted resuscitation from EMS with an overall crude incidence of attempted resuscitation cases of 47.6 per 100,000 population. This incidence is lower than what has been previously reported for North America (56.0 per 100,000 population) [12] and England (53.2 per 100,000 population) [4], but similar to that of Europe (49 per 100,000 population) [6]. In our study, rates of attempted resuscitation varied between 40% and 68%. Some of this variation may be explained by differences in the system responses to OHCA cases. For example, fire fighters act as first responders in Victoria [29] and cases in which fire fighters commence CPR, but resuscitation is subsequently ceased on arrival of paramedics, are counted as attempted resuscitation by EMS. Of cases with attempted resuscitation, 28% had a first monitored cardiac arrest rhythm that was shockable, and this varied from 20% to 37% between regions. In the region with the lowest rate of shockable rhythms (SJAWA), lower proportions of

Table 3
Outcomes for OHCA cases that received attempted resuscitation, by ambulance service. P-values reflect comparisons across all ambulance services.

	Overall	Australia					New Zealand		
		Victoria (AV)	South Australia (SAAS)	Western Australia (SJAWA)	Queensland (QAS)	Northern Territory (SJANT)	St John New Zealand (SJNZ)	Wellington Free Ambulance (WFA)	P-value*
ROSC in the prehospital setting									< 0.001
Yes	3143 (33.4%)	1024 (37.8%)	193 (26.2%)	301 (23.8%)	801 (34.3%)	20 (27.4%)	707 (34.7%)	97 (36.1%)	
No	6239 (66.2%)	1684 (62.2%)	509 (69.0%)	963 (76.1%)	1536 (65.7%)	50 (68.5%)	1325 (65.1%)	172 (63.9%)	
Missing	43 (0.5%)	0	35 (4.8%)	1 (0.1%)	0	3 (4.1%)	4 (0.2%)	0	
Survived event (ROSC on arrival at hospital)									< 0.001
Yes	2614 (27.7%)	824 (30.4%)	175 (23.7%)	271 (21.4%)	665 (28.5%)	18 (24.7%)	565 (24.7%)	96 (35.7%)	
No	6807 (72.2%)	1881 (69.5%)	562 (76.3%)	993 (78.5%)	1672 (71.5%)	55 (75.3%)	1471 (72.3%)	173 (64.3%)	
Missing	4 (0.1%)	3 (0.1%)	0	1 (0.1%)	0	0	0	0	
Survived to hospital discharge/ 30 days **									0.002
Yes	847 (12.1%)	340 (12.6%)	72 (9.8%)	119 (9.4%)	–	–	271 (13.3%)	45 (16.7%)	
No	6119 (87.2%)	2349 (86.7%)	656 (89.0%)	1138 (90.0%)	–	–	1753 (86.1%)	223 (82.9%)	
Missing	49 (0.7%)	19 (0.7%)	9 (1.2%)	8 (0.6%)	–	–	12 (0.6%)	1 (0.4%)	

*Note: p-values for comparisons of outcomes between ambulance services reflect data that excludes missing values. ** Note: SJNZ provided data on survival to 30 days while all other services that provided survival data (AV, SAAS, SJAWA and WFA) provided data on survival to hospital discharge. Missing data (see Supplementary Material) was subtracted from denominators.

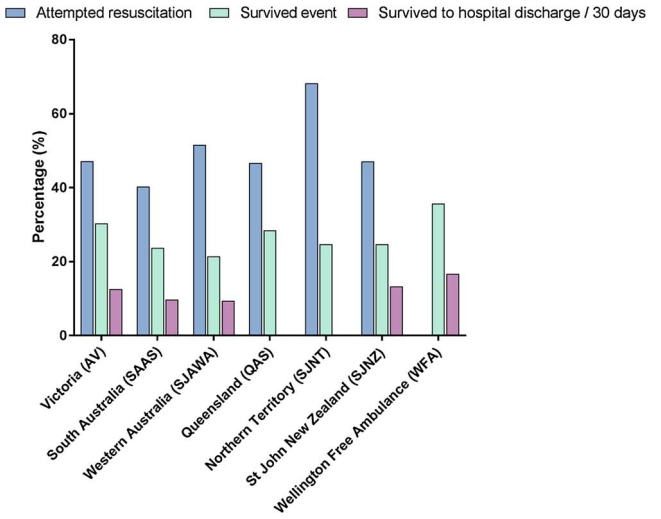

Fig. 2. Outcomes by ambulance service. Note that the percentage of cases that received attempted resuscitation reflects the proportion of all OHCA cases, while the proportion of cases that survived the event (ROSC on hospital handover) and survived to hospital discharge (reported by four ambulance services) or survival to 30 days (reported by one ambulance service: SJNZ) reflects the proportion of cases that received attempted resuscitation. Wellington Free Ambulance collected data only on those patients that received attempted resuscitation and therefore the proportion of patients with attempted resuscitation is not available.

EMS and bystander-witnessed cases were also observed. The region serviced by SJAWA, Western Australia, has a low population density (1.0 persons per square kilometre) [16] and this may explain, at least in part, the low rates of EMS and bystander-witnessed arrests. We have previously noted the wide variation in population density in areas serviced by ambulance services in Australia and New Zealand and the challenges that geographical remoteness place on EMS systems in providing appropriate and timely care for populations across entire states and territories [16].

For cases that had attempted resuscitation, the proportion of patients that survived the event (ROSC on hospital handover) (28%) was similar to that reported in England (26%) [4] and Europe (25%) [6]. Five services provided data on survival to hospital discharge or survival to 30 days, for which the overall rate was 12%. This is higher than the 10% in Europe [7] and the United States [7], 8% in England [4], and 5% in Asia [3]. Some of these differences may be explained by a more selective approach to the patients that receive attempted resuscitation in our region, which is demonstrated by the lower incidence of attempted resuscitation cases in our study compared to that of North America and England. In our study, significant variation in these outcomes was observed between ambulance services and may be partially explained by differences in definitions. For example, WFA defined attempted resuscitation as 'any purposeful initiation of CPR by paramedics', as opposed to the more inclusive definition used by other services of 'any chest compressions and/or defibrillation by EMS'. This is an important distinction as the reporting of outcomes is more favourable to WFA and this definition likely excludes patients with short resuscitation attempts, such as when futility is established shortly after the commencement of resuscitation. Within Australia and New Zealand (excluding WFA), event survival varied between 21% and 36% and survival to hospital discharge or 30 days varied between 9% and 13%. This variation is lower than that previously reported in North America, in which survival to hospital discharge varied between 1.1% and 8.1% [2]. The lower variation in our study may be explained by more homogenous and fewer EMS providers compared to North America. Additionally, our study demonstrated that survival to hospital discharge for EMS-witnessed cases varied between 19% and 25% and survival to hospital discharge in the Utstein comparator group (bystander-witnessed cases in a shockable rhythm) varied between 29% and 35%. The Utstein comparator group is considered to be a homogenous patient cohort that is often used to make comparisons between regions or to investigate changes over time. However, our results demonstrated that, even in this homogenous group, regional variation persisted. Large regional variation in survival from OHCA has been demonstrated in other international settings [2–7]. Girotra et al. [7] investigated regional variation in survival to discharge using data from the CARES registry and demonstrated that 41% of the county-level variation in outcome could be explained by patient-level demographics, cardiac arrest characteristics and bystander response. This increased to 50% upon inclusion of county-level sociodemographic characteristics. However, this demonstrates that a significant proportion of regional variation cannot be explained by patient and arrest characteristics and may be explained by system-level factors, such as the structure of the EMS workforce. Some of this variation may also be explained by variation in receiving hospital characteristics and post-resuscitation care [30,31]. However, we were unable to account for this variation in our study at this point. Regardless, understanding the fundamental drivers of the regional variation in outcomes observed in our study is a key component of improving survival from OHCA in Australia and New Zealand.

Strengths of the Aus-ROC Epistry include the attempted use of consistent definitions, the capture of all cases of OHCA for most services, not just those that receive attempted resuscitation from EMS, and the provision of data from only seven EMS providers. This is in contrast to the 264 EMS agencies that provided data to ROC. There is therefore less regional variation in systems, practice, data quality and case capture. Furthermore, data is provided by ambulance services that house and maintain existing OHCA registries [32–34]. All seven existing registries use multiple methods to identify OHCA cases and have in-built quality control measures [16]. However, the Aus-ROC Epistry is not without limitations. We noted varying amounts of missing data for all OHCA cases. However, there was minimal missing data for cases that had attempted resuscitation (range: 0.0% to 1.8%). As previously discussed, there were challenges with defining the capture population of SJANT and this may have impacted on incidence calculations. In this study, we excluded OHCA cases that were defibrillated and achieved ROSC prior to the arrival of EMS. We noted variation in the completeness of capturing these data between regions; and thus these figures are potentially subject to case ascertainment issues. Regardless, as the number and utilisation of public automated external defibrillators by lay people increases, the inclusion of these cases in OHCA registries will be important in reflecting the effectiveness of the system of care that is provided to OHCA patients. In this study, we reported crude outcome measures, rather than conducting multivariable analyses to account for regional variation in the underlying demographic and arrest characteristics; this analysis is planned for future work. Finally, the importance of measuring neurological outcomes and quality-of-life following OHCA is acknowledged [35]. However, only one registry participating in the Aus-ROC Epistry collects quality-of-life data (AV) and only one registry collects neurological outcomes measured using the Cerebral Performance Category (SJAWA). It is hoped that these data will become part of routine data collection in the future.

Conclusions

Significant regional variation was observed in the incidence, characteristics and outcomes of OHCA in Australia and New Zealand. Understanding the system-level and public health drivers of this variation will enable an optimisation of the delivery of care by EMS in our region with the aim of improving survival from OHCA.

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Table 4
Sub-group analyses of outcomes for OHCA cases that received attempted resuscitation, by ambulance service. P-values reflect comparisons across all ambulance services.

	Overall	Australia					New Zealand		
		Victoria (AV)	South Australia (SAAS)	Western Australia (SJAWA)	Queensland (QAS)	Northern Territory (SJANT)	St John New Zealand (SJNZ)	Wellington Free Ambulance (WFA)	P-value *
EMS witnessed cases									
Survived to hospital discharge/30 days **									0.126
Yes	255 (24.6%)	109 (24.8%)	20 (19.4%)	31 (22.3%)	–	–	83 (25.4%)	12 (44.4%)	
No	768 (74.2%)	326 (74.3%)	80 (77.7%)	105 (75.5%)	–	–	242 (74.0%)	15 (55.6%)	
Missing	12 (1.2%)	4 (0.9%)	3 (2.9%)	3 (2.2%)	–	–	2 (0.6%)	0	
Non-EMS witnessed cases									
Survived to hospital discharge/30 days ** – All non-EMS-witnessed cases									0.045
Yes	591 (9.9%)	231 (10.3%)	52 (8.4%)	87 (7.7%)	–	–	188 (11.0%)	33 (13.6%)	
No	5320 (89.4%)	2008 (89.0%)	561 (90.6%)	1032 (91.9%)	–	–	1511 (88.4%)	208 (86.0%)	
Missing	37 (0.6%)	15 (0.7%)	6 (1.0%)	5 (0.4%)	–	–	10 (0.6%)	1 (0.4%)	
Survived to hospital discharge/30 days ** – Shockable rhythm, bystander-witnessed									0.530
Yes	395 (31.2%)	146 (30.7%)	40 (35.4%)	34 (29.1%)	–	–	149 (30.0%)	26 (40.0%)	
No	858 (67.7%)	322 (67.8%)	71 (62.8%)	83 (70.9%)	–	–	343 (69.0%)	39 (60.0%)	
Missing	14 (1.1%)	7 (1.5%)	2 (1.8%)	0	–	–	5 (1.0%)	0	
Survived to hospital discharge/30 days ** – presumed cardiac cases (excluding EMS witnessed cases)									0.004
Yes	530 (11.5%)	202 (11.9%)	47 (9.9%)	73 (8.2%)	–	–	176 (13.0%)	32 (15.4%)	
No	4071 (87.9%)	1485 (87.6%)	421 (88.8%)	818 (91.4%)	–	–	1171 (86.4%)	176 (84.6%)	
Missing	28 (0.6%)	9 (0.5%)	6 (1.3%)	4 (0.4%)	–	–	9 (0.6%)	0	

*Note: *p*-values for comparisons of outcomes between ambulance services reflect data that excludes missing values. ** Note: SJNZ provided data on survival to 30 days while all other services that provided survival data (AV, SAAS, SJAWA and WFA) provided data on survival to hospital discharge. Missing data (see Supplementary Material) was subtracted from denominators.

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Competing interests

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2018.02.029.

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