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Clinical paper

Trends in out-of-hospital cardiac arrest incidence, patient characteristics and survival over 18 years in Perth, Western Australia

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Abstract

Objectives: To investigate trends in the incidence, characteristics, and survival of out-of-hospital cardiac arrests (OHCA) in the Perth metropolitan area between 2001 and 2018.

Methods: We calculated the crude incidence rate, age-standardised incidence rate (ASIR) and age- and sex-specific incidence rates (per 100,000 population) for OHCA of presumed cardiac aetiology. ASIRs were calculated using the direct method of standardisation using the 2001 Australian Population standard. Survival was assessed at return of spontaneous circulation at emergency department arrival and at 30 days. Temporal trends in patient and arrest characteristics were assessed with logistic regression, while trends in incidence were assessed using Joinpoint regression. Survival trends were assessed using binary logistic regression.

Results: A total of 18,417 OHCAs of presumed cardiac aetiology were attended by emergency medical services in Perth between 2001 and 2018. Overall, there were no significant changes in the crude or ASIR of OHCA over the study period, although OHCA incidence in 15–39 year-old males increased by 12.5% annually between 2011 and 2018. Both bystander cardiopulmonary resuscitation and bystander defibrillation increased over the study period, while the proportion of shockable arrests declined. Thirty-day OHCA survival improved significantly over time, with the odds of survival (in bystander-witnessed, initial shockable rhythm arrests) improving 12% (95% CI, 9.0% to 14.0%) annually, from 8.4% in 2001 to 44.0% in 2018.

Conclusion: Overall, there were no significant trends in OHCA incidence over the study period, although arrests in 15–39 year-old males increased significantly after 2011. There were significant improvements in 30-day survival between 2001 and 2018.

Keywords: Out-of-hospital cardiac arrest, Survival, Incidence, Trends

Introduction

Out-of-hospital cardiac arrest (OHCA) is a global health issue[1] that carries considerable societal and economic costs.[3] A recent study estimated that the annual economic loss to the Australian economy from sudden cardiac arrest was comparable to that from all cancers in Australia combined.[3] With an ageing population[4] it is likely these economic impacts will only be exacerbated in the future. Monitoring temporal trends in OHCA incidence enables the evaluation of the effectiveness of preventative public health strategies, while monitoring survival helps inform the clinical management of OHCAs. Importantly, understanding OHCA trends allows health authorities to better target future health spending.

Globally, temporal trends in OHCA incidence have shown considerable variation.[2,5,6] This variation is likely to be a result of regional differences in socioeconomic status[7] and underlying population health characteristics.[8] Encouragingly, recent international studies have generally reported increasing survival over time.[2,9–11] Our

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study aimed to investigate temporal trends in the incidence, patient and arrest characteristics, and 30-day survival of OHCA of presumed cardiac aetiology in the Perth metropolitan area over an 18-year period.

Methods

Study design

We conducted a population-based retrospective cohort study of patients (of all ages) who experienced an OHCA of presumed cardiac aetiology in the Perth metropolitan area and were attended by St John Western Australia (SJ-WA) emergency medical services (EMS) between 1st January 2001 and 31st December 2018. 'Presumed cardiac aetiology' was defined based on the exclusion of other obvious non-cardiac causes e.g., trauma, poisoning, drowning, drug overdose or asphyxia.[12] This study was approved by the Human Research Ethics Committee of Curtin University as a sub-study of the Western Australian Pre-hospital Care Record Linkage Project (HR128/2013).

Study setting

Perth is the capital, and largest city, in the state of WA, with a population of 1.39 million people in 2001[13] and 2.09 million in 2019.[14] The sole provider of road-based EMS in Perth is SJ-WA, which operates a single-tiered advanced life support service, staffed by nationally-registered paramedics. OHCA patients are currently transported to one of ten hospital emergency departments (ED) within the Perth area,[15] unless resuscitative efforts are ceased in the field by paramedics (or not commenced), due to futility or not-for-resuscitation orders.

Data sources

We sourced data from the SJ-WA OHCA Database[16] which contains details for all metropolitan OHCAs attended by SJ-WA EMS since 1996. The database is maintained by the Prehospital, Resuscitation and Emergency Care Research Unit (PRECRU) at Curtin University, extracting data from patient care records (PCR) completed by SJ-WA paramedics, and linked to computer-aided dispatch data. The database contains data on patient demographics, arrest characteristics, EMS response intervals, pre-ambulance care by bystanders, and EMS interventions. The 'Utstein' prognostic variables[12] in the database include patient age and sex, witnessed status (bystander-witnessed; EMS-witnessed; unwitnessed), bystander cardiopulmonary resuscitation (CPR), EMS response time (call answer to arrival on scene), initial cardiac arrest rhythm (as recorded by paramedics), return of spontaneous circulation (ROSC) in the field, and ROSC on arrival at the Emergency Department (ED). Thirty-day survival following OHCA is determined by manual look-up in the WA Death Registry.[17] As a result of industrial action by SJ-WA paramedics in 2008, a number of OHCA cases for that year are thought to be missing/incomplete. We therefore excluded all cases from 2008.

Statistical analysis

Patient and arrest characteristics of the study cohort were summarised across 3-year time intervals (2001–2003, 2004–2006, 2007–2009 [excluding 2008], 2010–2012, 2013–2015, 2016–2018) as counts and percentages. Patient and arrest characteristics examined were patient age group (0–17, 18–39, 40–64, 65–79, and 80 + years), sex (male/female), arrest locations (public/other), EMS witnessed arrest (yes/no), bystander witnessed (yes/no), bystander CPR (yes/no), automated external defibrillator (AED) shock-given by bystander (yes/no), initial arrest rhythm (ventricular fibrillation/pulseless ventricular tachycardia (VF/VT), Asystole/pulseless electrical activity (PEA), EMS-attempted resuscitation (yes/no), EMS response time (<10 mins, ≥10 mins), ROSC at ED (yes/no) and survived 30-days (yes/no). Annual crude, age- and sex-specific, and ASIR were calculated for the Perth metropolitan area and reported per 100,000 person-years. Additionally, ASIRs were determined for cases of EMS-attempted resuscitation, and the Utstein comparator group (bystander-witnessed arrests with initial shockable arrest rhythm).[12] Annual crude incidence rates were calculated as the number of OHCA events for each calendar year divided by the Perth population for that year (obtained from the Australian Bureau of Statistics (ABS)). Age- and sex-specific incidence rates were calculated by sex (male/female) and age group (0–14, 15–39, 40–64, 65–79, and 80 + years), using the number of OHCA cases for each group as the numerator and the Perth metropolitan population corresponding to each respective group as the denominator. ASIR were calculated using annual age-specific incidence rates across 5-year age groups, standardised using the direct method of standardisation to the 2001 Australian population standard.[18]

Temporal trends in patient and arrest characteristics were assessed using logistic regression for dichotomous variables (e.g. sex), and ordinal logistic regression [after confirmation of proportional odds assumption][19] for ordinal variables (e.g. patient age group). Temporal trends in OHCA incidence rates (e.g. crude, age- and sex-specific, and age-standardised) were examined using Joinpoint regression and reported as the Annual Percentage Change (APC) in incidence. Joinpoint regression applies a piecewise log-linear model using a permutation test to determine the optimal number of "joinpoints";[20] allowing it to identify overall trend as well as shorter intra-study period trends (where present). Temporal trends in survival outcome (ROSC at ED, 30-day survival) were assessed using unadjusted and adjusted logistic regression for two patient groups: i) those who received EMS-attempted resuscitation and ii) the Utstein comparator group.[12] Variables included in the adjusted models were: calendar-year of arrest [continuous], patient age (0–17, 18–39, 40–64, 65–79, and 80+ years), sex (female/male), arrest location (public/other), arrest witness status (unwitnessed/bystander witnessed/EMS witnessed), bystander CPR (no/yes), bystander AED shock (no/yes), initial arrest rhythm (Asystole/PEA, VF/VT) and EMS response time (in minutes, from call to scene). The logistic regression model for the Utstein comparator group excluded 'bystander status' and 'initial arrest rhythm' as these are specified in the definition of the sub-group. Analysis was performed using SPSS v26 (IBM Inc., Armonk, NY, USA) and Joinpoint regression version 4.9.0.0 (https://surveillance.cancer.gov/joinpoint/). Results were considered statistically significant for P values < 0.05.

Results

Between 2001 and 2018 EMS attended 25,561 OHCA cases in the Perth metropolitan area, of which 19,188 (75.1%) were of a presumed cardiac aetiology. After excluding cases from 2008 (n = 755) and those with missing key patient demographic data (n = 16), 18,417 cases were included in our final cohort (Fig. 1). Overall, 1677 (9.1%) patients from our cohort achieved ROSC at

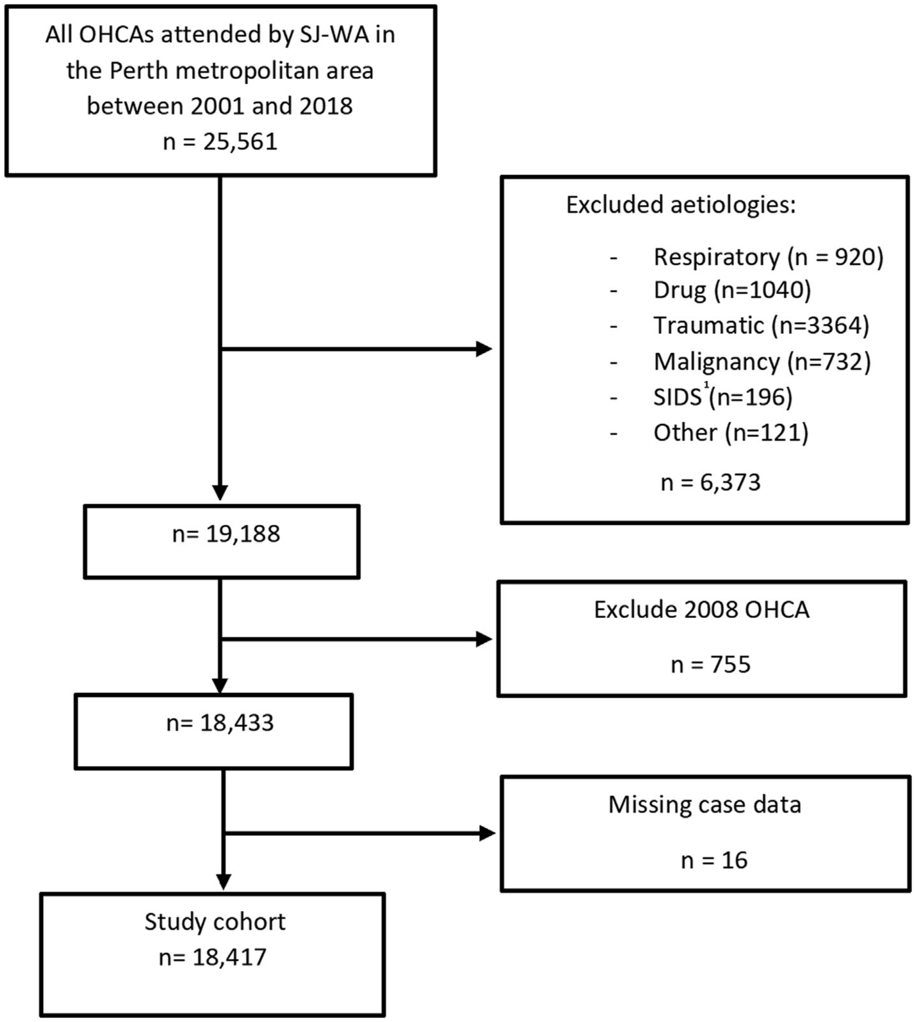

Fig. 1 – Flow diagram of study cohort.
1. Sudden Infant Death Syndrome.

ED and 920 (5.0%) survived to 30 days. Of the 8,340 (45.3%) cases who received a EMS-attempted resuscitation, 1599 (19.2%) attained ROSC at ED, and 841 (10.1%) survived to 30 days. Of the 1716 Utstein comparator group arrests (bystander-witnessed arrests with initial shockable rhythm), 585 (34.1%) achieved ROSC at ED and 435 (25.3%) survived to 30-days. Table 1 shows the characteristics of OHCA cases included over the study period, grouped by 3-year calendar intervals.

Trends in ROSC at ED

The overall proportion of OHCA patients with ROSC at ED increased over the study period, from 3.5% between 2001 and 2003 to 12.1% between 2016 and 2018 (Table 1). Fig. 2 shows the percentage of 30-day OHCA survivors by calendar year as a proportion of; i) all EMS-attempted resuscitations and ii) all Utstein comparator group resuscitations. In the EMS-attempted resuscitation group, the proportion of patients that attained ROSC at ED increased from 5.6% in 2001 to 26.5% in 2018 ($p < 0.001$), representing a crude improvement of 8.0% (OR 1.08; 95% CI, 1.07–1.10) per annum in the odds of ROSC at ED (Table 2a). In the Utstein comparator group, the proportion of patients that attained ROSC at ED increased from 9.5% in 2001 to 48.5% in 2018 ($p < 0.001$), representing a crude improvement of 12.0% (OR 1.12; 95% CI, 1.10–1.15) per annum in the odds of ROSC at ED. After adjustment for potential confounders (Table 2), the odds of ROSC at ED improved by 11.0% per annum for both the EMS-attempted resuscitation group (OR 1.11; 95% CI, 1.10–1.13) and the Utstein comparator group (OR 1.11; 95% CI, 1.09–1.14).

Trends in 30-day survival

There was a steady increase in 30-day survival over the study period, with overall 30-day survival in our study cohort increasing from 2.6% (between 2001 and 2003) to 6.7% (between 2016 and 2018). Fig. 2 shows the percentage of 30-day OHCA survivors by calendar year as a proportion of; i) all EMS-attempted resuscitations and ii) all Utstein comparator group resuscitations. Survival in the EMS-attempted resuscitation group increased significantly over the study period, from 4.2% in 2001 to 16.4% in 2018 ($p < 0.001$). The logistic regression model showed that for this group the odds of surviving 30-days improved by 5% (OR 1.05; 95% CI, 1.04–1.07) per annum in the unadjusted model, and by 9.0% (OR 1.09; 95% CI 1.07–1.10)

Table 1 – Descriptive characteristics of OHCAs of presumed cardiac aetiology attended by SJ-WA in Perth WA between 2001 and 2018 (n = 18,417 cases) across 3-year time intervals.

	2001–2003		2004–2006		2007-2009[a]		2010–2012		2013–2015		2016–2018	
	n = 2439		n = 2529		n = 1897		n = 3083		n = 4032		n = 4437	
Patient age, n (%)												
0–17	30	(1.2)	15	(0.6)	11	(0.6)	33	(1.1)	45	(1.1)	29	(0.7)
18–39	118	(4.8)	158	(6.2)	114	(6.0)	162	(5.3)	299	(7.4)	329	(7.4)
40–64	680	(27.9)	718	(28.4)	590	(31.1)	959	(31.1)	1326	(32.9)	1416	(31.9)
65–79	963	(39.5)	888	(35.1)	623	(32.8)	911	(29.5)	1177	(29.2)	1381	(31.1)
80+	648	(26.6)	750	(29.7)	559	(29.5)	1018	(33.0)	1185	(29.4)	1282	(28.9)
Sex, n (%)												
Male	1580	(64.8)	1668	(66.0)	1233	(65.0)	2032	(65.9)	2647	(65.6)	2860	(64.5)
Female	859	(35.2)	861	(34.0)	664	(35.0)	1051	(34.1)	1385	(34.4)	1577	(35.5)
Arrest location, n (%)												
Public	309	(12.7)	292	(11.5)	212	(11.2)	370	(12.0)	455	(11.3)	417	(9.5)
Other	2130	(87.3)	2237	(88.5)	1685	(88.8)	2713	(88.0)	3577	(88.7)	3952	(90.5)
EMS witnessed arrest n (%)												
Yes	93	(3.8)	113	(4.5)	91	(4.8)	168	(5.4)	245	(6.1)	320	(7.2)
No	2346	(96.2)	2416	(95.5)	1806	(95.2)	2915	(94.6)	3787	(93.9)	4117	(92.8)
Bystander witnessed n (%)												
Yes	703	(28.8)	626	(24.8)	408	(21.5)	688	(22.3)	904	(22.4)	1120	(25.2)
No	1736	(71.2)	1903	(75.2)	1489	(78.5)	2395	(77.7)	3128	(77.6)	3317	(74.8)
Bystander CPR, n (%)												
Yes	505	(21.5)	584	(24.2)	415	(23.0)	906	(31.1)	1331	(35.1)	1584	(38.5)
No	1841	(78.5)	1832	(75.8)	1391	(77.0)	2009	(68.9)	2456	(64.9)	2533	(61.5)
AED shock-given, n (%)												
Yes	2	(0.1)	4	(0.2)	9	(0.5)	32	(1.0)	48	(1.2)	91	(2.1)
No	2437	(99.9)	2525	(99.8)	1888	(99.5)	3051	(99.0)	3984	(98.8)	4346	(97.9)
Initial arrest rhythm, n (%)												
VF/VT	433	(17.8)	406	(16.1)	296	(15.6)	503	(16.3)	577	(14.3)	641	(14.4)
Asystole/PEA	1979	(81.1)	2122	(83.9)	1595	(84.1)	2555	(82.9)	3451	(85.6)	3791	(85.4)
Unknown	27	(1.1)	1	(0.0)	6	(0.3)	25	(0.8)	4	(0.1)	5	(0.1)
Attempted Resus, n (%)												
Yes	1047	(42.9)	978	(38.7)	769	(40.5)	1384	(44.9)	2064	(51.2)	2098	(47.3)
No	1392	(57.1)	1551	(61.3)	1128	(59.5)	1699	(55.1)	1968	(48.8)	2339	(52.7)
EMS response time, n (%)												
< 10 minutes	1558	(63.9)	1559	(61.6)	1143	(60.3)	1994	(64.7)	2963	(73.5)	2985	(67.3)
≥ 10 minutes	876	(35.9)	969	(38.3)	754	(39.7)	1088	(35.3)	1069	(26.5)	1451	(32.7)
Unknown	5	(0.2)	1	(<0.1)	0	(0.0)	1	(0.0)	0	(0.0)	1	(<0.1)
ROSC at ED, n (%)												
Yes	86	(3.5)	115	(4.5)	128	(6.8)	309	(10.1)	504	(12.5)	535	(12.1)
No	2352	(96.5)	2413	(95.5)	1762	(93.2)	2754	(89.9)	3522	(87.5)	3902	(87.9)
Survived 30-days, n (%)												
Yes	63	(2.6)	78	(3.1)	87	(4.6)	167	(5.4)	229	(5.7)	296	(6.7)
No	2376	(97.4)	2451	(96.9)	1810	(95.4)	2916	(94.6)	3803	(94.3)	4141	(93.3)

[a] Data for 2008 excluded.

per annum after adjustment for potential confounders (Table 2a). Survival in the Utstein comparator group showed the greatest improvement over time, from 8.4% in 2001 to 44.0% in 2018 ($p < 0.001$). In this group the odds of surviving 30 days following arrest improved by 12% (OR 1.12; 95% CI, 1.09–1.14) per annum in the unadjusted logistic regression model and by 11% (OR 1.11; 95% CI 1.08–1.14) per annum after adjustment for potential confounders (Table 2b).

Trends in patient and arrest characteristics

Fig. 3 shows the temporal trends in patient and arrest characteristics, as a proportion of all arrests in each respective year. Patients tended to be younger over time, with the odds of belonging to an older age group decreasing by 1.0% annually (OR 0.99; 95% CI, 0.98–0.99). An increasing trend was seen in EMS-witnessed arrests (OR 1.05; 95% CI, 1.03–1.06), bystander CPR (OR 1.06; 95% CI, 1.05–1.07), bystander delivered AED shocks (OR 1.20; 95% CI, 1.16–1.25) and attempted EMS resuscitations (OR 1.03; 95% CI, 1.02–1.03). In contrast, there was a decreasing trend in arrests in public locations (OR 0.98; 95% CI, 0.97–0.99), bystander witnessed arrests (OR 0.99; 95% CI, 0.98–0.99), arrests with an initial VF/VT rhythm (OR 0.98; 95% CI, 0.98–0.99) and EMS response time (OR 0.98; 95% CI, 0.97–0.98). There was no significant trend in patient sex (OR 1.00; 95% CI, 1.00–1.01).

Trends in OHCA incidence

Fig. 4 shows the overall crude, and age-standardised OHCA incidence rates along with the ASIR of the subgroup analyses (EMS-attempted resuscitation, and Utstein comparator group). Supplementary Table 1 show the results of the trend analysis (i.e. Joinpoint

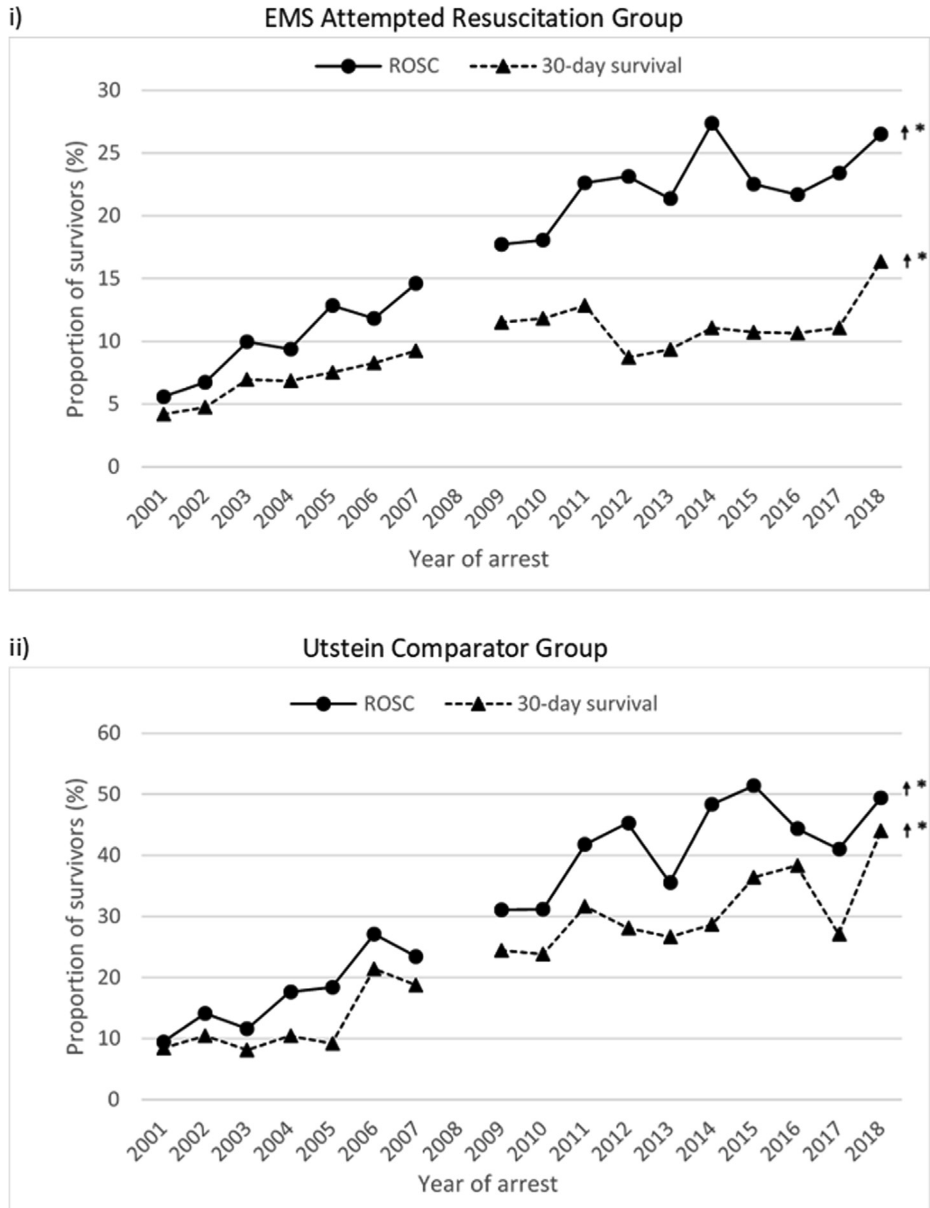

Fig. 2 – Temporal trends in ROSC at ED and 30-day OHCA survival in i) patients with an EMS attempted resuscitation and ii) the Utstein comparator group.
↑* Binary logistic regression showing increasing survival over calendar year p < 0.05.

regression results). There were no significant temporal trends in overall crude incidence rate (APC 1.5; 95% CI, −1.1 to 4.2) or ASIR (APC 0.8; 95%, CI −1.9 to 3.5). Likewise, there were no overall significant temporal trends in the ASIR of EMS-attempted resuscitations (APC 0.7; 95% CI, −1.0 to 2.4) or Utstein comparator group arrests (APC 0.2; 95% CI, −3.3 to 3.8). However, ASIR of EMS-attempted resuscitations did show statistically significant intra-study period changes: incidence declined between 2001 and 2004 (APC −7.3; 95% CI, −13.4 to −0.8) and 2015–2018 (APC −8.3, 95% CI, −12.6 to −3.8), but increased between 2011 and 2015 (APC 13.4; 95% CI, 7.7–19.5). Likewise, ASIR of the Utstein comparator group rose significantly after 2007 (APC 4.7; 95% CI, 1.1–8.4). Some age and sex demographic groups showed small (albeit statistically significant) changes in OHCA incidence over time (Supplementary Fig. 1). The largest change occurred in 15–39 year old males with incidence increasing by 12.5% (APC 12.5; 95% CI, 4.8–20.7) per annum after 2011.

Discussion

Our study examined temporal trends in EMS attended OHCAs of presumed cardiac aetiology, in Perth WA, between 2001 and 2018. Overall, there was an upward trend in OHCA survival over the study period. In arrests with EMS attempted resuscitation, 30-day survival increased from 4.2% in 2001 to 16.4% in 2018. The greatest improvement in survival was in the Utstein comparator group (bystander-witnessed arrests presenting with initial shockable arrest

Table 2 – Unadjusted and adjusted odds ratios for OHCA patients achieving ROSC or 30-day survival in (a) EMS attempted resuscitation (n = 8340) or (b) Utstein comparator arrests (n = 1716) between 2001 and 2018.

Table 2a. EMS attempted resuscitation (n = 8340)

	ROSC at Emergency Department				30-day survival			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Year of arrest								
Per year	1.08	(1.07–1.10)	1.11	(1.10–1.13)	1.05	(1.04–1.07)	1.09	(1.07–1.10)
Age group								
0–17	ref	ref		ref	ref		ref	
18–39	1.63	(0.94–2.84)	1.21	(0.66–2.21)	1.72	(0.88–3.33)	0.94	(0.41–2.11)
40–64	1.52	(0.90–2.56)	0.92	(0.52–1.64)	1.54	(0.82–2.89)	0.54	(0.25–1.18)
65–79	1.41	(0.84–2.38)	0.96	(0.54–1.70)	0.99	(0.52–1.87)	0.38	(0.17–0.82)
≥ 80	1.13	(0.67–1.92)	0.83	(0.47–1.48)	0.43	(0.22–0.83)	0.19	(0.09–0.43)
Sex								
Female	ref		ref		ref		ref	
Male	0.95	(0.85–1.07)	0.70	(0.61–0.80)	1.41	(1.19–1.66)	0.81	(0.67–0.99)
Arrest location								
Other	ref		ref		ref		ref	
Public	2.04	(1.79–2.31)	1.58	(1.36–1.84)	3.26	(2.80–3.80)	2.22	(1.83–2.70)
Arrest witness status								
Unwitnessed	ref		ref		ref		ref	
Bystander witnessed	2.35	(2.06–2.66)	1.44	(1.25–1.66)	3.28	(2.70–3.97)	1.36	(1.09–1.69)
EMS witnessed	4.60	(3.90–5.43)	3.37	(2.76–4.12)	9.34	(7.52–11.60)	8.75	(6.55–11.69)
Bystander CPR								
No	ref		ref		ref		ref	
Yes	1.21	(1.08–1.35)	1.11	(0.96–1.28)	1.13	(0.98–1.30)	1.11	(0.89–1.39)
Bystander AED shock								
No	ref		ref		ref		ref	
Yes	5.12	(3.58–7.32)	1.25	(0.84–1.86)	5.71	(3.94–8.26)	1.01	(0.66–1.54)
Presenting arrest rhythm								
Asystole	ref		ref		ref		ref	
PEA	2.89	(2.45–3.41)	2.48	(2.07–2.96)	7.29	(4.91–10.83)	5.37	(3.52–8.20)
VF/VT	5.82	(5.04–6.72)	5.63	(4.79–6.63)	37.62	(26.28–53.83)	34.15	(23.24–50.18)
EMS response time								
Per minute	0.98	(0.97–0.99)	0.98	(0.97–0.99)	0.97	(0.96–0.99)	0.96	(0.95–0.98)

Table 2b. Utstein comparator arrests (n=1716)

	ROSC at Emergency Department				30-day survival			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Year of arrest								
Per year	1.12	(1.10–1.15)	1.11	(1.09–1.14)	1.12	(1.09–1.14)	1.11	(1.08–1.14)
Age group								
0–17	ref		ref		ref		ref	
18–39	1.75	(0.48–6.32)	2.01	(0.49–8.30)	1.51	(0.42–5.46)	1.79	(0.43–7.41)
40–64	0.98	(0.28–3.36)	1.20	(0.30–4.72)	0.76	(0.22–2.63)	0.93	(0.24–3.68)
65–79	0.85	(0.25–2.94)	1.19	(0.30–4.71)	0.48	(0.17–1.65)	0.64	(0.16–2.54)
≥ 80	0.62	(0.18–2.19)	0.90	(0.22–3.65)	0.21	(0.06–0.76)	0.30	(0.07–1.24)
Sex								
Female	ref		ref		ref		ref	
Male	0.82	(0.64–1.06)	0.64	(0.48–0.85)	1.02	(0.77–1.35)	0.75	(0.54–1.04)
Arrest location								
Other	ref		ref		ref		ref	
Public	2.22	(1.81–2.73)	1.98	(1.55–2.53)	3.17	(2.53–3.99)	2.71	(2.07–3.55)
Arrest witness status								
Unwitnessed	NA	NA	NA	NA	NA	NA	NA	NA
Bystander witnessed	NA	NA	NA	NA	NA	NA	NA	NA
EMS witnessed	NA	NA	NA	NA	NA	NA	NA	NA

Bystander CPR								
No	ref		ref		ref		ref	
Yes	2.21	(1.69–2.88)	1.35	(1.01–1.81)	2.95	(2.14–4.08)	1.67	(1.17–2.39)
Bystander AED shock								
No	ref		ref		ref		ref	
Yes	6.16	(4.25–8.92)	2.80	(1.84–4.27)	5.72	(4.05–8.07)	2.25	(1.50–3.38)
Presenting arrest rhythm								
Asystole	NA	NA	NA	NA	NA	NA	NA	NA
PEA	NA	NA	NA	NA	NA	NA	NA	NA
VF/VT	NA	NA	NA	NA	NA	NA	NA	NA
EMS response time								
Per minute	0.94	(0.92–0.97)	0.93	(0.90–0.96)	0.95	(0.92–0.98)	0.93	(0.90–0.97)

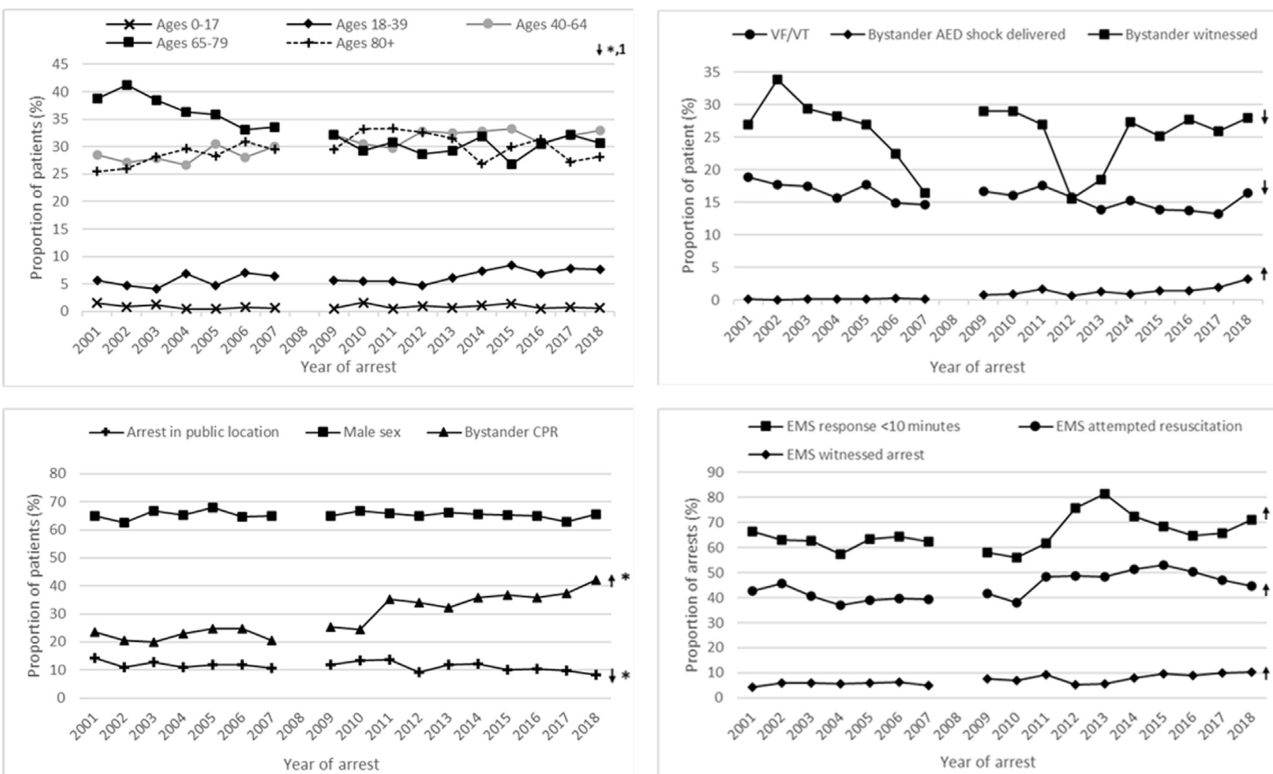

Fig. 3 – Trends over time in patient and arrest characteristics (as a proportion of all EMS attended arrests in each respective year) of OHCA of presumed cardiac aetiology attended by EMS between 2001 and 2018 in Perth WA. ↓*,1 Ordinal logistic regression showing decreasing patient age-group across calendar year $p < 0.05$. ↓* Binary logistic regression showing decreasing trend across calendar year $p < 0.05$. ↑* Binary logistic regression showing increasing trend across calendar year $p < 0.05$.

rhythm), where 30-day survival increased from 8.4% in 2001 to 44.0% in 2018; representing a 5-fold improvement in survival over an 18-year period.

The improvement in the Utstein comparator group survival was particularly noteworthy, as survival in this sub-group of OHCAs is less susceptible to regional variations in EMS policy (with regards to selective resuscitation) or patient/arrest 'case-mix'; thereby providing a more comparable measure of survival trend. We speculate increasing rates of bystander CPR and AED use, coupled with improving EMS response times and provision of high-quality CPR over the study period have acted to increase survival. The benefits of high-quality CPR to OHCA survival has been well established.[21] Since 2000, resuscitation guidelines have progressively placed greater emphasis on optimizing chest compression (in relation to compression depth and rate) and limiting 'hands-off' periods.[22] Interestingly however, after adjusting our logistic regression models for pre/peri-arrest factors, the trends in 30-day survival and ROSC at ED for the Utstein group remained strong, with the odds of both outcomes increasing 11% annually (both were 12% in unadjusted models). This suggests the improvement in survival may have largely resulted from other, unmeasured factors. Ultimately, we were unable to identify the factors responsible for the large increase in 30-day survival.

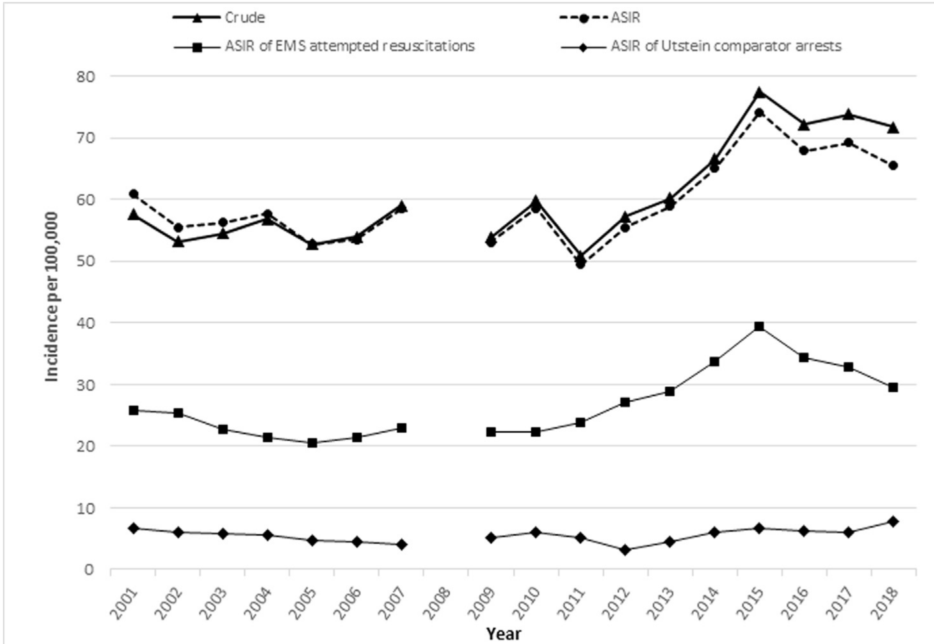

Fig. 4 – Trends in crude incidence, ASIR, ASIR of EMS attempted resuscitations and ASIR of Utstein comparator group arrests of OHCA of presumed cardiac aetiology attended by EMS between 2001 and 2018 in Perth, WA.

There were no significant trends in either crude or ASIRs between 2001 and 2018. A previous study[23] examining OHCA of presumed cardiac aetiology in Perth did not find a significant trend in crude incidence between 1997 and 2010, consistent with our study. This earlier study did however report a significant decrease in the ASIR, though this decrease appears to have exclusively occurred prior to 2002. A study[24] from Victoria, Australia, reported significant declines in the crude incidence and ASIR of OHCA of presumed cardiac aetiology between 2002 and 2012. However, this Victorian study only included adults (≥18 years) and excluded all EMS-witnessed arrests, making direct comparisons with our present study challenging.

Concerningly, our study identified a growing prevalence of OHCA incidence in young males. Between 2011 and 2018, OHCAs in 15–39 year-old males increased at a rate of 12.5% per annum - the largest rate of annual increase of any demographic group. Although we were unable to identify the reason for this increase, a 2012 study[25] reported the most common underlying cause of OHCAs in those between 25 and 35 years of age was coronary artery disease (CAD). We suspect, as others[26–28] have suggested, that the rising prevalence of cardiovascular disease risk factors may be partly responsible for this trend.

Despite encouraging OHCA survival trends, some trends are a cause for concern. Firstly, we found the proportion of OHCA patients presenting with initial shockable arrest rhythms has been steadily decreasing over time; consistent with findings from other Australian[5,29] and international[30,31] studies. Although the association between initial arrest rhythm and survival is well established,[32,33] the reason for this decreasing trend in shockable rhythms is poorly understood. A 2021 study[34] from the Netherlands suggested that comorbidity burden may be associated with lower odds of a shockable arrest, although this relationship was only found in males. Secondly, we found a decreasing trend in both the proportion of bystander-witnessed arrests and arrests occurring in public locations. Both these factors result in a delay to resuscitative efforts, resulting in reduced survival. Lastly, given the generally negative effect comorbidity has on OHCA survival outcomes,[35] projected increases in population comorbidity[36] could result in lower OHCA survival in the future.

Limitations

Our study has several limitations. Firstly, our study excluded all data from 2008. However, this exclusion did not impact reported trends as our regression analyses modelled 'time' (i.e. calendar year) as a continues variable. Secondly, our study only included arrests of 'presumed cardiac aetiology'. We chose to focus on arrests of this aetiology as they make up the bulk of arrests in Western Australia (>70%) and therefore represent the greatest burden to healthcare. Thirdly, we defined the geographical boundary of metropolitan Perth according to the 2016 ABS definition. This may have resulted in the inclusion of some cases (prior to 2016) that were considered, at the time of arrest, to be rural. Lastly, our study did not examine survival outcomes beyond 30 days. However, in a prior study[9] we demonstrated that between 1998 and 2017 there was a significant improvement in 10-year survival, relative to the age- and sex-matched general population, of initial (30-day) OHCA survivors in Perth.

Conclusion

There were no significant trends in the overall incidence of OHCA of presumed cardiac origin in metropolitan Perth between 2001 and 2018, however incidence in 15–39 year-old males increased sharply after 2011. The rates of bystander CPR and the provision of bystander AED shocks increased over the study period, however the proportion of arrests presenting with initial VF/VT rhythms decreased. There was an overall improvement in OHCA survival, with the odds of 30-day survival in the Utstein comparator group (bystander witnessed, initial VF/VT rhythm arrests) improving on average by 12% per annum.

CRediT authorship contribution statement

David Majewski: Conceptualization, Methodology, Validation, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Stephen Ball:** Conceptualization, Methodology, Validation, Data curation, Writing – review & editing. **Paul Bailey:** Conceptualization, Writing – review & editing, Funding acquisition. **Janet Bray:** Conceptualization, Writing – review & editing. **Judith Finn:** Conceptualization, Methodology, Validation, Writing – review & editing, Project administration, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Some of the authors are affiliated with St John WA as follows: Paul Bailey (Medical Director); Judith Finn (Adjunct Research Professor & recipient of research funding); Stephen Ball (Adjunct Research Fellow).

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2022.100201.

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