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Clinical paper

Trends in survival from out-of-hospital cardiac arrests defibrillated by paramedics, first responders and bystanders

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Abstract

Background: Although survival from out-of-hospital cardiac arrest (OHCA) is increasing, little is known about the long-term trends in survival for patients defibrillated by first responders and bystanders.

Methods: Between 2000 and 2017, we included adult non-traumatic OHCA with an initial shockable rhythm from the Victorian Ambulance Cardiac Arrest Registry. Adjusted logistic regression analyses were used to assess trends in survival to hospital discharge according to whether the patient was initially shocked by paramedics, first responders or bystanders.

Results: Of the 10,451 initial shockable arrests, 796 (7.6%) and 526 (5.0%) were initially shocked by first responders and bystanders, respectively. Between 2000–02 and 2015–17, the proportion of cases initially shocked by first responders and bystanders increased from 3.8% to 8.2% and from 2.0% to 11.2%, respectively. Over the same period, survival to hospital discharge increased from 11.6% to 28.8% for cases initially shocked by paramedics, from 10.5% to 37.8% for cases initially shocked by first responders, and from 6.7% to 55.5% for cases initially shocked by bystanders (p trend <0.001 for all). In the adjusted analyses, patients initially shocked by first responders (AOR 1.40, 95% CI: 1.18, 1.67; $p < 0.001$) and bystanders (AOR 2.11, 95% CI: 1.72, 2.59; $p < 0.001$) were more likely to survive to hospital discharge than those initially shocked by paramedics. The odds of survival increased year-on-year by 8.1% for patients shocked by paramedics ($p < 0.001$), 6.1% for patients shocked by first responders ($p = 0.004$), and 11.8% for patients shocked by bystanders ($p < 0.001$).

Conclusion: OHCA patients initially defibrillated by bystanders yielded the largest improvements in survival over time.

Keywords: Out-of-hospital cardiac arrest, Resuscitation, Emergency medical service, Defibrillation, Public access defibrillation

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Introduction

Out-of-hospital cardiac arrest (OHCA) is a global health issue affecting millions of people every year.[1] Reducing the time to defibrillation remains one of the most significant barriers to improving survival from OHCA.[2] Each minute that passes without treatment of cardiac arrest reduces the likelihood of being found in a shockable rhythm,[2–4] and this is associated with lower rates of survival and long-term favourable outcomes.[5–7]

Integrated system-based initiatives that optimise the early use of defibrillation by emergency medical service (EMS)-dispatched first responders (e.g. police or firefighter) and non-dispatched lay bystanders reduce delays to defibrillation and are associated with increases in survival after OHCA.[8–11] A recent systematic review reported median survival rates of 28.6% and 53.0% for OHCAs defibrillated by professional first responders and lay bystanders, respectively.[12] These survival rates compare favourably with those reported for initial shockable OHCAs, which range between 14.8% and 23.0%.[5]

Despite this, there is considerable variability in the reported survival rates of OHCA patients treated by first responders and bystanders. Observational studies published between 1984 and 2015 have reported survival rates of between 9.0% and 76.0% for OHCAs defibrillated by professional first responders.[12] Similarly, studies involving OHCAs defibrillated by bystanders have reported highly variable survival rates of between 26.0% and 72.0%.[12] As these studies span a period of three decades, it is unclear if differences in the reported outcomes are related to temporal changes in system and/or patient characteristics. It is also possible that survival outcomes are increasing independent of typical Utstein factors.[13] To date, few studies have examined temporal changes in survival from OHCAs defibrillated by first responders and bystanders.

In this study, we sought to examine temporal trends in patient outcomes from initial shockable OHCAs defibrillated by paramedics, first responders and bystanders.

Methods

Study design

We performed a retrospective analysis of adult (aged ≥16 years) non-traumatic OHCA cases with an initial shockable rhythm occurring between 1st January 2000 and 31st December 2017. Patients witnessed to arrest by EMS personnel and those with traumatic aetiology were excluded. The study, including the collection and use of registry data, was approved the Victorian Department of Health Human Research Ethics Committee as a quality assurance project.

Setting

The state of Victoria, Australia, operates a single state-wide EMS system servicing 6.4 million people across 227,000 square kilometres. Suspected cardiac arrest events receive a two-tiered response including advanced life support paramedics and intensive care paramedics. In metropolitan Melbourne and select areas of rural Victoria, basic life support trained first responders, including firefighters and community volunteers, are dispatched concurrently with paramedics.[14] Cardiac arrest treatment protocols for paramedics and first responders follow the recommendations of the Australian Resuscitation Council (resus.org.au/guidelines).

Public access defibrillation

The state of Victoria has a public network of automated external defibrillators (AED) that are either operated by the EMS or privately deployed by organisations in locations such as businesses, workplaces, shopping centres, and recreational facilities. The EMS maintains a non-compulsory public register of these AEDs which has had limited electronic integration into the emergency dispatch system. By the end of the study period, the location of approximately 3700 AEDs were registered with the EMS, including 21 AEDs which were owned and maintained by the EMS in high-incidence locations.[11] These high incidence locations include Melbourne airport, railway stations, shopping complexes and major tourist venues. In addition to these 3700 AEDs, the EMS estimates that an additional 15,000 AEDs have been deployed for public use but are not currently registered.[15]

Data sources & definitions

The Victorian Ambulance Cardiac Arrest Registry (VACAR) records details of all OHCA events attended by EMS in the state of Victoria. Registry processes including case ascertainment, data capture and completeness, and quality assurance have been described elsewhere.[13] Briefly, patient care records are recorded by paramedics using computer tablets, which are synchronised daily to a clinical data warehouse. A highly sensitive electronic search algorithm is used to identify potential cardiac arrest cases, which then undergo eligibility screening by registry staff. Information from patient care records is supplemented with data collected from computer-aided dispatch records, emergency call logs and first responder treatment records. The registry collects over 150 data elements, including the Utstein-style descriptors[16] and patient discharge outcomes from over 100 participating hospitals. Hospital outcome data is validated against death records from the Victorian Registry of Births, Deaths and Marriages.

Definitions used in this study follow the recommendations of the Utstein guidelines.[16] Arrest aetiology is presumed to be of cardiac cause in the absence of an obvious precipitator on the patient care record. Bystander CPR is defined as any attempt at chest compressions, with or without ventilations. Event survival denotes evidence of sustained ROSC (i.e. a palpable pulse) on the patient care record on arrival at the emergency department. Survival to hospital discharge was defined as discharge from acute hospital care. A ‘first responder’ refers to an EMS-dispatched professional firefighter or community volunteer, while ‘bystander’ refers to all non-EMS dispatched persons.

Data analysis

The primary outcome of the study was survival to hospital discharge. The secondary outcomes included event survival and any prehospital return of spontaneous circulation (ROSC).

Statistical analyses were undertaken using Stata Statistical Software 15 (StataCorp, 2018, College Station, TX). A two-sided significance level of less than 0.05 was considered statistically significant. Baseline characteristics were reported using descriptive statistics and stratified by shock provider (i.e. paramedic, first responder or bystander). Comparison of baseline characteristics across shock providers were made using the $\chi 2$ test and the Kruskal–Wallis test, as appropriate. For each shock provider, we categorised study year into groups (i.e. 2000–02, 2003–05, 2006–08, 2009–11, 2012–14, and 2015–17) and examined changes in baseline characteristics over time using a non-parametric test for trend.[17] Trends in unadjusted survival to hospital discharge, event survival and ROSC were also assessed using the same approach.

To examine the impact of shock provider on survival to hospital discharge, event survival and ROSC we performed logistic regression adjusting for the following variables: age, sex, witness status, bystander CPR, arrest aetiology, location of arrest, urban region, and EMS response time (i.e. time from emergency call to arrival at scene). Patients initially shocked by paramedics were used as the reference category. The models were performed as complete case analyses, therefore excluding a small number of cases with one or more missing variables (n = 340, 3.3%). To assess temporal trends in outcomes over time, we repeated the approach above stratifying the population by shock provider. In these models, the temporal trend was modelled using a continuous term denoting consecutive calendar years in the study period. The variable provides an estimate of the adjusted year-on-year change in outcomes that are independent of other variables. Results from all logistic regression models were reported as adjusted odds ratios (AORs) with 95% confidence intervals (CIs).

Results

Sample population

Between 2000 and 2017, a total of 91,064 OHCA were attended by EMS, of which 10,451 involved non-traumatic arrests with an initial shockable rhythm (Figure S1 in the supplementary appendix). Of these, 9129 (87.4%) were initially shocked by paramedics, 796 (7.6%) were initially shocked by first responders and 526 (5.0%) were initially shocked by bystanders.

Trends in shock provider

Fig. S2 in the Supplementary appendix shows that the proportion of cases initially shocked by paramedics declined significantly over the study period among arrests in all locations and arrests in public locations. In all locations, there was a two-fold increase in the proportion of cases initially shocked by first responders (from 3.8% in 2000–02 to 8.2% in 2015–17; p-trend $<$0.001) and a five-fold increase in cases initially shocked by bystanders (from 2.0% in 2000–02 to 11.2% in 2015–17; p-trend $<$0.001). In public locations, the increase in the proportion of cases initially shocked by first responders was similar to all locations. However, there was an eight-fold increase in cases initially shocked by bystanders, from 2.9% in 2000–02 to 23.5% in 2015–17 (p-trend$<$0.001).

Trends in characteristics

Table 1 shows the baseline characteristics of patients stratified by shock provider. Patients initially shocked by bystanders were more often male, more likely to arrest in public locations, be witnessed by bystander and receive bystander CPR ($p < 0.001$). The time between emergency call and receiving the first shock was also lowest in cases initially shocked by bystanders compared to first responders and paramedics (median: 6 vs. 8 vs. 11 min, $p < 0.001$).

Trends in baseline characteristics over the study period are shown in Table 2. For all groups, the proportion of cases receiving bystander CPR increased significantly over time ($p < 0.001$). Although the time from emergency call to the delivery of the first shock increased for cases shocked by paramedics (from 9 min in 2000–02 to 10 min in 2015–17), it did not change for cases initially shocked by first responders and bystanders.

Table 1 – Characteristics of initial shockable OHCA cases according to shock provider.

	Overall n = 10,451	Shocked by paramedic n = 9129	Shocked by first responder n = 796	Shocked by bystander n = 526	p-Value	Missing, n (%)
Age in years, median (IQR)	67 (56, 77)	67 (56, 76)	68 (57, 78)	65 (55, 76)	0.05	0
Male sex, n (%)	8347 (79.9)	7252 (79.5)	645 (81.0)	450 (85.6)	0.002	1 (<0.1)
Arrest location, n (%)						1 (<0.1)
Private residence	6112 (58.5)	5604 (61.4)	475 (59.7)	33 (6.3)	<0.001	
Aged care or supported accommodation	344 (3.3)	311 (3.4)	25 (3.1)	8 (1.5)	0.06	
Public location	3627 (34.7)	2976 (32.6)	278 (34.9)	373 (70.9)	<0.001	
Other	367 (3.5)	237 (2.6)	18 (2.3)	112 (21.3)	<0.001	
Presumed cardiac aetiology, n (%)	10,018 (95.9)	8744 (95.8)	765 (96.1)	509 (96.8)	0.51	0
Metropolitan region, n (%)	7767 (74.3)	6620 (72.5)	757 (95.1)	390 (74.1)	<0.001	1 (<0.1)
Bystander witnessed, n (%)	8020 (76.7)	6947 (76.1)	612 (76.9)	461 (87.6)	<0.001	0
Bystander CPR, n (%)	7008 (67.1)	5939 (65.1)	568 (71.4)	501 (95.3)	<0.001	0
Call to EMS arrival time, median (IQR)	8 (6, 10)	8 (6, 10)	7 (5, 8)	8 (6, 11)	<0.001	128 (1.2)
Call to first shock time, median (IQR)	10 (8, 13)	11 (9, 13)	8 (7, 10)	6 (3, 8)	<0.001	573 (5.5)
EMS arrival to first ROSC, median (IQR)[a]	13 (9, 22)	15 (9, 22)	15 (9, 22)	9 (4, 17)	<0.001	164 (3.3)

CPR denotes cardiopulmonary resuscitation, EMS emergency medical service, IQR interquartile range, ROSC return of spontaneous circulation, Proportions exclude missing data.

[a] Measured in cases achieving return of spontaneous circulation between 2003 and 2017 (n = 4969). Time to first ROSC not captured prior to 2003.

Table 2 – Trends in the characteristics of initial shockable OHCA cases according to shock provider.

	2000–02 n = 1538	2003–05 n = 1809	2006–08 n = 1612	2009–11 n = 1755	2012–14 n = 1907	2015–17 n = 1830	p-Value for trend
Shocked by paramedic							
Age in years, median (IQR)	69 (59, 77)	69 (57, 77)	66 (54, 76)	66 (55, 76)	65 (56, 77)	66 (54, 76)	<0.001
Male sex, n (%)	1133 (78.3)	1327 (79.8)	1197 (82.2)	1218 (79.1)	1211 (78.4)	1166 (79.0)	0.69
Public location, n (%)	449 (31.0)	517 (31.1)	528 (36.2)	535 (34.8)	490 (31.7)	457 (31.0)	0.94
Metropolitan region, n (%)	1167 (80.5)	1218 (73.2)	1102 (75.6)	1076 (69.9)	1056 (68.4)	1001 (67.8)	<0.001
Bystander witnessed, n (%)	1036 (71.5)	1274 (76.6)	1119 (76.8)	1188 (77.2)	1222 (79.2)	1108 (75.1)	0.006
Bystander CPR, n (%)	733 (50.6)	842 (50.6)	822 (56.4)	1097 (71.3)	1224 (79.3)	1221 (82.7)	<0.001
Call to EMS arrival, median (IQR)	7 (5, 8)	7 (6, 9)	8 (6, 10)	8 (6, 11)	8 (6, 11)	8 (6, 10)	<0.001
Call to first shock, median (IQR)	9 (7, 12)	10 (8, 13)	11 (9, 14)	12 (10, 15)	12 (9, 14)	10 (8, 13)	<0.001
Shocked by first responder							
Age in years, median (IQR)	71 (55, 79)	68 (60, 77)	68 (59, 78)	67 (57, 77)	66 (55, 77)	68 (55, 78)	0.18
Male sex, n (%)	45 (77.6)	104 (82.5)	96 (80.0)	133 (82.6)	147 (81.2)	120 (80.0)	0.97
Public location, n (%)	16 (27.6)	48 (38.1)	51 (42.5)	60 (37.3)	59 (32.6)	44 (29.3)	0.23
Metropolitan region, n (%)	54 (93.1)	124 (98.4)	116 (96.7)	150 (93.2)	167 (92.3)	146 (97.3)	0.58
Bystander witnessed, n (%)	34 (58.6)	93 (73.8)	95 (79.2)	134 (83.2)	143 (79.0)	113 (75.3)	0.05
Bystander CPR, n (%)	24 (41.3)	75 (59.5)	70 (58.3)	124 (77.0)	145 (80.1)	130 (86.7)	<0.001
Call to EMS arrival, median (IQR)	7 (6, 9)	6 (5, 7)	6 (5, 8)	7 (6, 9)	7 (6, 8)	6 (5, 8)	0.05
Call to first shock, median (IQR)	8 (6, 11)	8 (7, 9)	8 (7, 9)	9 (8, 11)	9 (7, 11)	7 (5, 10)	0.23
Shocked by bystander							
Age in years, median (IQR)	74 (64, 81)	75 (59, 82)	65 (57, 81)	68 (54, 78)	63 (53, 73)	64 (53, 75)	<0.001
Male sex, n (%)	22 (71.0)	18 (94.7)	30 (85.7)	45 (81.8)	160 (87.9)	175 (85.8)	0.18
Public location, n (%)	14 (45.2)	11 (57.9)	17 (48.6)	38 (69.1)	139 (76.4)	154 (75.5)	<0.001
Metropolitan region, n (%)	28 (90.3)	18 (94.7)	32 (91.4)	43 (78.2)	127 (69.8)	142 (69.6)	<0.001
Bystander witnessed, n (%)	29 (93.6)	17 (89.5)	21 (60.0)	46 (83.6)	164 (90.1)	184 (90.2)	0.08
Bystander CPR, n (%)	23 (74.2)	16 (84.2)	30 (85.7)	49 (89.1)	181 (99.5)	202 (99.0)	<0.001
Call to EMS arrival, median (IQR)	6 (4, 8)	6 (5, 7)	7 (6, 9)	8 (5, 10)	8 (6, 13)	8 (6, 12)	<0.001
Call to first shock, median (IQR)	5 (1, 9)	5 (3, 6)	4 (2, 7)	5 (3, 9)	6 (3, 9)	5 (3, 7)	0.63

CPR denotes cardiopulmonary resuscitation, EMS emergency medical service, IQR interquartile range, Proportions exclude missing data.

Trends in unadjusted outcomes

In the overall population, 5586 (53.5%) patients achieved ROSC, 4796 (46.5%) survived the event and 2401 (23.5%) survived to hospital discharge. Fig. 1 shows that between 2000–02 and 2015–17, survival to hospital discharge increased from 11.6% to 28.8% for cases initially shocked by paramedics, from 10.5% to 37.8% for cases initially shocked by first responders, and from 6.7% to 55.5% for cases initially shocked by bystanders (p-trend <0.001 for all). Unadjusted trends in event survival and ROSC also increased significantly over time for all groups, and are shown in Figs. 2 and S3 of the Supplementary appendix, respectively.

Impact of shock provider on outcomes

Fig. 3 shows the impact of shock provider on survival to hospital discharge, event survival and ROSC in the overall population after adjustment for baseline characteristics. When compared to patients

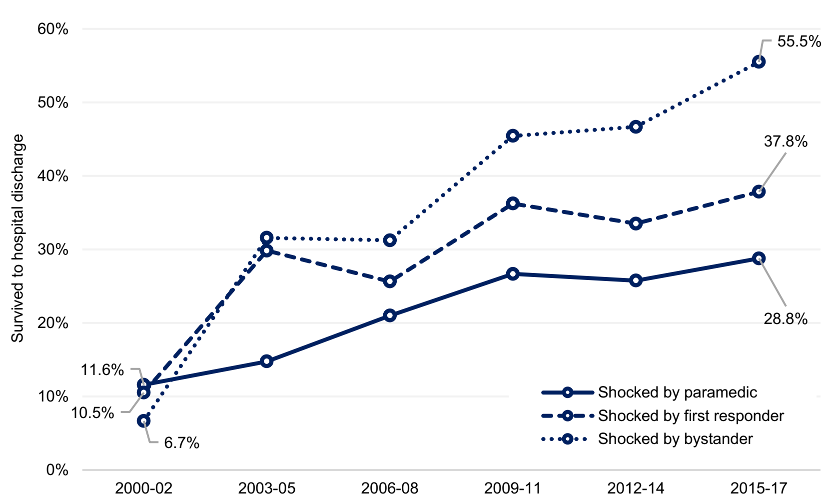

Fig. 1 – Unadjusted trends in survival to hospital discharge according to shock provider.

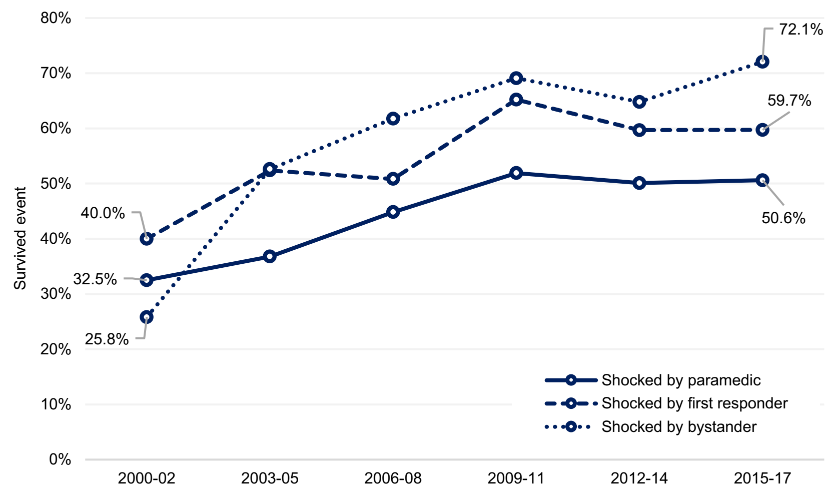

Fig. 2 – Unadjusted trends in event survival according to shock provider.

initially shocked by paramedics, patients initially shocked by first responders were more likely to survive to hospital discharge (AOR 1.40, 95% CI: 1.18, 1.67; p < 0.001), survive the event (AOR 1.32, 95% CI: 1.13, 1.54; p < 0.001) and achieve ROSC (AOR 1.43, 95% CI: 1.23, 1.68; p < 0.001). Similarly, patients initially shocked by bystanders were more likely to survive to hospital discharge (AOR 2.11, 95% CI: 1.72, 2.59; p < 0.001), survive the event (AOR 2.01, 95% CI: 1.64, 2.47; p < 0.001) and achieve ROSC (AOR 1.83, 95% CI: 1.49, 2.25; p < 0.001). For arrests occurring in public locations, first responder (AOR 1.89, 95% CI: 1.45, 2.45; p < 0.001) and bystander (AOR 2.25, 95% CI: 1.78, 2.85; p < 0.001) shocks had an even larger effect on survival to hospital discharge.

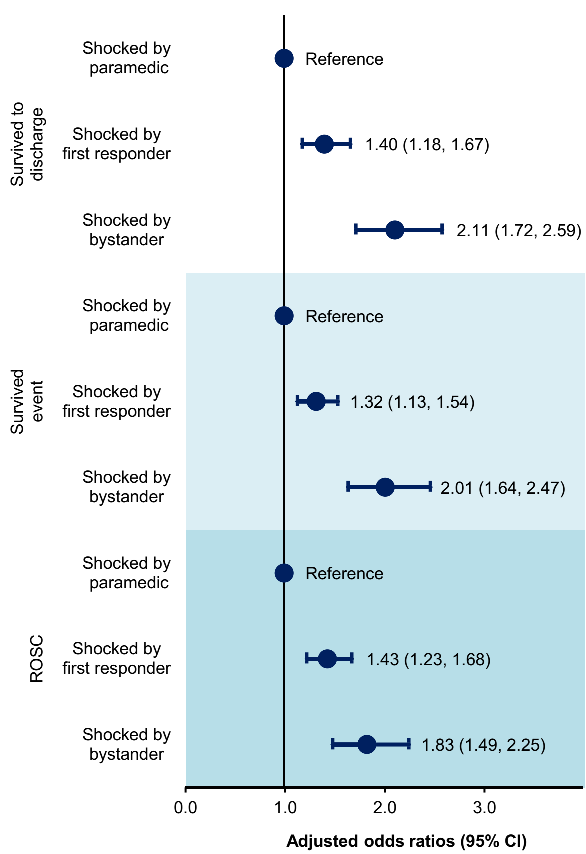

Fig. 3 – Adjusted odds ratios (95% confidence intervals) for the impact of shock provider on ROSC, event survival and survival to hospital discharge. Models adjusted for age, male sex, bystander witness, bystander CPR, arrest aetiology, arrest location, urban region, and the time from call to EMS arrival.

Trends in adjusted outcomes

Stratified analyses assessing the association between study year and outcomes are presented in Fig. 4 according to shock provider. For patients initially shocked by paramedics, the odds of survival to hospital discharge, event survival and ROSC increased by 8.1%, 6.5%, and 7.2% per year, respectively (p < 0.001 for all). For patients initially shocked by first responders, the odds of survival to hospital discharge, event survival and ROSC increased by 6.1%, 3.8%, 4.5% per year, respectively (p < 0.05 for all). For patients initially shocked by bystanders, the odds of survival to hospital discharge, event survival and ROSC increased by 11.8%, 10.7% and 12.0% per year, respectively (p < 0.001 for all).

Discussion

In this study, short-term survival following initial shockable OHCA increased significantly over an 18-year period. In particular, survival to hospital discharge increased over time among OHCA populations initially treated by first responders and bystanders. The largest temporal increase in survival occurred in patients initially shocked by bystanders, with a near 50 percentage point increase in survival to hospital discharge by the end of the study period. Rates of event survival and prehospital ROSC also increased across all groups, with the largest increase seen in patients initially shocked by bystanders. Our results also suggest that yearly improvements in survival were independent of changes to patient and system characteristics, including an increase in bystander CPR, a reduction in the mean age of patients, and an increase in events occurring in public locations.

Although survival from PAD has been reported to be as high as 72%, the majority of observational studies have included small

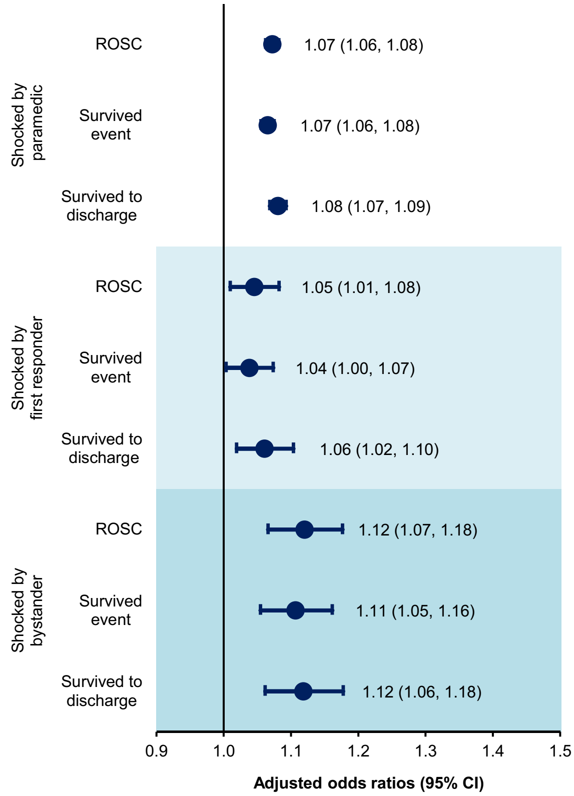

Fig. 4 – Adjusted odds ratios (95% confidence intervals) for the impact of study year (per year increase on a continuous scale) on ROSC, event survival and survival to hospital discharge, stratified by shock provider. Models adjusted for age, male sex, bystander witness, bystander CPR, arrest aetiology, arrest location, urban region, and time from call to EMS arrival.

populations or non-generalisable cases occurring in public locations, such as airports, office buildings or sporting facilities.[12] In addition, few studies have explored long-term trends in outcomes for OHCA patients treated by PAD. A recent analysis of PAD from four western European regions showed that survival rates varied over an eight year period, although this variation in survival was not explained.[18] Similarly, a report from the Danish Cardiac Arrest Registry showed that 30-day survival for patients defibrillated by bystanders in public locations increased six-fold between 2001 and 2013, but this was not adjusted for changes in patient and/or system characteristics occurring over that time (e.g. increases in bystander CPR).[19] Other PAD investigations from the United States[8,20] and Japan[21] have shown increases in the number of patients receiving PAD, but did not report temporal trends in patient outcomes.

In line with international findings, our study indicates that patient outcomes following initial shockable OHCA are improving over time.[8–10,19–21] While earlier studies have attributed this improvement to an increase in bystander CPR, first responder programs and PAD use, our findings suggest that temporal increases in patient outcomes are also independent of these factors. Importantly, year-on-year increases in the odds of survival increased at a greater rate for cases shocked by PAD than cases shocked by paramedics and first-responders. This could explain why the overall odds ratio for the effect of bystander shocks was higher in this study (AOR 2.25, 95% CI: 1.78, 2.85) compared with an earlier investigation of PAD use in public locations conducted in our region between 2002 and 2013 (AOR 1.62, 95% CI: 1.12, 2.34).[11]

It is possible that temporal increases in survival are being driven by factors that we could not adjust for in our models. For instance, an increasing proportion of OHCA patients are receiving optimal post-resuscitation care, including targeted temperature management and coronary intervention.[22,23] It is also plausible that post-resuscitation interventions are more effective in populations who experience shorter durations of resuscitation, such as those treated by PAD. A recent retrospective single-centre study from Austria showed that the impact of targeted temperature management on survival was inversely proportional to the duration of resuscitation, and highest in patients with low flow times less than 12 min.[24] While these findings could explain the variability in temporal outcomes observed in our study, other studies have found no relationship between the duration of resuscitation and the effect of post-resuscitation interventions.[25]

As rates of ROSC and event survival also improved over time, it is possible that increases in survival were primarily driven by improvements to prehospital care.[26] Although rates of bystander CPR improved significantly over the time period, we could not adjust for the quality and timing of CPR which could also play a role in survival.[27] In comparison, first responder and bystander shocks increased over the study period, but this was not associated with a reduction in the time to first shock, which remains higher compared to other regions.[28] A number of initiatives could reduce delays to the application of PAD, such as improving the supply, access and signage of AEDs in the community.[29] In addition, crowdsourcing of bystander CPR and PAD use has recently been implemented in our system, and integration of AED locations in the emergency dispatch system will also soon be fully automated. These initiatives could also help minimise delays in the application of PAD and translate into further increases in survival.

Limitations

Our study has several limitations. Although we had very little missing data overall, a small number of cases with one or more missing variables were excluded from our models (3.3%). Our study included patients who presented with an initial shockable rhythm either on arrival of EMS or on analysis by a public AED. Unfortunately, the VACAR does not record instances where a public AED is applied but no shocks are delivered (i.e. initial non-shockable rhythms). The time to first shock was also missing in a small number of cases in our population (5.5%). We did not adjust for the time to first shock, as this would naturally eliminate the effect on outcomes associated with shock provider. Finally, our models did not adjust for variables that are not routinely collected by the VACAR, such as hospital-based interventions. In addition, other confounding variables, such as changes to resuscitation guidelines occurring over the study period, may have also contributed to improvements in patient outcomes.

Conclusion

In this study, long-term trends in survival following initial shockable OHCA increased for all types of shock providers. The largest temporal increase in survival occurred in patients initially shocked by bystanders, where the odds of survival improved by 12% per year between 2000 and 2017. These temporal increases in survival were independent of other patient and system changes occurring over time, including increases in bystander CPR. The findings support ongoing efforts to expand the utility of PAD in private and public settings. Importantly, efforts to optimise the performance of laypersons in the application of PAD could also help bring about further improvements in survival.

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Conflicts of interest

None declared.

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.2019.08.018.

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