



Victorian Ambulance Cardiac Arrest Registry

2021-2022 Annual Report



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The VACAR Annual Report 2021-2022 is a publication produced by the Centre for Research and Evaluation, Ambulance Victoria.

If you would like to receive this publication in an accessible format please contact the VACAR team at: VACAR2@ambulance.vic.gov.au.

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This publication has been produced to provide Ambulance Victoria stakeholders with an overview of out-of-hospital cardiac arrest epidemiology and outcomes in the state of Victoria. The views contained in this document are not necessarily those of Ambulance Victoria, the State Government of Victoria or any Government departments.

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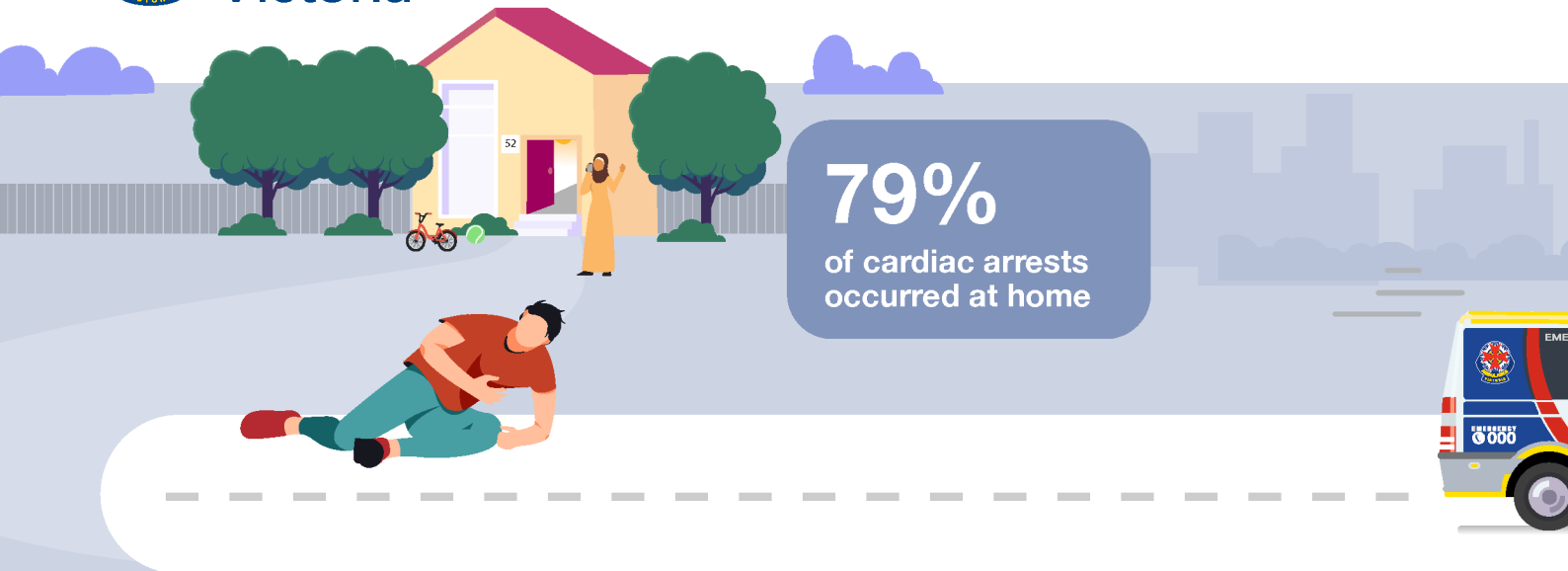
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**Ambulance
Victoria**

Executive Summary: 2021-2022



This year we treated more cardiac arrest patients than ever before

7,361

Out-of-hospital cardiac arrest patients across Victoria

5.8%

increase from the previous year

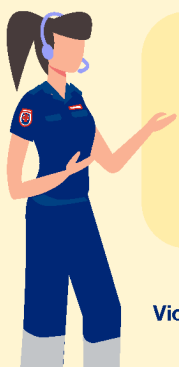
65% were male



The majority of cardiac arrest patients were attended within 10 minutes

93%

of calls were correctly directed by bystanders to Triple Zero (000) ambulance



83%

of cardiac arrests were identified in the Triple Zero (000) call

Average response time
8.2 minutes

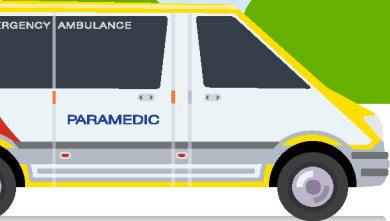
Half of all patients were defibrillated within
10.4 minutes

2021–22 Key Highlights

Despite COVID-19, the community stepped in to help in cardiac arrest emergencies

79%

of EMS-treated cases received bystander CPR



107 cases had a shock delivered from a public AED

47%

survived when first shocked by public AED

26%

survived when first shocked by paramedics



11%

survived when they received bystander CPR

5% survived with no bystander CPR



Cardiac arrest patients are returning home to their families

90%

of survivors were discharged from hospital directly home to their families

360

patients were discharged alive

34%

of patients discharged alive (Utstein cohort)

83%

of patients who survived to 1 year report good neurological recovery



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About this Report

“A cardiac arrest registry is the essence of measurement”.

The Global Resuscitation Alliance

Out-of-hospital cardiac arrest (OHCA), otherwise known as ‘sudden cardiac death’, is a significant cause of disability and death in Australia, with a reported crude incidence of 107.9 events per 100,000 person-years (Bray et al. 2022). OHCA in Australia most commonly occur in adult males and are unwitnessed, of presumed medical aetiology and occur in private residences (Bray et al. 2022). Much of the burden associated with OHCA occurs before a patient reaches hospital. Thus, the role of Emergency Medical Services (EMS) is crucial in minimising burden of illness and increasing survivorship from OHCA in our communities.

Although there have been many recent advances in resuscitation and post-arrest treatment strategies for OHCA patients, survival to hospital discharge rates remain low and varies greatly between communities and countries (Bray et al. 2022; Dyson et al. 2019). Routine monitoring of the quality of OHCA treatment provided by EMS agencies is recommended by the American Heart Association (Nichol 2008), and several countries around the globe monitor these data through clinical registries, such as the Victorian Cardiac Arrest Registry (VACAR).

This report contains VACAR data from all OHCA events attended by Ambulance Victoria (AV) in the period 1 July 2021 to 30 June 2022, as well as additional information from previous years for the purposes of trend analyses. The data for this report was extracted on 21 October 2022 and again on 12 January 2023 for quality assessment. Analyses in this report are described across two predominant populations, either: ‘all cardiac arrest patients’ where AV was in attendance (regardless of whether emergency treatment was provided) or ‘EMS-treated patients’, which specifically refers to patients who receive an attempted resuscitation by EMS including eligible first responders.

OHCA outcomes are defined by two major endpoints. These are ‘event survival’ (i.e. survival to hospital handover) and ‘survival to hospital discharge’. These endpoints define patients with sustained return of spontaneous circulation (ROSC) on arrival at hospital and those discharged alive from hospital, respectively.

Patients who suffer a cardiac arrest in the presence of paramedics represent a unique sub-group of patients. These patients differ considerably to the rest of the OHCA cohort, with respect to time to defibrillation, presenting rhythm and other factors which skew analyses when combined. As such, data relating to paramedic or EMS-

witnessed OHCA have been analysed and depicted separately to those which are unwitnessed by paramedics. Unless specifically stated, all analyses should be assumed to exclude EMS-witnessed events.

Descriptive statistics in this report are presented as frequencies and proportions for categorical data and median and interquartile range for continuous variables. Comparisons of proportions were undertaken using the chi-square test. A logistic regression analysis was used to describe the risk-adjusted odds of survival to hospital discharge across years for different patient subgroups. These models were adjusted for known predictors of survival and are described in more detail in the report. Unless otherwise stated, all other statistical comparisons were unadjusted.

Analyses in this report contain Metropolitan and Rural comparisons. Geospatial mapping has been used to define regional boundaries according to the Victorian Government Department of Health regions[^]. The Melbourne metropolitan region is comprised of three geographical regions: North and West, Eastern and Southern regions. The rural region comprises five geographical regions: Barwon South Western, Grampians, Loddon Mallee, Hume and Gippsland. The major rural urban centre of Geelong falls within the Barwon South Western region. Ballarat and Bendigo, two other rural urban centres, fall within the Grampians and Loddon Mallee regions, respectively.

AV may be dispatched to a small number of OHCA events in New South Wales and South Australia which occur close to the Victorian border; these cases are included in VACAR if AV is the primary care giver. Any cases which occur off the coastline of Victoria are attributed to the nearest Victorian Department of Health Services region.

Population-level data for this report was sourced from the Australian Bureau of Statistics (ABS) Regional Population Growth report (published July 2022) and the ABS National, State and Territory Population report (published June 2022). The latter report also specifies the 2001 Australian Standard Population, used here for age-standardisation. The estimated Victorian population as at 30 June 2021 was 6,613,727 persons (ABS National, state and territory population report, June 2022).

[^]<https://www2.health.vic.gov.au/about/publications/formsandtemplates/Department-of-Health-regional-boundaries-and-local-government-areas-map>

Ambulance Victoria

The state of Victoria, Australia has an estimated population of 6.6 million spread over almost 227,500km², with over 5.0 million people living in the state's capital city of Melbourne (ABS Regional population report, July 2022). AV is the state-wide EMS provider and comprises ambulance paramedics who have advanced life support skills (e.g. laryngeal mask airway, intravenous epinephrine) and Mobile Intensive Care Ambulance (MICA) paramedics who are authorised to perform endotracheal intubation, rapid sequence induction, Pneumocath® insertion and administer a wider range of medications.

Paramedics in Victoria have the base qualification of a three-year bachelor degree in emergency health sciences or Paramedicine. MICA paramedics are experienced paramedics who undergo a university-level post graduate diploma in Intensive Care Paramedic Practice. Since December 2018, all paramedics are required to be registered with the Paramedicine Board of Australia via the Australian Health Practitioner Regulation Agency in order to practice.

Australia operates a single national telephone number for community access to emergency services (i.e. Triple Zero '000'). Telephone triage of emergency calls in Victoria is performed using the Medical Priority Dispatch System. Unless circumstances suggest ventilations (as is the case for patients under the age of 18 years old), suspected cardiac arrest events identified in-call receive further call-taker instruction (telephone cardiopulmonary resuscitation (CPR)) recommending chest compressions until professional help can take over.

Advanced Life Support and MICA paramedics are dispatched concurrently to suspected cardiac arrest events in the community. A first responder program for early defibrillation by fire-fighters operates for cardiac arrest patients in greater Melbourne and a number of large regional towns. In addition, AV co-responds with 101 volunteer community teams in smaller, predominately rural communities across the state. Approved community first responders, called GoodSAM responders, may also be dispatched to suspected cardiac arrest events. For more information about GoodSAM, see **page 34** of this report.

The AV cardiac arrest protocols follow the recommendations of the Australian Resuscitation Council. AV paramedics are not obliged to commence resuscitation when the clinical presentation is inconsistent with life. Paramedics may discontinue resuscitation if advanced life support has been performed for 45 minutes without ROSC, the rhythm is not Ventricular Fibrillation (VF) or pulseless Ventricular Tachycardia (VT), there are no signs of life, no gasps or evidence of pupillary reaction and no evidence of hypothermia or drug overdose.

AV also maintains a registry of public automated external defibrillators (AEDs) throughout Victoria.

The public are encouraged to contact the registry and ascertain if their AED, or one that they become aware of, is registered with up-to-date information.



To learn more about Ambulance Victoria please scan the QR code or visit <https://www.ambulance.vic.gov.au/>





Team effort saves life of teen basketballer

When 16-year-old Jasper Wickes collapsed during basketball training one Sunday evening in January this year, his teammates thought he was joking around because he had been beaten to the ball.

It took a few moments for the South End Spirit players gathered at Hoop Culture in Carrum Downs to recognise their tallest teammate was not 'playing'—in fact, he was losing his life.

The star defender, who had no prior medical conditions, had started seizing and with gasped breaths up to 20 seconds apart, he soon went into cardiac arrest in front of the stunned crowd.

The countdown clock was on.

It was Jasper's coach of four years, Hayden Jardine, who "immediately recognised something wasn't right" thanks to years of training as a former security guard.

With a spectator calling Triple Zero (000) and emergency services dispatched, Hayden tried to help Jasper breathe while checking for a heartrate and answering the call taker's questions.

"He was lying there with his eyes wide open, completely unresponsive. It is not something you'd expect from an active teenager," Hayden recalled.

"At one point I looked up and could see the boys watching on and the (scared) look on all their faces."

It was then that GoodSAM responder Jess Purcell came running onto the court. It was a chaotic scene and with Hayden performing mouth to mouth, she had no idea the person she was about to give chest compressions to was a teenager.

GoodSAM is a life-saving app that connects patients in cardiac arrest with a nearby volunteer who are willing to start hands-only CPR while an ambulance is on the way.

Remarkably, Jess had registered to be a GoodSAM responder a few days earlier and had only received email confirmation of her GoodSAM accreditation on the morning of Jasper's cardiac arrest.

Jess, who knew CPR after years of attending Scouts, had been at a dance studio 200 meters down the road when her watch buzzed with a notification.

"When I saw it, I thought it was a practice notification or something, because I had only just signed up to GoodSAM," Jess said.

"I opened my phone and realised it was real, it was happening; I ran outside and saw someone standing on the street for emergency services and I could hear the sirens in the background, so I just started running."

Fire Rescue Victoria responded to the emergency, as well as Ambulance Victoria Mobile Intensive Care Ambulance (MICA) paramedics Kate Dalrymple, MICA student Chloe Abel and Advanced Life Support paramedics Anna Janssen, James Munro and Matt Teofilo.



Chloe said Jasper's team of heroes, including Hayden and Jess, helped get the ball rolling on 'the chain of survival' through early bystander intervention and contributed to saving his life.

"Jasper was incredibly lucky everything aligned for him. It was a real team effort that helped save his life," Chloe said.

"He showed good signs of stability immediately post cardiac arrest, and he's gone on to make a quick recovery. If that cardiac arrest happened somewhere else—where there was no one around—we know it is most likely would have been a different outcome.

"I've been a paramedic for more than 10 years and I can count on one hand the times where everything has lined up like that. You couldn't have asked for a better response.

"This young person is going to go on to live a normal life and that outcome is something that everyone should be incredibly proud of."

Jasper's mother Simone said her son's traumatic event had come as a shock.

"Jasper is a basketballer; he's fit, he's healthy, he's happy and we never expected this could have happened," she said.

"We can't thank everyone enough. When Jasper arrived at the hospital, they kept saying the paramedics were truly amazing and everything they did for him gave him the best chance of survival.

"Every time he sees a paramedic or an ambulance now, he salutes them."

Jasper was fitted with a pacemaker a few days after his cardiac arrest and spent 15 days recovering at Monash Hospital. In a whirlwind month, he was discharged and has even eased his way into starting Year 11.

"Life is precious," Jasper said.

"I feel very supported knowing that so many people stepped in to help me, right there in the middle of basketball training.

"I imagine it would have been a shock to everyone there.

"I'm very thankful for what everyone did. They're heroic."

With one more heart surgery on the horizon, Jasper hopes to continue his recovery and work towards returning to the court.

In the meantime, coach Hayden has handed over the reins and let Jasper be coach during training so that he is still part of the team.

"The first time he coached he dressed up in a suit do it," Hayden said.

GoodSAM responder Jess said the knowledge that early bystander intervention had saved Jasper's life was enough to bring her to tears.

"I am encouraging everyone to sign up and become a GoodSAM responder," she said.

For more information about GoodSAM, see **page 34** of this report.



You don't need to be a paramedic to be a life saver, you just have to be willing to give hands-only CPR. Anyone who is over 18, is familiar with CPR and has a smartphone can download the free [GoodSAM app](#).



Victorian Ambulance Cardiac Arrest Registry

VACAR was established in 1999 and represents an internationally recognised standard of OHCA monitoring and reporting. It is managed by AV and is overseen by a multidisciplinary Steering Committee, chaired by Dr Ziad Nehme (Acting Director, Centre for Research and Evaluation, Ambulance Victoria). VACAR incorporates prehospital clinical and operational data as well as hospital follow-up data from all OHCA events in Victoria where AV are in attendance.

Data are sourced from Communication Centre dispatch records, EMS patient care records, hospital medical records, and telephone interviews conducted with adult survivors (or their proxies) 12 months post-arrest (commenced January 2010). Hospital outcome data is supplemented by death records from the Victorian Registry of Births, Deaths and Marriages.

Data for over 122,700 cardiac arrest patients attended by AV since October 1999 have been successfully captured in VACAR. The data is collated in the registry based on the internationally recognised Utstein template and definitions (Perkins 2015).

VACAR provides essential information for the assessment of EMS performance in relation to the treatment and outcomes of OHCA patients. In particular, a number of key clinical indicators have been implemented, which are designed to measure the quality of care and allow for the benchmarking of EMS performance. These clinical indicators include ambulance response times, event survival and survival to hospital discharge.

VACAR is also used to measure the impact of ambulance programs such as the fire-fighter Emergency Medical Response Program, 'Call, Push, Shock' community CPR education program, Heart Safe Community (in partnership with Heart Foundation Victoria) and Public AED use.

In addition, VACAR has successfully established an internationally recognised research program, with the publication of scientific literature in key medical journals (see 2021-2022 Peer-reviewed Publications, **page 53**). The

results of the research program are used to provide an evidence base for AV treatment of cardiac arrest patients.

In 2010, VACAR expanded its methodology to become one of few registries globally that routinely captures the quality-of-life and functional recovery of adult survivors of OHCA. A structured telephone interview with adults 12 months following the event is conducted using previously validated quality-of-life assessment tools. This initiative ensures that VACAR provides a robust framework for the measurement of immediate, early and long-term quality clinical outcomes following OHCA. In July 2020, we added additional instruments to the follow-up interviews which assess the impact of fatigue, anxiety and depression on OHCA survivors.

VACAR contributes to the Australian Resuscitation Outcomes Consortium (Aus-ROC) Epistry, which is an OHCA epidemiologic registry (<https://www.ausroc.org.au/>). The Aus-ROC Epistry was established with the aim of understanding regional, ambulance service and treatment factors associated with improved OHCA survival and outcomes in Australia and New Zealand. The Epistry will enable benchmarking across providers and identification of system-wide strategies associated with survival for OHCA patients in Australia and New Zealand.

In 2019, VACAR also began contributing to the End Unexplained Cardiac Death (EndUCD) Registry which was established in 2018 by the Baker Heart and Diabetes Institute. The Registry aims to collect data on all sudden cardiac arrests in patients aged 1-50 years, including pre-hospital, hospital, coronial, genotype and phenotype data. The program has also established new multi-disciplinary post-discharge clinics for cardiac arrest survivors and families. The EndUCD Registry will provide insight into the causes of sudden cardiac arrest in younger individuals based on clinical, demographic, and genetic analyses.

Eligibility

VACAR captures data on all OHCA patients where EMS are in attendance. For the purposes of this report, EMS is defined as AV and participating first responder organisations (Metropolitan Fire Brigade, Country Fire Authority (selected areas) and GoodSAM.

VACAR defines the state of cardiac arrest as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation, including the absence of a detectable carotid pulse, unresponsiveness and apnoea or agonal breathing. Patients eligible for inclusion in or exclusion from VACAR are described below (see **Table 1**).

Data capture

AV’s in-field recording of patient data is performed electronically using VACIS, an electronic data capture system. All electronic patient care records (PCRs) are synchronised daily with organisational databases. To ensure the capture of all OHCA events attended by AV, a broad electronic search is conducted utilising specific criteria. This search strategy is focused at identifying potential cardiac arrest cases. Paper PCRs are used in cases where in-field electronic data capture is not possible. In these instances, paramedic team managers forward all potential cardiac arrest cases to VACAR for review. A hand search of all paper PCRs forwarded to the AV Accounts department (from metro and rural areas) is performed periodically to ensure complete case capture. Following review of potential cases, eligible cardiac arrest cases are entered into the VACAR database, with PCR data being supplemented by information from communication centre dispatch records. The VACAR participating hospitals (i.e. those for whom ethics approval has been obtained) are contacted for survival status and patient discharge direction. A cross-match of VACAR records with the Victorian Registry of Births, Deaths and Marriages is undertaken for verification of deaths. Structured telephone interviews are conducted 12 months post-cardiac arrest for adult patients identified as having survived to 12 months.

Table 1: VACAR inclusion and exclusion criteria

Inclusion criteria (all of the following)

1. Patients of all ages who suffer a documented cardiac arrest.
2. Occurs in the state of Victoria where Ambulance Victoria is the primary care giver. Cardiac arrests occurring in the neighbouring states of New South Wales and South Australia are considered for inclusion where Ambulance Victoria is clearly documented as the primary care giver.
3. Patients who are pulseless on arrival of EMS; OR
Patients who become pulseless in the presence of EMS (EMS-witnessed arrests); OR
Patients who have a pulse on arrival of EMS, where a successful attempt at defibrillation was undertaken by a bystander prior to arrival of EMS.

Exclusion criteria (any of the following)

1. Patients who suffer a cardiac arrest in a hospital facility, where Ambulance Victoria may be in attendance but are not the primary care giver.
2. Brief episodes of pulselessness which do not receive cardiopulmonary resuscitation or defibrillation by EMS.
3. Bystander-suspected cardiac arrest, where the patient is not in cardiac arrest on arrival of EMS, or no defibrillation was provided prior to arrival, or no other evidence verifying a cardiac arrest state is present.



Data quality

The integrity and reputation of the registry relies on complete and accurate data collection, including hospital discharge data. VACAR undergoes rigorous data quality control to ensure the accuracy of data collected. During data entry, automated validation rules and error messages are embedded into the VACAR database to capture erroneous values or sequences. Quality control audits are conducted monthly on a random sample of 10% of cases to validate data accuracy. Verification of data entry undergoes routine audit to identify inconsistencies with data coding. Trend analysis is performed on a quarterly basis to ensure consistency of case numbers, patient outcomes and response times. VACAR has undergone one independent external audit over the last decade. Cardiac arrest cases also undergo clinical auditing by team managers.

The data in the registry is subject to ongoing audit and quality control, with any necessary changes being incorporated back into the registry as needed. Quality assurance measures are conducted routinely, leading to improvements in data integrity with time. As such, data presented in this report may differ slightly from previously published data. Data from previous years is subject to updates and is most current within this report. Data on survival to hospital discharge is also being continually updated and hence should be treated and interpreted with caution.

Ethical review

The registry has ethics approval as a Clinical Quality Registry from Monash University Human Research Ethics Committee (project number: 21046). VACAR is supported by more than 100 ethics approvals from Victorian hospitals for the access to medical records. This successful program has resulted in the capture of outcomes for almost 99% of OHCA's transported to a Victorian emergency department.

In accordance with the National Health and Medical Research Council's National Statement on Ethical Conduct in Human Research, all paper and electronic data are securely stored at AV, with access restricted to authorised VACAR staff.

Missing data

The value of VACAR relies on completeness of data capture. Missing data remains relatively low for all variables (see **Table 2**). Periodic quality control checks and data verification activities ensure the long-term validity of registry data.

Table 2: Missing data for select registry variables, 2021-2022

Patient age	54 (1%)
Patient sex	15 (0%)
Arrest location	2 (0%)
Witnessed status	41 (1%)
Bystander CPR	0 (0%)
Rhythm on arrival	10 (0%)
EMS response time	46 (1%)
Defibrillation time	59 (1%)
Outcome at scene	1 (0%)
Event survival	1 (0%)
Hospital discharge status	42 (1%)
Hospital discharge direction	15 (0%)



Impact of the COVID-19 pandemic

The COVID-19 pandemic has introduced unprecedented challenges and implications for healthcare services, including EMS, worldwide. Analysis of health service data is essential to understand the impact of the pandemic on processes, patient care and outcomes, with these findings used to inform policies, procedures and clinical practice guidelines to improve pandemic response and future wave preparedness.

In the pre-hospital response to OHCA, highly co-ordinated systems of care that optimise survival and functional outcomes are routinely monitored.

Any disruption to the system of care has potential to influence patient outcomes, as has been the case during the COVID-19 pandemic.

The VACAR research team has previously investigated and reported on the early impact of the COVID-19 pandemic on OHCA incidence, management and outcomes in Victoria (Ball et al, 2020).

The key findings from this analysis were:

- ▶ initiation of resuscitation by paramedics decreased during the pandemic period
- ▶ arrests occurring in public locations decreased
- ▶ the proportion of patients receiving defibrillation from a public access defibrillator decreased
- ▶ delays were observed in the commencement of key time-sensitive interventions
- ▶ overall survival to hospital discharge decreased by 50%

This year, we have continued to monitor the impact of the COVID-19 pandemic on the OHCA system of care. **Table 3** illustrates the demographic differences for OHCA patients (excluding EMS-witnessed events) between periods of 'lockdown' vs. 'non-lockdown' in Victoria for the last two financial years (01 July 2020—30 June 2022).



During periods of lockdown, there were 2,774 cardiac arrests (excluding EMS-witnessed events) compared with 9,994 in non-lockdown periods. Statistically significant differences were found between the proportion of arrests occurring in public locations (5.4% in lockdown vs. 8.9% in non-lockdown), the proportion of bystander-witnessed arrests (26.4% in lockdown vs. 29.3% in non-lockdown), the proportion of arrests where initial defibrillation was performed by a public AED (7.0% in lockdown vs. 15.7% in non-lockdown), the proportion of patients who survived to hospital (47.5% in lockdown vs. 55.2% in non-lockdown) and survived to hospital discharge (23.1% in lockdown vs. 31.3% in non-lockdown).

The following periods of time were considered to be 'lockdown' in this analysis: 08 July 2020 - 19 October 2020; 13 February 2021 - 18 February 2021; 28 May 2021 - 11 June 2021; 16 July 2021 - 28 July 2021, and 06 August 2021 - 31 August 2021.

Table 3: Characteristics and survival outcomes according to COVID-19 lockdown period in 2020-2022

	Lockdown period	Non-lockdown period
Total events[^]	2,774	9,994
Baseline characteristics		
Age (years), mean (SD)	66.7 (19.2)	66.2 (18.9)
Male gender, n (%)	1,841 (66.5)	6,621 (66.4)
EMS response time (minutes), median (90th percentile)	8.5 (20.0)	9.0 (26.0)
Public location, n (%)	150 (5.4)	892 (8.9) †
Presumed cardiac aetiology, n (%)	1,957 (70.6)	7,090 (70.9)
Metropolitan region, n (%)	1,904 (68.6)	6,672 (66.8)
Bystander-witnessed, n (%)	731 (26.4)	2,923 (29.3) †
EMS attempted resuscitation, n (%)	1,017 (36.7)	3,851 (38.5)
Initial shockable rhythm, n (%)	266 (9.6)	1,034 (10.4)
Initial defibrillation by public AED*, n (%)	18 (7.0)	160 (15.7) †
Survival outcomes*		
Event survival, n (%)	116 (47.5)	544 (55.2) †
Discharged alive, n (%)	56 (23.1)	303 (31.3) †

[^]Includes adult patients, excluding EMS-witnessed events. *For patients presenting in a shockable rhythm. †p<0.05 for comparison between lockdown and non-lockdown period.





1999

**Victorian
Ambulance
Cardiac Arrest
Registry (VACAR)
established**



2000

**Metropolitan Ambulance
Service and Rural
Ambulance Victoria**
start training paramedics
in Advanced Life Support (ALS)

**Firefighters in metropolitan
Melbourne are trained**
as emergency medical responders
(EMRs), being dispatched at the same
time as Ambulance Victoria paramedics
to life-threatening emergencies

2012

**Expansion of MICA
single responder units**
in metropolitan Melbourne
and rural Victoria



**VACAR starts collecting
patient-reported quality
of life (QOL) and functional
recovery data**

2010



**AV commences
an AED Registry** which
records the locations of
AEDs across Victoria

2016

**AV clinical practice
guidelines for
resuscitation updated**



2017



240+
**career
firefighters**

across Victoria are trained
through the EMR program



**Commencement
of the EXACT
clinical trial**
(titration of oxygen
after cardiac arrest)

2018

AV CPR award

**Heart Safe
Communities
train more
1 million
people since**

2022

**Commencement
of FIRST and
AUGMENT-VA
clinical trials**

**Artificial Intelligence
developed** to improve the
detection of cardiac arrest
in Triple Zero (000) calls
(the AIDE study)



2020

**Introduction of Team
Performance Report** for
cardiac arrest debriefing
for AV paramedics



**Roll out of
Performance
Report**
for paramedics



Improve Cardiac Arrest Outcomes

2003

CPR awareness program launched in Victoria by Metropolitan and Rural Ambulance Services



2007

Simplification of telephone-assisted CPR instructions to 400 compressions before mouth-to-mouth

x400 compressions



2009

Expansion of the firefighter EMR program to outer metropolitan and regional areas of Victoria



2008

Metropolitan Ambulance Service

Rural Ambulance Victoria

Alexandra District Ambulance Service

merge to form

Ambulance Victoria (AV)

awareness programs, including

activities, more than 100,000 people since 2004



Pilot of real-time and post event feedback on CPR quality for paramedics

Launch of the GoodSAM first responder app to paramedics and members of partner organisations



High chance CPR

Establishment of Sudden Cardiac Arrest Australia (SCAA) support group for cardiac arrest survivors

Expansion of the GoodSAM first responder app to appropriately trained first aid members of the public

2019

VACAR 20-year anniversary and milestone 100,000th OHCA case recorded



Incidence & demographics

Incidence of all adult & paediatric events[†]

The annual incidence of OHCA events are steadily increasing. In 2021-2022, AV attended 7,361 OHCA events in Victoria whilst 10 years prior, this number was 5,296. Although the Victorian population has increased in both number and average age over this period, the unadjusted incidence of OHCA confirms the trend with 111 events per 100,000 population observed in 2021-2022 compared with 94 events per 100,000 population in 2012-2013 (see Figure 1). The age-adjusted incidence rate in 2021-22 was 94 events per 100,000 population compared to 82 per 100,000 in 2012-13.

In line with previously reported international data, most (66%) OHCA events occurred in males and the majority (99%) of OHCA patients were adults, i.e. patients aged 15 years and over. This is the highest number of adult OHCA events ever attended by AV in one year, and a 5.8% increase in events from 2020-2021.

The total number of paediatric events (n=88) attended in 2021-2022 was lower than in 2020-2021 (n=98). This difference is considered to be within normal yearly fluctuations.

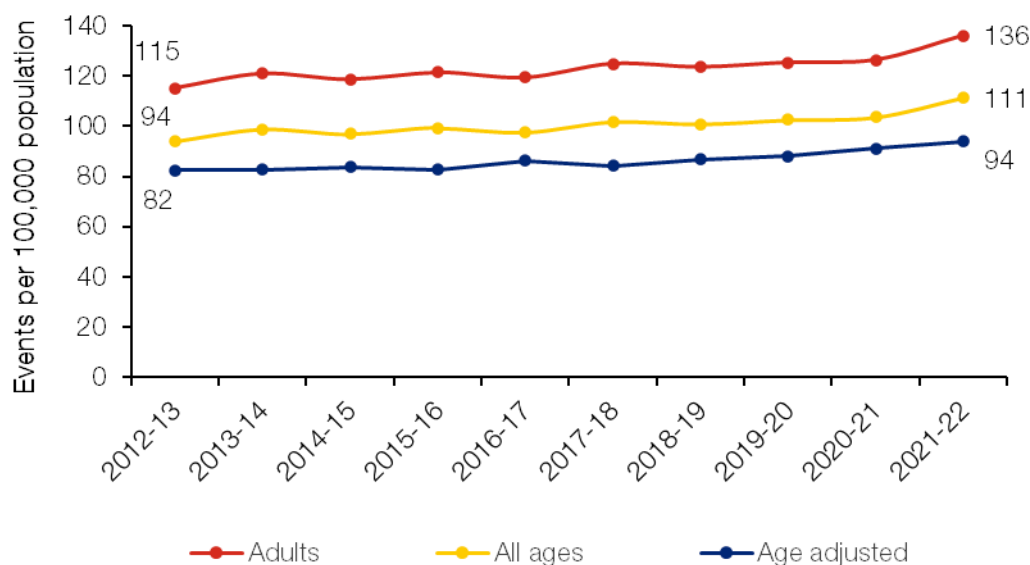


Figure 1: Crude incidence of adults-only and all ages EMS-attended OHCA events in Victoria, and age-adjusted incidence rate of EMS-attended events (includes EMS-witnessed events).

[†] All results in this section include EMS-witnessed events.

Incidence across regions of Victoria

In 2021-2022 there were 4,906 cases reported in the metropolitan regions compared with 2,455 in rural regions (67% and 33% respectively). Although more arrests occurred in the metropolitan regions (Eastern Metro, North and West Metro and Southern Metro), the crude incidence in all five rural regions is higher (148 vs. 100 events per 100,000 population, see Figure 2) and has been increasing over the last decade whilst metropolitan incidence has remained relatively steady.

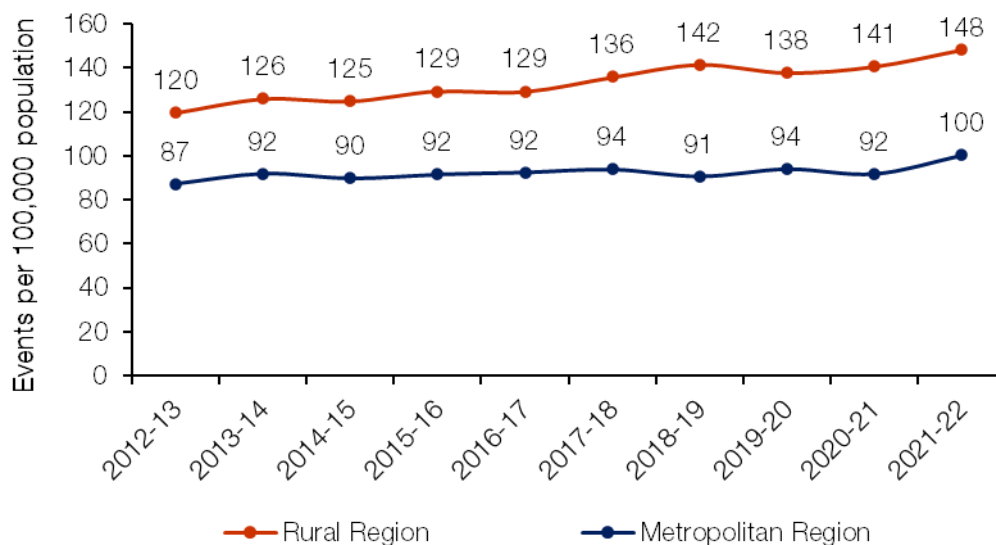


Figure 2: Yearly crude incidence of EMS-attended events across metropolitan and rural regions of Victoria (includes EMS-witnessed events).

As illustrated in Figure 3, the lowest crude incidence during 2021-2022 was observed in the Southern Metropolitan region (99 events per 100,000 population) whilst the highest incidence was in the Gippsland region (175 events per 100,000 population).

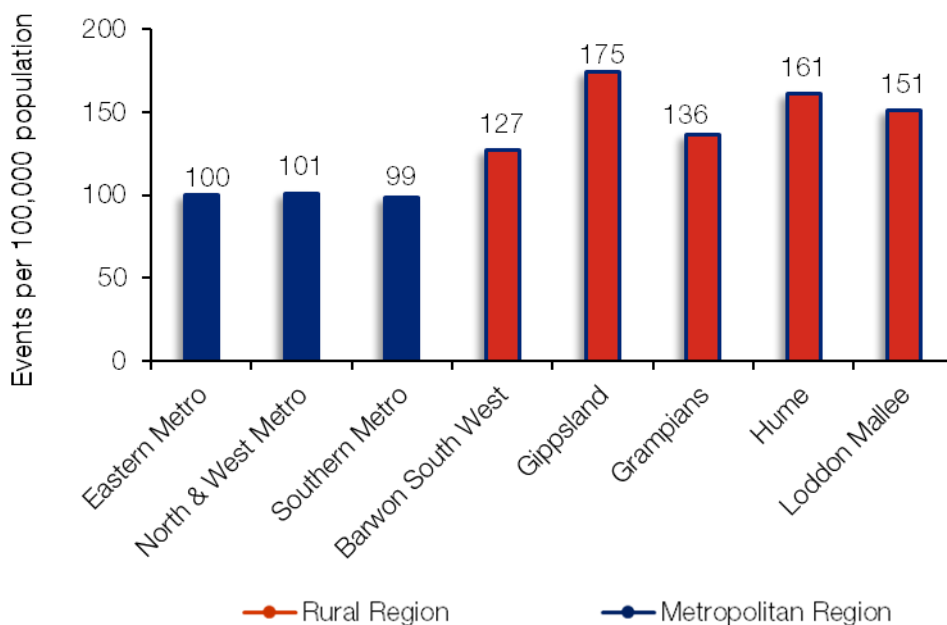


Figure 3: Regional crude incidence of EMS-attended events



Demographics of adults

In 2021-2022, the median age of OHCA patients was 70 years, similar to the median age of 69 years in the year prior. The age distribution in OHCA events (excluding EMS-witnessed events) varied significantly across the sexes (see Figure 4), with females having a higher median age of arrest (73 vs. 63 years, $p < 0.001$).

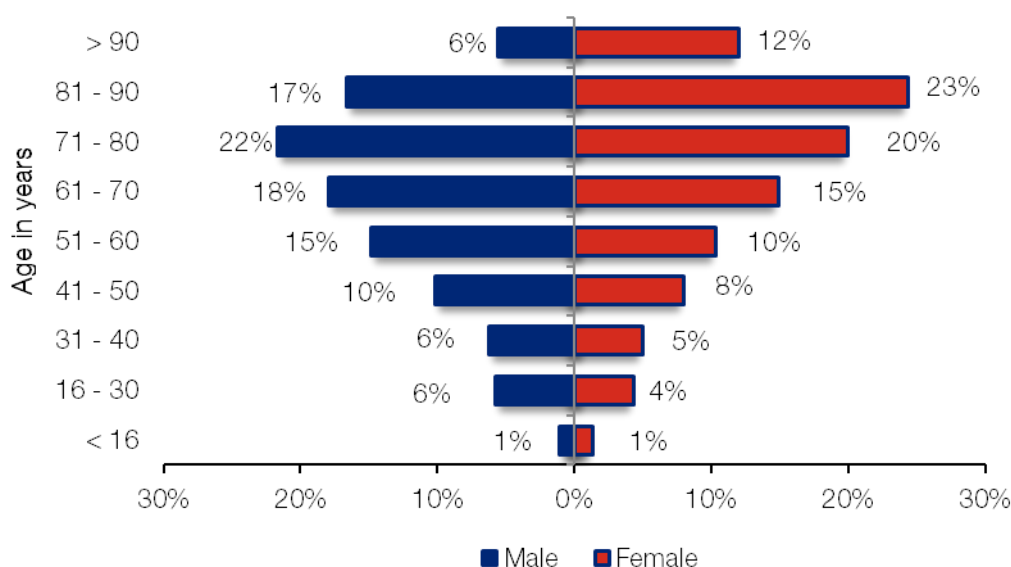


Figure 4: Age distribution of EMS-attended OHCA events (excluding EMS-witnessed events), males vs. females.

† All results in this section include EMS-witnessed events.

Attempted resuscitations, adult population

Of all adult OHCA events (including EMS-witnessed) attended in 2021-2022, 41% received an emergency resuscitation attempt by paramedics and/or first-responders compared with 42% in the previous year. The rate of EMS-attempted resuscitation for adult OHCA events has slowly declined over the last 10 years (46% in 2012-2013; 46% vs. 41%, $p = 0.002$). This may be explained by differences in the number of events witnessed by bystanders and the impact this has on prolonged downtime (a major contributor to EMS withholding resuscitation attempts).

Of all OHCA events excluding EMS-witnessed arrests, paramedics attempted resuscitation in 38%. The demographic profile of these patients differed significantly from that of the patients who did not receive a resuscitation attempt. See Table 4.

Table 4: Demographic profile of adult OHCA events (excl. EMS-witnessed) where resuscitation was not attempted vs. where resuscitation was attempted

	Resuscitation not attempted	Resuscitation attempted	p-value
Male (%)	64%	70%	<0.001
Median age	71	67	<0.001
Public location	5%	14%	<0.001
Witnessed	16%	50%	<0.001
Bystander CPR	20%	74%	<0.001

Demographics of paediatrics

The majority of paediatric patients (74%) received an attempted resuscitation by EMS during 2021-2022. EMS attendance to paediatric OHCA events (excluding EMS-witnessed arrests) has remained relatively infrequent over the last decade, with fewer than 100 events per year (min: 70, max: 93). In 2021-2022, there were 79 cases and the median age of arrest was twenty months old. The demographic profile of paediatric OHCA events varies significantly across reporting years due to the low incidence. In 2021-2022, paediatric events (excluding EMS witnessed) occurred primarily in males (61%), with 15% of events occurring in public locations and 39% of events witnessed by a bystander.

In 2021-2022, more paediatric patients received bystander CPR than adult patients (61% vs. 40%, respectively; $p < 0.001$) and the rate of EMS-attempted resuscitation amongst paediatric patients remained high compared with adults (72% vs. 38%, $p < 0.001$; excludes EMS-witnessed events).

Precipitating events

The underlying causes, or 'precipitating events', of OHCA events are determined by paramedics in the field based on clinical and situational factors. Unless the cause of arrest is clearly described (e.g. trauma, submersion, overdose/poisoning, hanging etc) it is presumed to be of cardiac origin in line with international OHCA reporting guidelines (Perkins 2015).

In 2021-2022, 71% of adult OHCA events (excluding EMS-witnessed events) were presumed to be of a cardiac cause, after which terminal illness (7%) and trauma (6%) were most common. **Figure 5** illustrates the most common precipitating cause by age group. Most (75%) OHCA events in persons aged above 36 years were presumed to be of cardiac causes, whilst the primary cause in the 16-36 year old age group was trauma and hanging.

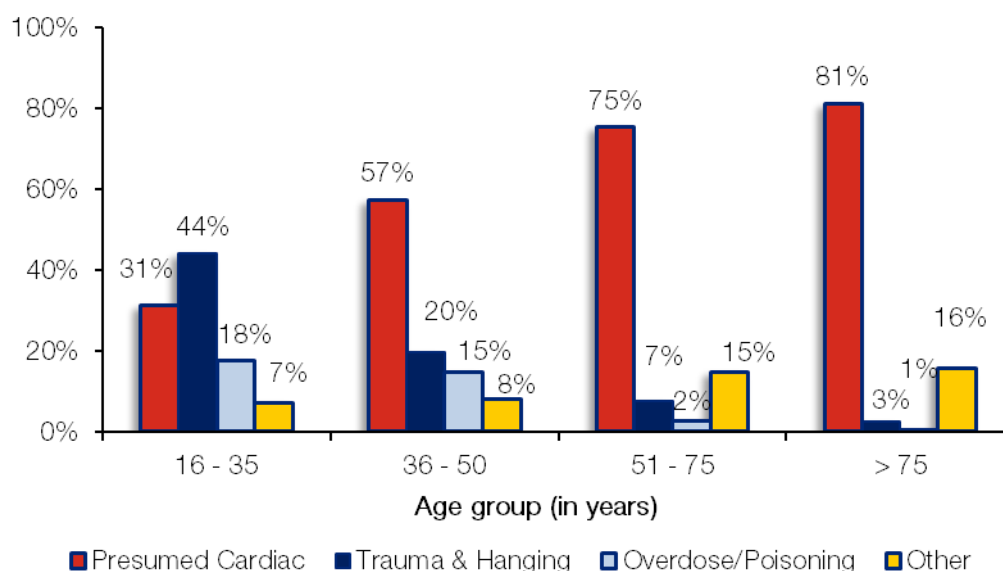


Figure 5: Adult precipitating events across age groups for EMS-attended events.

The proportion of events where resuscitation was attempted by EMS varies according to the precipitating event. During 2021-2022, most OHCA events in adults with a respiratory cause (59%) received EMS-attempted resuscitation whilst 41% of presumed cardiac, 34% of trauma, 39% of overdose and poisoning, 9% of terminal illness and 30% of hanging cases received EMS-attempted resuscitation.



As expected, the precipitating events for paediatric OHCA vary considerably from those of adults (see Figures 6 and 7). In 2021-2022, 29% of EMS-attended paediatric events occurred due to a presumed cardiac cause compared with 14% in the previous year. Sudden infant death syndrome (SIDS) remained a dominant cause of paediatric OHCA (19% in 2021-2022). Other common causes of paediatric OHCA included trauma (18%) and respiratory issues (8%).

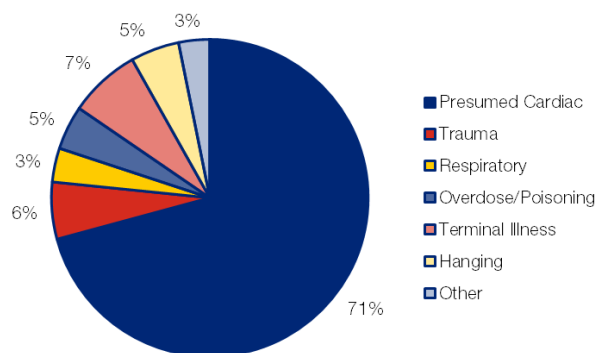


Figure 6: Adult precipitating events for EMS-attended events.

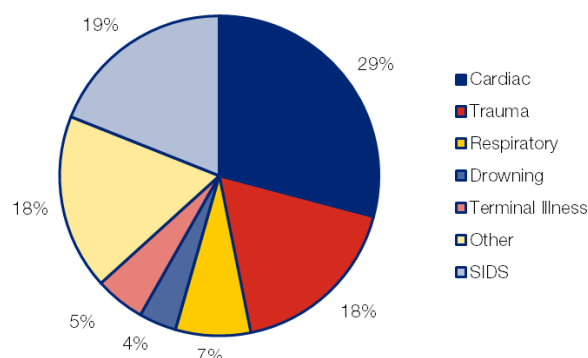


Figure 7: Paediatric precipitating events for EMS-attended events.

Location of arrest

In 2021-2022, most (79%) adult OHCA events occurred within a private residence. Other common arrest locations were a public place (this includes places of work, streets or roads, shops, vehicles and sporting/recreational facilities; 15%) and aged care facilities (7%).

Among adult patients who received an attempted resuscitation by EMS in 2021-2022, 74% occurred in a private residence. This was followed by a public place (14%) and aged care facilities (6%). Among paediatric patients, who received an attempted resuscitation by EMS in 2021-2022 (excluding EMS-witnessed arrests), 68% occurred in a private residence and 21% occurred in a public place. The location and witness status of OHCA have important implications on outcomes.

In comparison to arrests in the home, patients who arrested in public places were far more likely to be witnessed by a bystander and receive bystander CPR prior to EMS arrival (see Figure 8). In 2021-2022, the unadjusted rates of survival to hospital discharge for adult patients were highest in public places (25%) and medical facilities (13%) and lowest when they occurred in a private residence (6%) or aged care facility (1%).

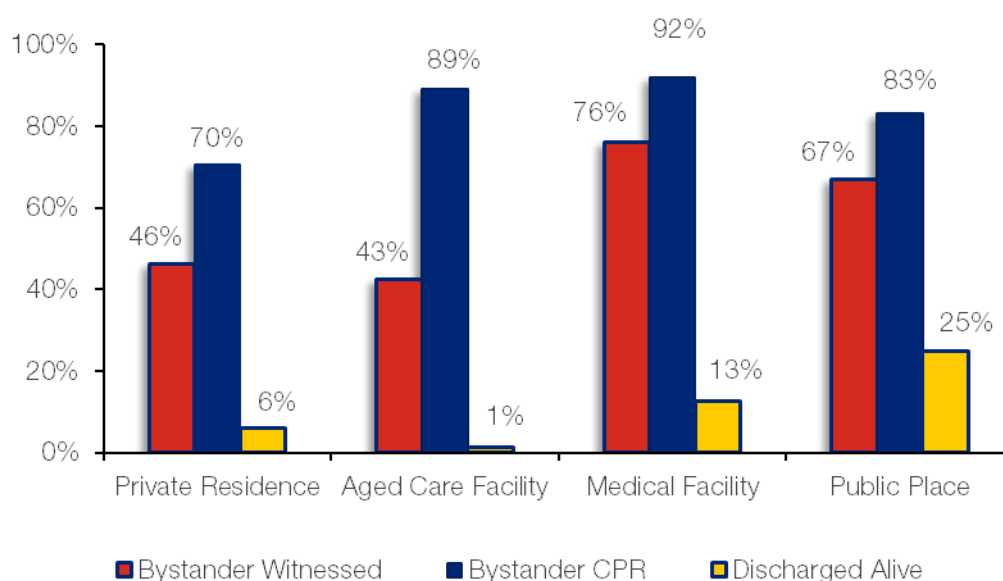


Figure 8: Proportion of EMS-treated adult events that were bystander witnessed, received bystander CPR and were discharged alive across arrest locations, 2021-2022.

X-LARGE



MEDIUM



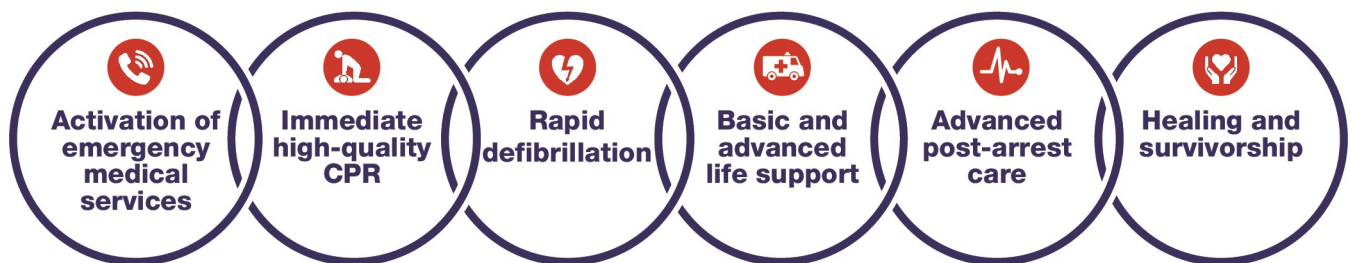
LARGE



Chain of Survival

The chain of survival is an internationally recognised initiative aimed at maximising survival following out-of-hospital cardiac arrest.

Survival from OHCA is determined by the provision of quality and timely pre-hospital interventions, known as the 'Chain of Survival'. Early recognition and activation of EMS, quality cardiopulmonary resuscitation (CPR), timely defibrillation, early advanced life support, and advanced post-arrest care are the hallmark components of the Chain of Survival. More recently, 'Healing and Survivorship' has been added to the Chain of Survival, highlighting the need for increased investment in initiatives which aim to improve the long-term outcomes and quality-of-life of OHCA survivors.



Early recognition and activation of EMS

Bystander call for help

In 2021-2022, the first bystander call for help after an OHCA was correctly directed to ambulance in the majority of cases (93%), however, for the remaining 7% of cases, there were delays as calls were first made to relatives or friends (3%), neighbours (1%), police (2%) or other (1%). This is a slight improvement on the previous year, when 91% of calls were directed to ambulance.

Emergency response to the incident

In 2021-2022, 83% of all cardiac arrests (excluding EMS-witnessed) were identified during the Triple Zero (000) call. This is a slight decrease when compared to the previous year (87%). For cases with a presumed cardiac cause, arrests were identified during 87% of calls.

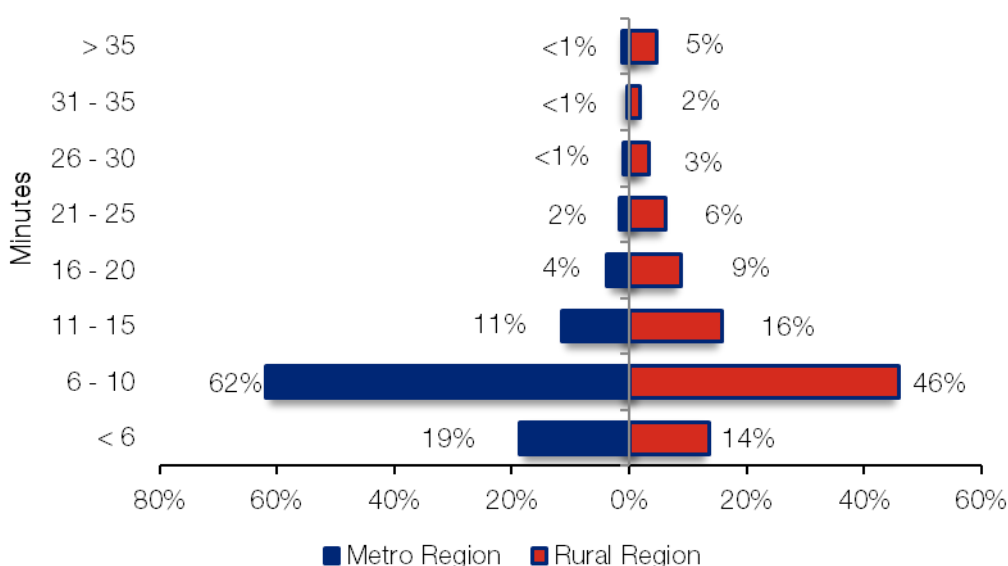


Figure 9: Distribution of time from 000 call to arrival of EMS on scene.

In 2021-2022, the state-wide median EMS response time was 8.2 minutes (90th percentile 17.7 minutes). This was similar to the response time noted in the previous year (median time 8.3 minutes; 90th percentile 17.2 minutes). In metropolitan regions, the median response time was 7.9 minutes (90th percentile 14.4 minutes), also similar to the previous year (median time 8.0 minutes; 90th percentile 13.6 minutes). And, the median response time in rural areas was 9.4 minutes (90th percentile 25.7 minutes), compared to 9.5 minutes (90th percentile 26.5 minutes) in the previous year.

Overall, in 2021-2022, 75% of all OHCA patients (excluding EMS-witnessed arrests) who received a resuscitation attempt were attended to by EMS within 10 minutes of their call being answered and 87% were attended to within 15 minutes. See **Figure 9** for more detail.



Immediate CPR

Bystander cardiopulmonary resuscitation

Over the last decade in Victoria, there have been notable increases in rates of bystander CPR (see **Figure 10**). Of OHCA patients witnessed to collapse by bystanders in 2021-2022, 62% of patients received bystander CPR, in comparison to 56% in 2012-2013 (this trend is not statistically significant). However, of bystander-witnessed OHCA events receiving an attempted resuscitation by EMS, 79% received bystander CPR in 2021-2022, compared to 71% in 2012-2013 ($p=0.029$). Improvements in CPR rates can be partly attributed to more accurate identification of OHCA during the emergency call and delivery of dispatcher-assisted CPR instructions (Bray 2011).

Previous VACAR research has shown that early and effective bystander CPR increases the likelihood of an initial shockable rhythm (i.e. of the patient being receptive to EMS-attempted resuscitation efforts) and improves the chances of survival following OHCA (Fridman 2007).

Variation in rates of bystander CPR observed over the past few years (2019-2020, 2020-2021 and 2021-2022) are likely to be associated with the COVID-19 pandemic where periods of lockdown influenced the number of witnessed arrests. See **page 18** of this report for more information.

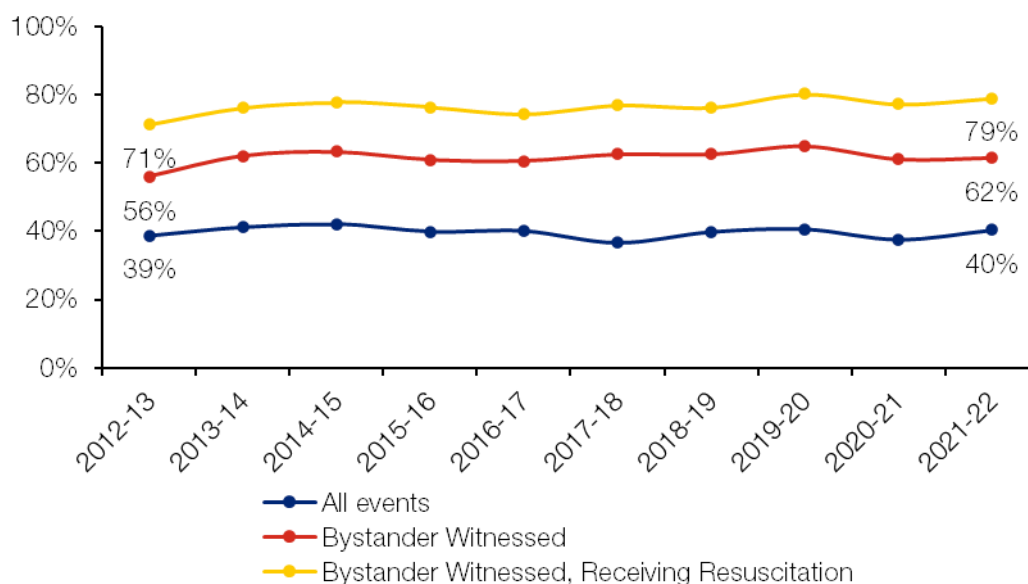


Figure 10: Patients receiving bystander CPR.

Unadjusted survival to hospital and to hospital discharge were strongly associated with the presence of bystander CPR (excludes EMS-witnessed events; see **Figure 11**). In 2021-2022, OHCA event survival (i.e. survival to hospital) for patients receiving bystander CPR was significantly higher than for patients not receiving bystander CPR (30% vs. 23%, $p<0.001$). Survival to hospital discharge was significantly higher for patients receiving bystander CPR versus no bystander CPR (10% vs. 5%, $p<0.001$).

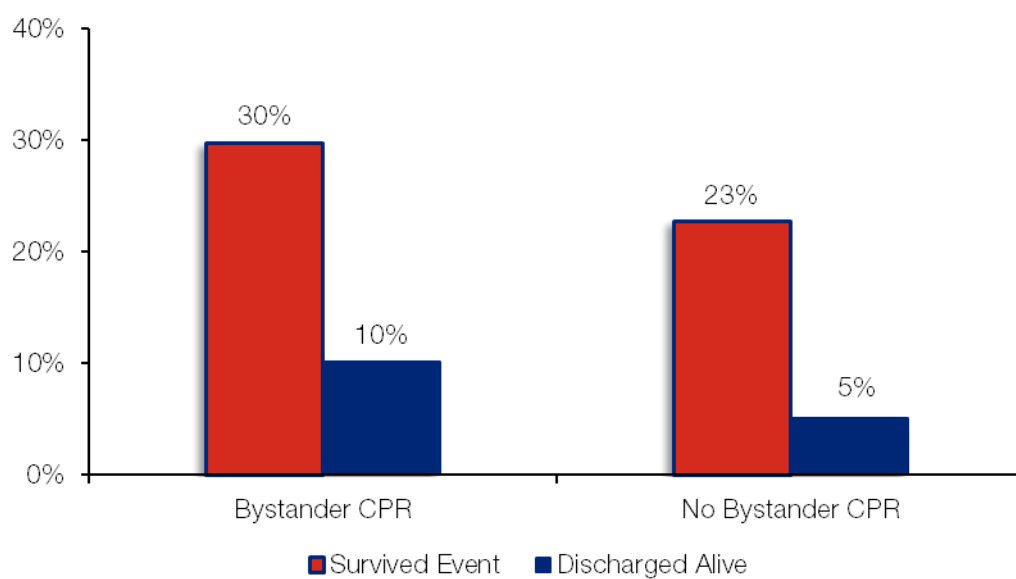


Figure 11: Unadjusted survival outcomes after bystander CPR in the EMS-treated population.



Rapid defibrillation

Time to first defibrillation

The time from emergency call to first defibrillation for patients presenting in a shockable rhythm is a key measure of quality of care for EMS. The proportion of cases where AV performed the first defibrillation has reduced from 80% in 2012-2013 to 70% in 2020-2021 ($p=0.005$). This decline has been driven by an increase in the use of automated external defibrillators (AEDs) by bystanders over the same period (9% to 16%, $p=0.005$) and the expansion of first responder programs. This year, we saw the second highest ever proportion of arrests defibrillated by public AEDs (16%) prior to EMS arrival. The proportion of cases initially defibrillated by first responders during 2021-2022 was 15%, the highest proportion in the last decade and an increase from the 10% that has been reported consistently over the past four years.

The time to first defibrillation by EMS is recorded for EMS-treated patients whose rhythm is shockable on EMS arrival. In 2021-2022, the median state-wide time to defibrillation of 10.4 minutes (90th percentile 17.0 minutes) was consistent with the previous year (median time 10.5 minutes; 90th percentile 16.2 minutes). The median time to defibrillation in the metropolitan region in 2021-2022 was 9.9 minutes (90th percentile 15.5 minutes), a reduction from the year prior (10.4 minutes; 90th percentile 15.1 minutes), whilst in the rural region, the median time was 11.2 minutes (90th percentile 19.9 minutes), a slight change from the previous year (10.8 minutes, 90th percentile 19.9 minutes).

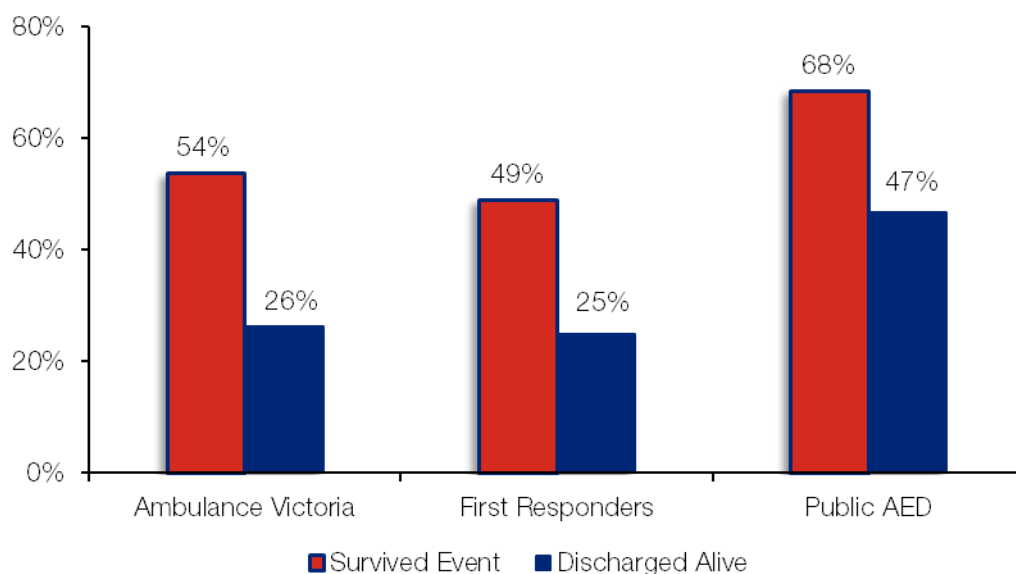


Figure 12: Unadjusted survival outcome according to who shocked first in the EMS-treated population with a shockable rhythm on or before EMS arrival.

It is widely accepted that reducing delays to defibrillation leads to better outcomes for patients in a shockable rhythm. Unadjusted survival outcomes for patients presenting in a shockable rhythm on or before EMS arrival vary according to who performed the first defibrillation (see Figure 12).

In 2021-2022, the proportion of OHCA patients surviving the event when first defibrillated with a public AED was 68%, compared with 49% of patients first shocked by first responders ($p=0.004$) and 54% of patients first shocked by paramedics ($p<0.001$). Survival to hospital discharge was also significantly higher when a public AED was used compared to when patients were shocked by paramedics (47% vs. 26%, $p<0.001$). The small sample size of these groups should be taken into consideration as this can result in yearly fluctuations in survival rates. The survival rate for patients defibrillated with a public AED compared to those defibrillated by first responders and EMS illustrates how early intervention, especially the application of an AED for patients in a shockable rhythm, has an obvious and positive impact on survival outcomes.



GoodSAM Community Responders

Cardiac arrests often occur unexpectedly. For every minute that a patient experiencing a cardiac arrest goes without CPR and/or defibrillation, their likelihood of surviving the event falls by around 10% (Larsen et al. 1993). The importance of emergency services' rapid response therefore plays a large role in the survival of these patients, as does the community response.

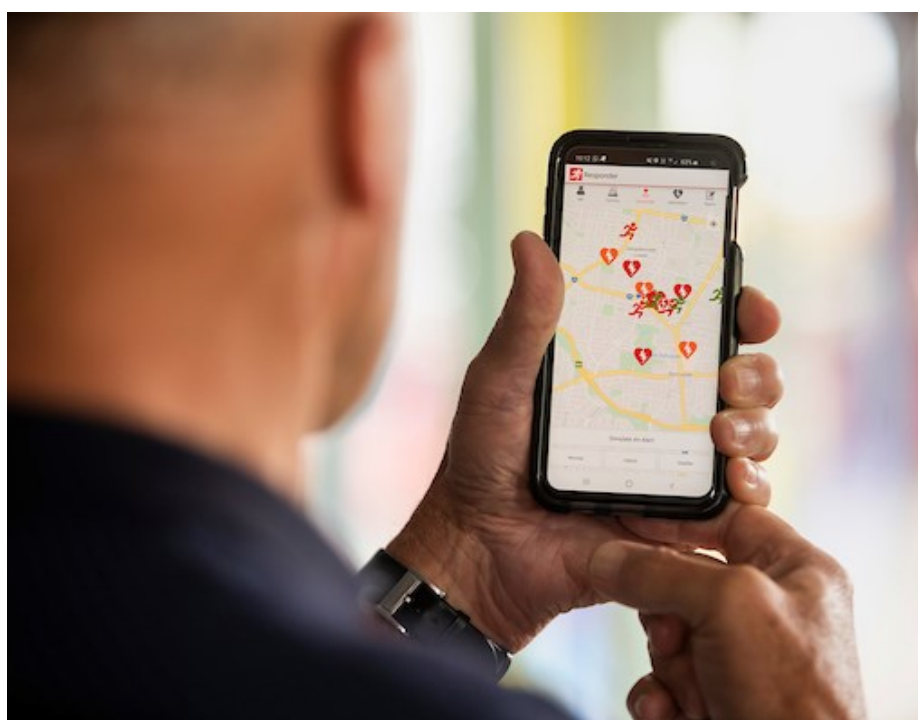
Early intervention by bystanders (i.e. witnesses to the event and/or persons nearby at the time) is also a significant factor. Community engagement around cardiac arrest first aid is incredibly important. There are several community-based initiatives being led by AV as well as other emergency response services worldwide.

GoodSAM (Smartphone Activated Medic) is a free global smartphone application that is used to facilitate a rapid response to cardiac arrests across the globe by connecting nearby persons to patients experiencing a cardiac arrest in those critical minutes before emergency services arrive.

GoodSAM is activated at the same time as ambulance dispatch by Triple Zero (000) and alerts nearby registered users of the app of an event occurring, as well as the location of the nearest AED.

Since the launch of the GoodSAM app in Victoria on January 28th of 2018, more than 8,800 individuals and businesses have registered their AEDs through the app. As of 30 June 2022 there were over 5,850 active GoodSAM responders (i.e. responders with the app installed, who have GPS/phone reception and are marked as being available at the time).

To become a GoodSAM responder or to register an AED, please visit the AV website or access the QR codes over the page. The availability of AEDs to GoodSAM responders and bystanders increases the likelihood that a patient will be defibrillated within the first critical minutes of their arrest. AEDs can be used by anyone.



How does GoodSAM work?

1. A Triple Zero (000) call triggers an alert to be sent to a GoodSAM Responder.
2. The responder is told the location of the patient and the nearest available defibrillator (AED).
3. At the same time, the closest available ambulance is sent to the patient, and in some parts of Victoria, the fire brigade is also dispatched.
4. Meanwhile, the GoodSAM Responder can provide CPR and, if possible, make use of the nearest available defibrillator.



REGISTER AN AED



BECOME A GOODSAM
RESPONDER



FIND MY CLOSEST
AED

Anyone who wants to save lives can now register with GoodSAM



Basic and advanced life support

Early basic and advanced care in the chain of survival refers to the phase of OHCA management when paramedics step in and provide additional life-saving measures. This phase includes the provision of high-quality CPR and defibrillation, amongst other clinical interventions designed to achieve ROSC. These include, but are not limited to:

- i. Timely defibrillation, and timely and accurate placement of defibrillation pads
- ii. Rapid commencement of high-quality CPR (see below)
- iii. Early placement of a laryngeal mask airway, and the administration of adrenaline and amiodarone
- iv. Acquiring a 12 lead electrocardiogram, achieving blood pressure targets and transporting to an appropriate hospital for advanced care

High-performance cardiopulmonary resuscitation (HP-CPR)

HP-CPR is a term that describes the ideal means of providing CPR, and involves focused efforts on improving various elements of CPR that are known to increase survival (Eisenberg et al, 2018). The quality of CPR can be measured using internationally recognised standards. CPR is considered to be of high quality if it meets these international standards and follows a well-practiced choreography (the “pit-crew” approach) aimed at minimising interruptions to resuscitation.

The main components of HP-CPR are:

- ▶ high chest compression fraction,
- ▶ targeted chest compression rate and depth,
- ▶ allowing full chest recoil, and
- ▶ avoidance of over-ventilation.

Recommendations for optimal chest compressions include a target depth of ≥ 5 cm for adults and a rate of 100-120 compressions per minute. To maximise perfusion, guidelines for CPR and external cardiac compressions recommend minimising pauses in chest compressions. Lower chest compression fraction (i.e. longer pauses and

lower proportion of time with CPR being performed) during resuscitation is associated with a decreased likelihood of ROSC and survival. Interruptions in chest compressions result in a fall in coronary perfusion pressure, and an associated decrease in the likelihood of successful defibrillation. It has been previously demonstrated that the odds of survival to hospital discharge decline by 7%-18% for every consistent five-second increase in pre-shock CPR interruptions (Cheskes et al. 2011 and Ibrahim 2007).

In February 2019, AV transitioned to a HP-CPR model with training provided to all First Responders, advanced life supporters and MICA paramedics, and in August 2020, AV introduced detailed routine feedback for all paramedics.

In a relatively recent VACAR research publication, AV's resuscitation quality improvement program, which consisted of HP-CPR, was associated with a 33% increase in the risk-adjusted odds of survival over the first 12 months of the program (Nehme 2021).

Providing feedback to paramedics

Feedback is provided in a Team Performance Report (TPR), a structured report sent to all paramedics present at a cardiac arrest case and their associated Team Managers. TPRs contain timely, objective clinical feedback on paramedic performance for every adult medical cardiac arrest attended. The reports provide an opportunity to recognise and celebrate good performance, identify areas for improvement and facilitate discussion between paramedics, their manager, and clinical leaders.

TPRs use the technology of a chest compression sensor applied to the patient's chest early in the resuscitation attempt and collates it with other routinely collected data into a standardised report. There are 19 key performance metrics reported, all of which are measurable and evidence based. These metrics target each of the links in the 'Chain of Survival' which are strongly associated with patient outcomes following OHCA and have been tailored specifically for paramedics, such that they represent real-life interventions that can be improved with training.

Since the introduction of HP-CPR into AV clinical practice in February 2019, a significant increase in all metrics optimising chest compression rate, depth and chest compression fraction, has been demonstrated in Victoria. In addition, significant improvements in pre- and post-shock pauses have been demonstrated.

As cardiac arrest cases are both challenging and infrequent, the feedback provided within the TPR capitalises on every cardiac arrest attended, encouraging self-reflection, as well as identifying learning opportunities and guiding skills-based training as required. Furthermore, recognising and celebrating good performance may help foster a positive workplace culture, promoting discussion and improvement.

Last year, we published a research letter detailing a novel post-cardiac arrest debrief report to inform other EMS agencies of the approach used by AV (Villani 2021).





Achieving optimal outcomes for OHCA patients is dependant on the quality of resuscitation delivered by paramedics.

Following every resuscitation attempt, the Victorian Ambulance Cardiac Arrest Registry provides data-driven Team Debriefing Reports to all paramedics present on scene. The report includes 19 evidence-based metrics which target each of the links in the 'Chain of Survival' and are strongly associated with patient outcomes following OHCA. The metrics have been tailored specifically for paramedics, such that they represent skills or interventions that can be improved with training and education.

The findings of these reports are summarised in our 2021-22 Resuscitation Quality Snapshot. The snapshot demonstrates excellent performance across key resuscitation metrics, spanning early recognition, high-quality CPR, early defibrillation and advanced care.

Early recognition

88%

of cases had placement of pads within **2 minutes** of EMS arrival

94%

of cases had compressions underway on pad placement

93%

of cases had the initial rhythm correctly identified



High quality CPR

91%

median chest compression fraction



82%

median compressions at the target depth



73%

median compressions at the target rate

Snapshot 2021–22

driven
d
ent
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Early defibrillation

62%

of cases had the first defibrillation or monitor disarm within **2 minutes** of EMS arrival at patient

 **5.6 sec**

median pre-shock pause



 **3.6 sec**

median post-shock pause



Advanced care

81%

first pass intubation success



89%

of transported cases had a systolic blood pressure > 100mmHg on hospital arrival



66%

of VF/VT patients who died on scene had an adequate duration (**45 minutes**) of resuscitation

 **45 min**



Witnessed events. VF/VT denotes ventricular fibrillation/pulseless ventricular tachycardia, ROSC return of spontaneous circulation.

Advanced post-arrest care

Transport to a cardiac centre

Prior research conducted by the VACAR team has shown that transport of OHCA patients to a percutaneous coronary intervention (PCI)-capable hospital is associated with improved survival to hospital discharge (Stub 2011).

During 2021-2022, 92% of all OHCA state-wide with a presumed cardiac cause were transported to a PCI-capable hospital, in line with recent years. Within the metropolitan region, 97% of patients were transported to a PCI-capable hospital, whilst in rural regions, this figure was 79%. This represents the second highest rate of transportation to PCI-capable hospitals in the rural region in the last 10 years (79% vs 43% in 2012-2013). Rates of transportation to PCI-capable hospitals in rural regions vary due to the location of arrests.

This year, 38% of OHCA patients who were transported to PCI-capable hospitals survived to hospital discharge (unadjusted survival, see **Figure 13**) compared with the 24% OHCA patients who were transported to hospitals without PCI capability. It is likely that hospital-based factors contribute to the variation in outcomes observed across hospitals, including optimal post-arrest treatment strategies.

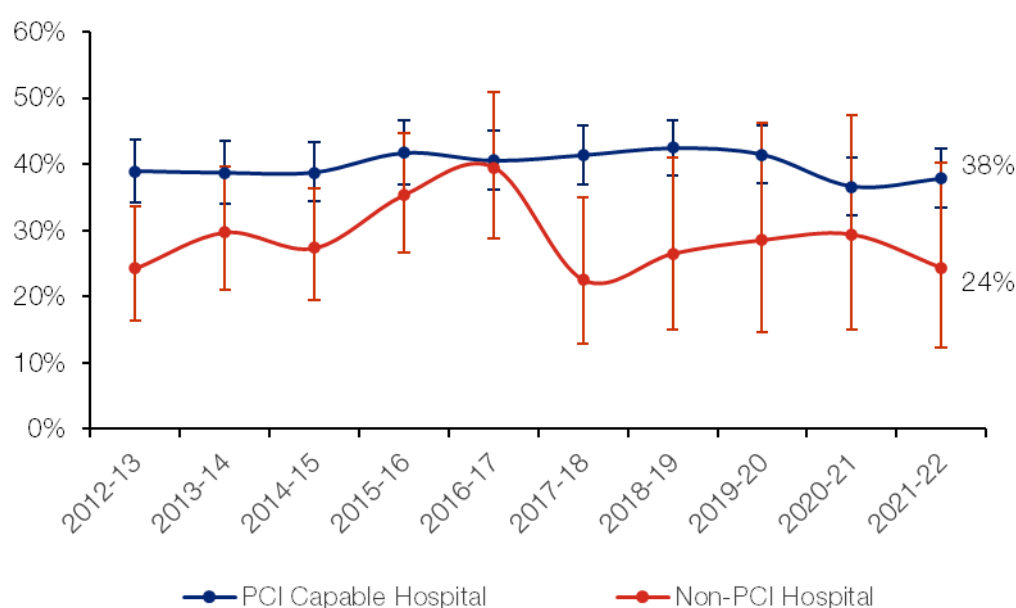


Figure 13. Unadjusted survival to hospital discharge for adult presumed cardiac EMS-treated events according to transport to a PCI-capable hospital. Error bars show the 95% confidence interval around the proportion.

Data refers to Victorian hospitals with a current process to receive AV emergency patients via a pre-notification system, have full-time PCI capabilities and were the first hospital that the OHCA patient was transported to.

Survival outcomes

Scene outcomes in adults

Successful attempts at resuscitation following OHCA are often evaluated by the attainment of ROSC in the field and transportation of patients to hospital. During 2021-2022, ROSC was most commonly achieved amongst adult OHCA patients who arrested in the presence of EMS (66%). Bystander-witnessed arrests attained higher rates of ROSC than unwitnessed arrests (47% vs. 18%, respectively).

Across the entire state in 2021-2022, ROSC was achieved in 38% of all adult EMS-treated events (includes EMS-witnessed arrests) which is higher than the previous year (37% in 2020-2021). In the metropolitan region, ROSC was achieved in 38% of OHCA events (in the previous year, this was 37%) while in the rural region, this figure was 39% (the same as the previous year).

Over time, there has been an increase in the proportion of OHCA events where resuscitation efforts were ceased at scene (see Figure 14). In 2021-2022, the proportion of adult EMS-treated events which were transported from the scene with ROSC was 27%. Efforts were ceased at scene for 71% of adult EMS-treated events and the rate of transportation with CPR was low (1%).

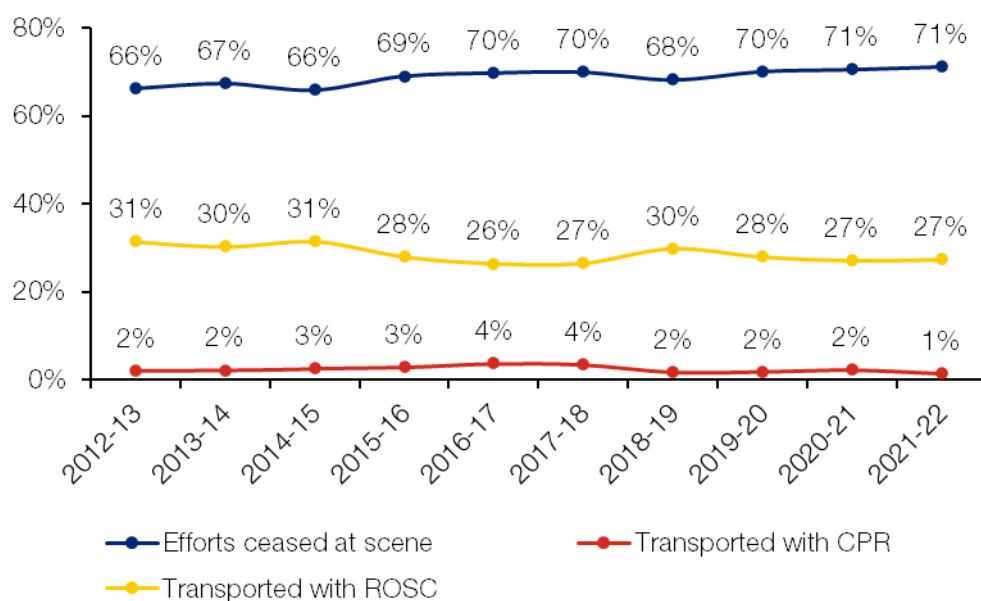


Figure 14: Scene outcomes for adult EMS treated events.

Previous VACAR research has shown that the majority of OHCA patients with an initial shockable rhythm who do not achieve sustained ROSC in the field are declared deceased rather than being transported to hospital (Stub 2014). There are several reasons for the low rate of transport with ongoing CPR. Firstly, the transportation of a patient with ongoing CPR is potentially hazardous to the EMS crews. Secondly, if advanced life support measures have been provided by paramedics at the scene for >30 minutes and the patient remains in a non-shockable rhythm, there are typically very limited additional treatment options at hospital.



Adult survival from all-cause cardiac arrest

In 2021-2022, 28% of adult EMS-treated patients survived the event and 9% were discharged from hospital alive (see Figure 15). The rate of event survival has declined slightly since 2012-2013 (32% and 11% respectively), however survival to hospital discharge is relatively consistent with recent observations. The reduced survival rates observed in the past few years are likely to be influenced by the COVID-19 pandemic, as previously discussed (see page 16 of this report). In the metropolitan region during 2021-2022, event survival was 29% and 10% were discharged alive. In the rural region, event survival was 26% and 9% were discharged alive.

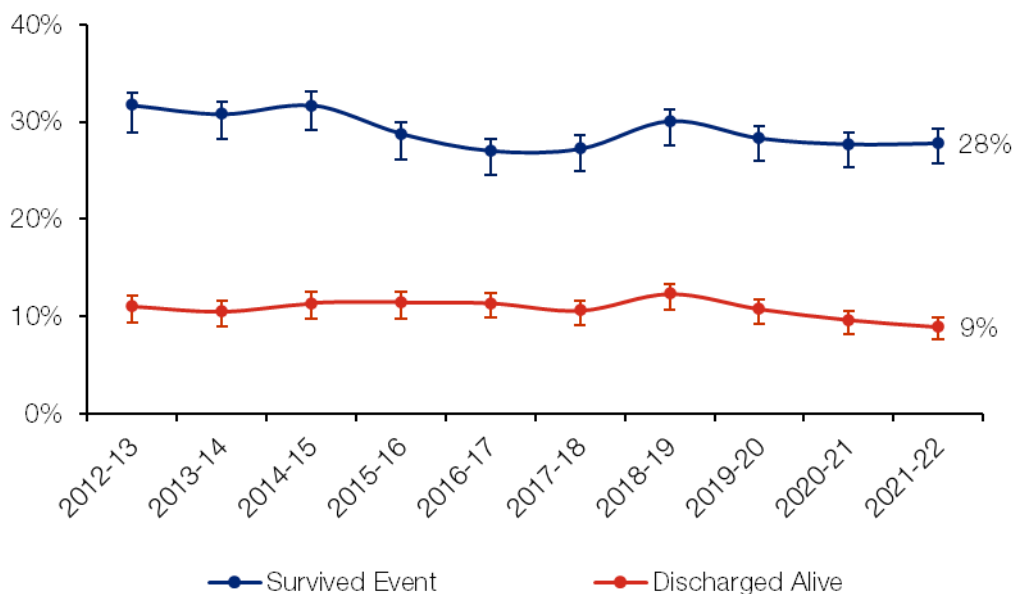


Figure 15: Unadjusted survival outcomes for all-cause adult EMS-treated events.

Adult survival, by presenting rhythm

In 2021-2022, 26% of the overall adult EMS-treated patient population presented to EMS or bystanders in a shockable rhythm. The proportion of adults presenting in a shockable rhythm has decreased slowly over the last 10 years (30% in 2012-2013; 30% vs. 26%, $p=0.003$), consistent with international trends. As the number of arrests presenting in a shockable rhythm decreases, overall survival is subsequently impacted. Survival outcomes for patients presenting to EMS or bystanders in a shockable rhythm are consistently better than patients presenting in pulseless electrical activity (PEA) or asystole. A shockable rhythm is a strong predictor of OHCA survival (Fridman 2007).

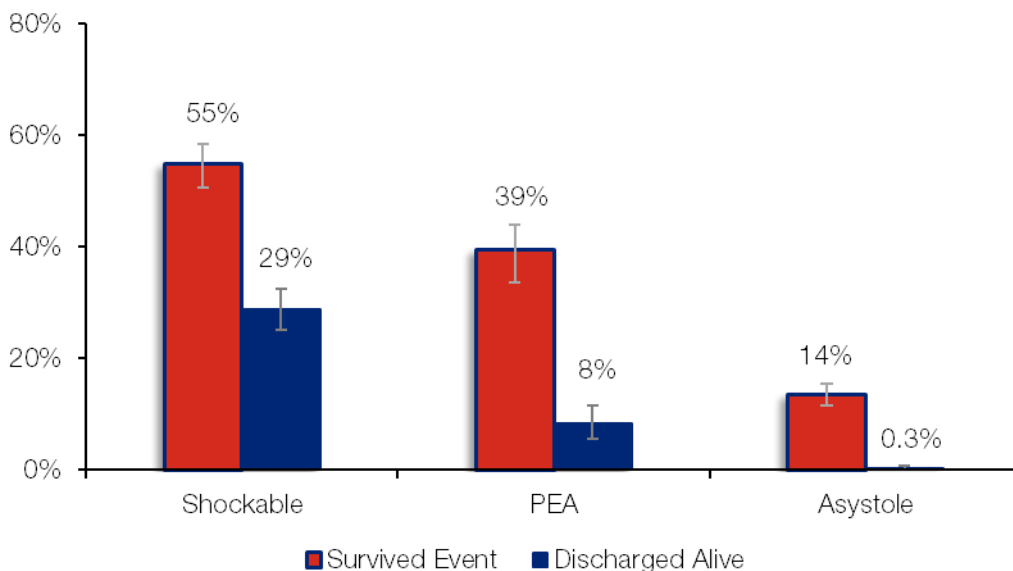


Figure 16: Unadjusted survival outcomes for adult EMS-treated events, according to presenting rhythm.

Adult survival from shockable rhythms

Event survival for adults in shockable rhythms has increased to former rates after a brief decrease observed last year (55% in 2021-2022, 53% in 2020-2021). Survival to hospital discharge for adult patients presenting in a shockable rhythm has decreased slightly (29% in 2021-2022, 30% in 2020-2021). However, survival rates have remained relatively consistent over the last decade (see **Figure 17**). Reduced survival rates observed last year were likely influenced by the COVID-19 pandemic, as fewer patients arrested in public places, were witnessed to arrest by a bystander, and delays to time-critical EMS interventions were observed.

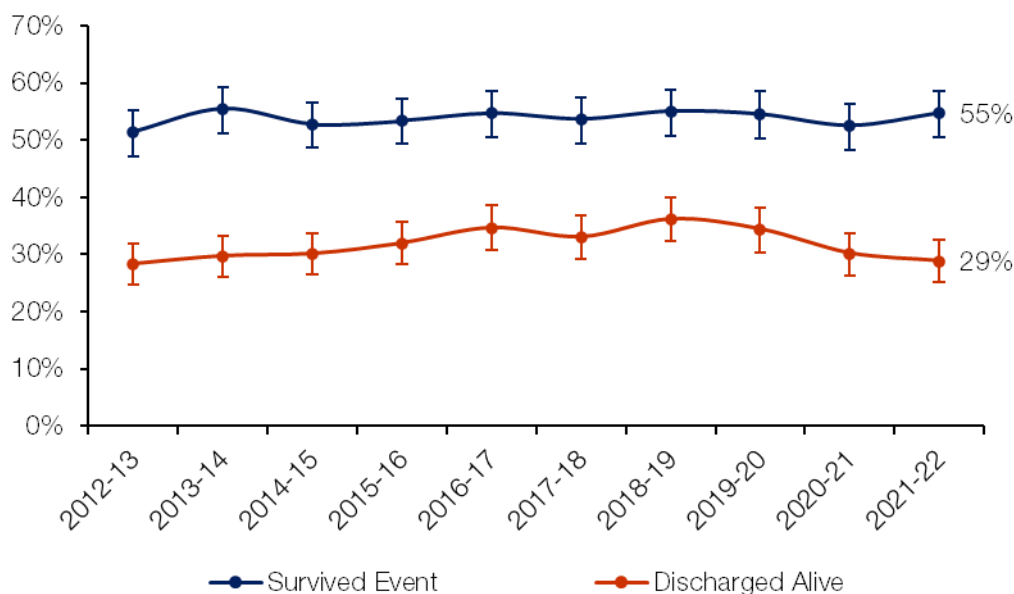


Figure 17: Unadjusted survival outcomes for adult EMS-treated patients presenting in a shockable rhythm.

Adult survival, EMS-witnessed arrests with shockable rhythms

In 2021-2022, for adult EMS-witnessed events arresting into a shockable rhythm, the rate of event survival was 80%, a decrease from 84% in 2020-2021. The rate of survival to hospital discharge in the same cohort was 70%, a decrease from 76% in 2020-2021 (see **Figure 18**). When considering all adult EMS-witnessed events during 2021-2022, the rate of event survival was 54% (in the previous year, this was 52%) and 32% were discharged alive (in the previous year, this was 31%).

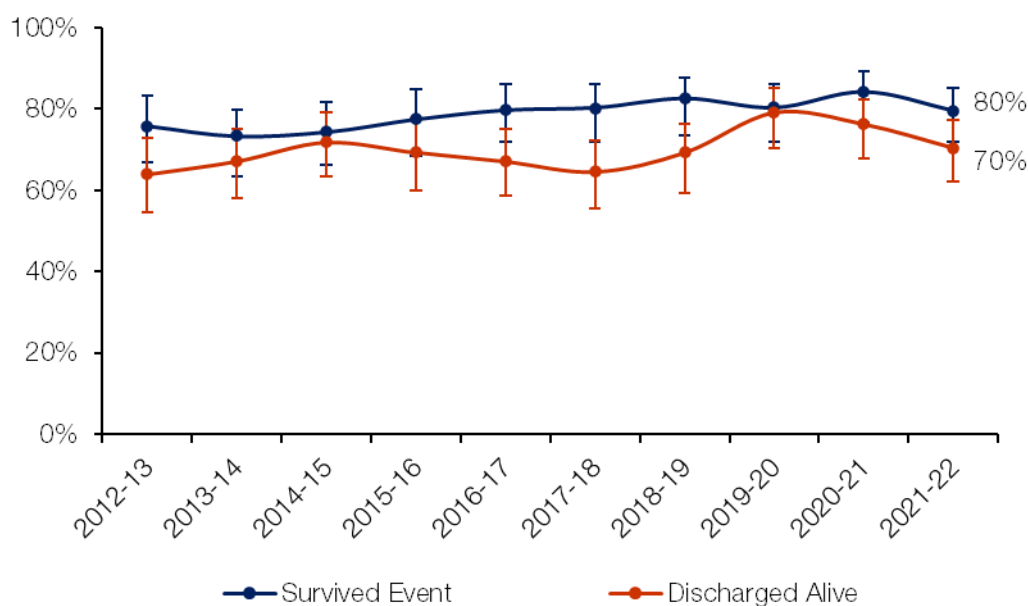


Figure 18: Unadjusted survival outcomes for adult EMS-witnessed, EMS-treated events with a shockable arrest rhythm.



Utstein patient group survival

The Utstein template is part of a set of guidelines which was developed to promote uniform presentation of OHCA survival data across different regions of the world (Perkins 2015). These guidelines define key data fields to ensure consistency in terminology and makes recommendations as to core and supplementary data to be recorded for each OHCA event. The Utstein template focuses on survival within the following patient subgroup: OHCA events where EMS attempted resuscitation, the arrest was witnessed by

a bystander and the presenting cardiac rhythm was shockable (VF or VT). **Figure 19** shows state-wide survival to hospital discharge for the Utstein patient subgroup for the last decade. In 2021-2022, the state-wide rate of survival to hospital discharge for this cohort was 34%, continuing a decreasing trend since 2019-2020. This reduced survival rate is likely to be influenced by the COVID-19 pandemic.

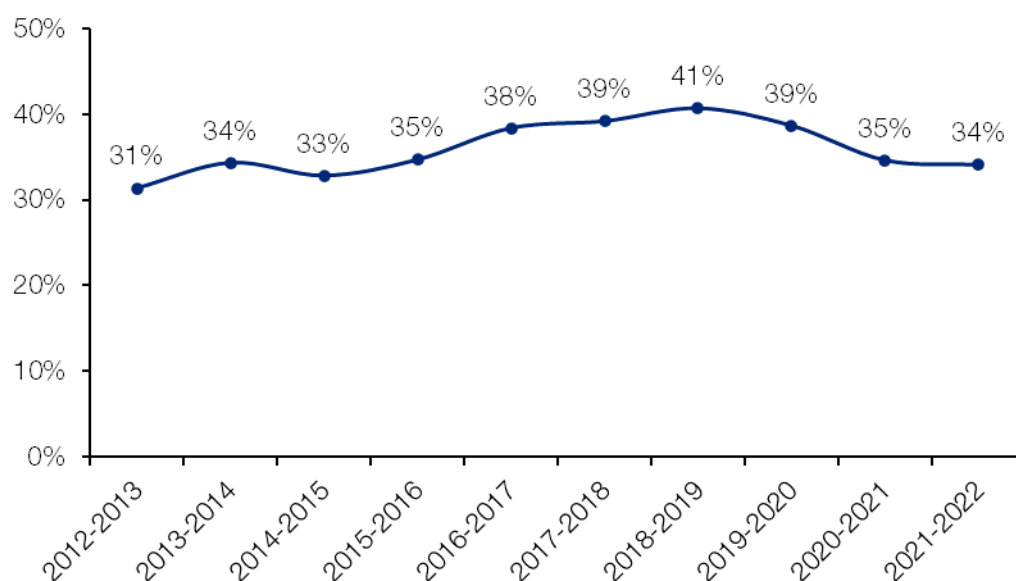


Figure 19: Survival outcomes for the Utstein patient group over the last decade.

Survival per million population

Understanding the number of survivors per million population allows for international comparison, and controls for variations within populations that influence absolute case numbers. **Figure 20** presents the rate of survival per million population. In 2021-2022, there were 57 all-cause OHCA survivors per million population, 43 survivors per million for patients with an initial rhythm of VF/VT, 23 survivors per million within the Utstein group, and 24 survivors per million for patients whose OHCA was witnessed by EMS.

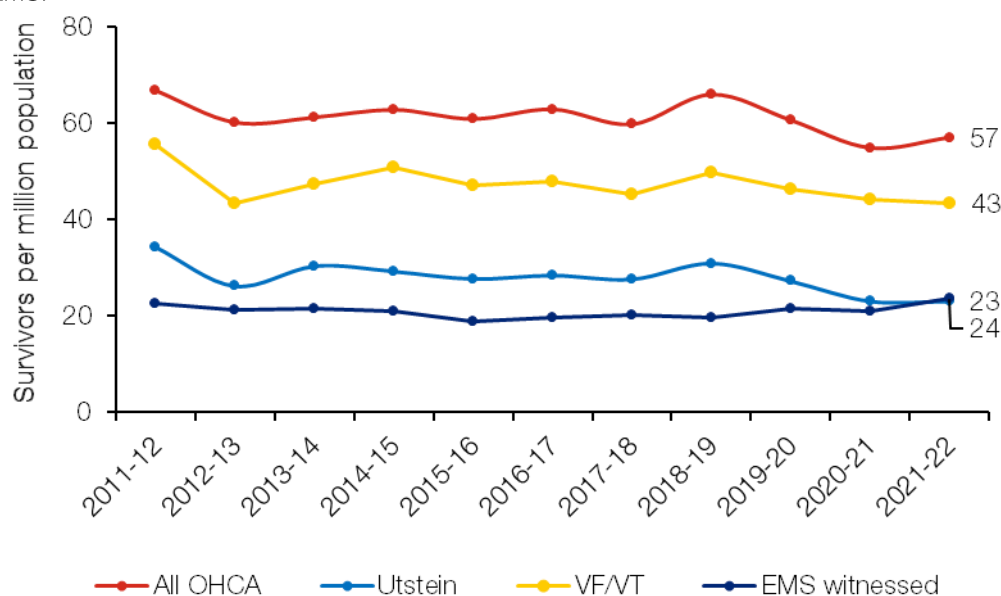


Figure 20: Survival per million population for all OHCA, the Utstein patient group, patients presenting in VF/VT, and EMS-witnessed arrests.

Benchmarking Utstein survival

Table 5 compares survival to hospital discharge in Victoria for the Utstein patient group to national and international data.

It should be noted that there are discrepancies in the definition of the Utstein patient subgroup by international ambulance services, making comparison of survival rates difficult. The Utstein patient subgroup definition used by AV no longer specifically selects patients where the arrest was due to a presumed cardiac cause. Instead, we include arrests due to any causes, as per the most recent recommendations for reporting of the Utstein comparator group (Perkins 2015). As evident in **Table 5** some groups still focus on the presumed cardiac patient subgroup and some exclude patients arresting due to a traumatic cause. Some groups also only include adult patients.

Other factors to consider in interpreting this data and drawing comparisons include: some ambulance services follow different guidelines for when to start and/or stop resuscitation; it is possible that some organisations omit short, yet futile resuscitation attempts from their analyses of patient outcome data; ambulance agencies service markedly different land areas and population sizes; some of the survival data presented in **Table 5** are from the pre-COVID-19 pandemic period, and results should therefore be interpreted with caution given the impact COVID-19 has had on OHCA survival in Victoria.

The survival to hospital discharge rate in the Utstein patient subgroup in Victoria was 34% in 2021-2022 which is comparable to a number of other ambulance services or other large collaborative studies/registries around the world.

Survival for metropolitan Melbourne was 36% in 2021-2022, and 34% in the year prior. For the Australian Bureau of Statistics (ABS) Statistical Area Level 4 Inner Melbourne (comprising Melbourne—Inner, Melbourne—Inner East and Melbourne—Inner South and a population of over 1.5 million in total), Utstein survival was 49% whilst the year prior it was 41%.

Table 5: Published Victorian, interstate and international OHCA survival to hospital discharge data for the Utstein patient cohort.

Organisation	Time period	% survival
Australia & New Zealand		
Ambulance Victoria		34%
- Metropolitan Melbourne	2021-2022	36%
- Inner Melbourne*		49%
St John Western Australia, 2020	2020	35.7%
Queensland Ambulance Service, 2021	2020	28%
NSW Ambulance, 2019	2019	31%
St John New Zealand, 2020-2021^	2020-2021	28%
International		
Seattle & King County, 2022^^	2021	46%
London Ambulance Service, 2018-2019^^^	2018-2019	37%
CARES (Cardiac Arrest Registry to Enhance Survival), 2021^^	2021	29%
Out-of-Hospital Cardiac Arrest Register (OHCAR) Ireland, 2020^^	2020	28%
British Columbia Emergency Health Services, 2019/2020	2019-2020	30%

*ABS Statistical Area 4 (SA4 which is made up of regions with populations in the range 100,000—500,000) Inner Melbourne which includes Melbourne—Inner, Melbourne—Inner East and Melbourne Inner South.

^Adult (≥15 years) survival to 30 days.

^^ Excludes patients arresting due to a traumatic cause.

^^^Only includes patients arresting due to a presumed cardiac cause.



Yearly risk-adjusted odds of adult survival

Assessing the risk-adjusted odds of survival provides a balanced method of measuring yearly trends in resuscitation performance and outcome. We evaluated the odds of survival to hospital discharge for the adult EMS-treated population across years using a multivariable model adjusted for known predictors of survival. These predictors included: age, sex, public location, initial shockable rhythm[^], bystander-witnessed status and bystander CPR. The 2006-2007 year was used as the reference category.

Figure 21 demonstrates strong growth in the survival to hospital discharge outcomes from 2006-2007 to 2018-2019. However, the relative odds of survival has steadily decreased since then. Such findings are likely to be associated with the COVID-19 pandemic. Despite this, in 2021-2022, the relative odds of survival to hospital discharge for adult EMS-treated patients were 1.5-times that of 2006 - 2007 (adjusted odds ratio 1.5, 95% CI 1.1-1.9, $p=0.0034$).

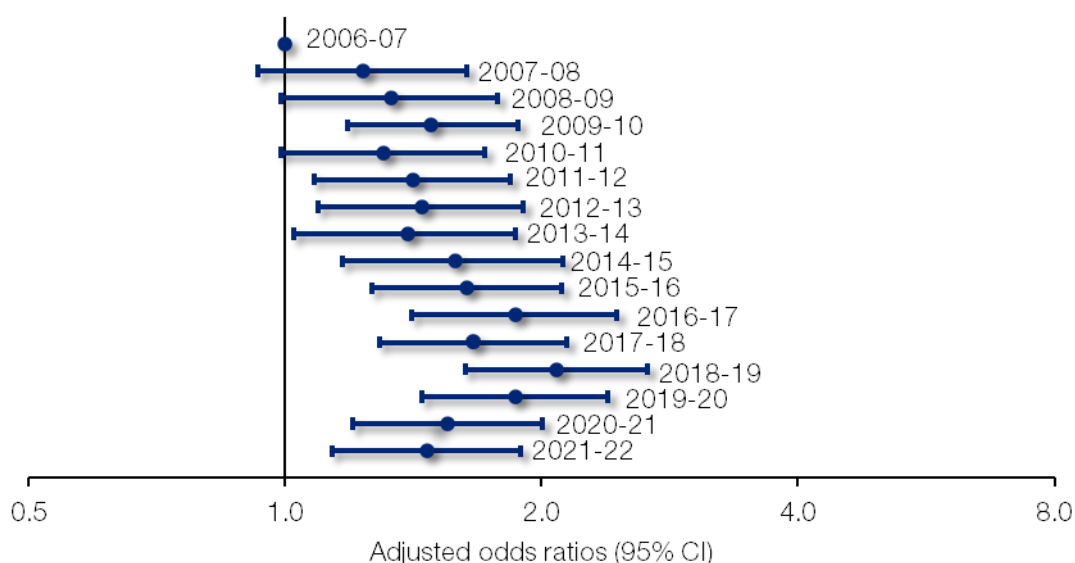


Figure 21: Risk-adjusted odds of adult survival to hospital discharge by year in the overall EMS-treated population.

Similarly, over time there have been improvements in the odds of survival to hospital discharge for patients presenting in a shockable rhythm (see **Figure 22**), although the impact of the COVID-19 pandemic can again be observed here. In 2021-2022, the relative odds of being discharged alive had increased by 80% compared to 2006-2007 (adjusted odds ratio 1.8, 95% CI 1.3-2.4, $p=0.0001$).

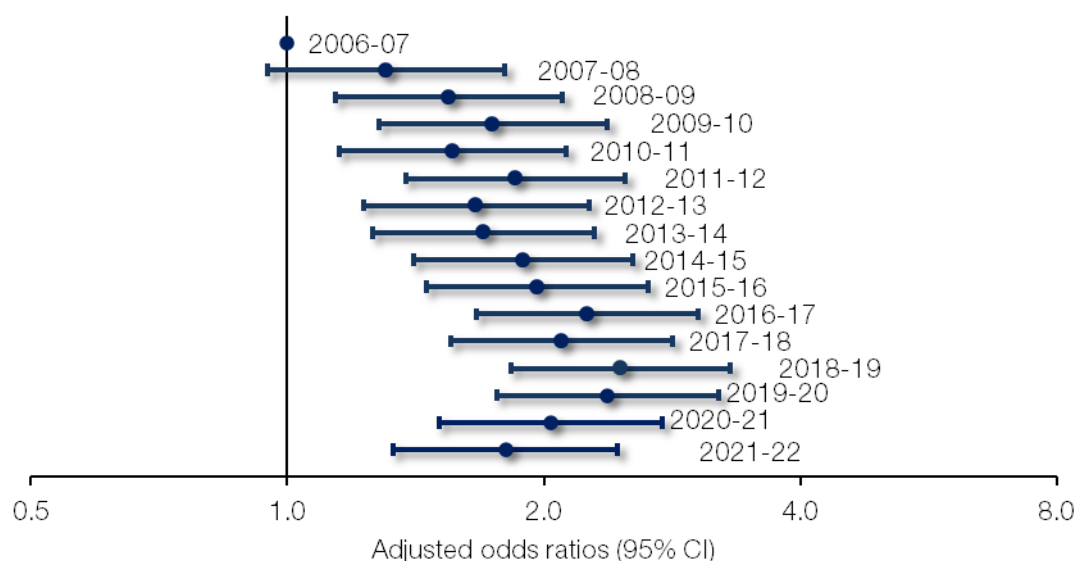


Figure 22: Risk-adjusted odds of survival to hospital discharge for adults presenting in a shockable rhythm by year in the EMS-treated population.

[^]The shockable rhythm factor was not included in this regression model.



Long-term outcomes

Discharge direction for all survivors

When considering all adult OHCA survivors to hospital discharge, 90% were discharged home (including EMS-witnessed events and excluding unknown discharge status). The rate of discharge to the home for adult survivors has largely remained consistent over the last decade (see **Figure 23**). In 2021-2022, remaining adult survivors were discharged to rehabilitation (9%) and nursing homes (1%). If a patient resided in a nursing home and was discharged to a nursing home, this was considered 'home'.

For adult OHCA survivors who presented in a shockable rhythm, 90% were discharged home. This is the highest proportion in the last decade.

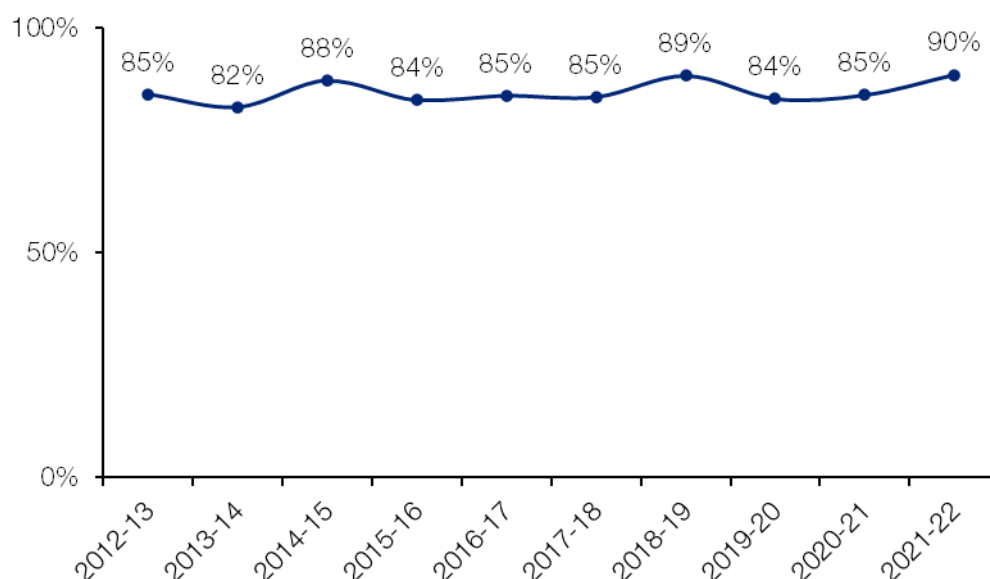


Figure 23: Proportion of adult survivors to discharge who were discharged to a private residence (includes EMS-witnessed events).

Assessing quality of life post-arrest

Since January 2010, surviving adult OHCA patients (aged ≥ 18 years) who were discharged alive have undergone health-related quality of life (HRQoL) interviews via telephone follow-up approximately 12-months after their arrest. Where necessary, a proxy is interviewed in place of the patient (if appropriate for the tool being used). Of 360 individuals who arrested between 1 July 2020 and 30 June 2021 and were discharged alive from hospital, 353 (98%) were alive 12 months post-arrest and were eligible for HRQoL interviews in 2021-2022.

A total of 247 interviews were conducted, with 228 patients and 19 proxies, producing a response rate of 70% (response rate excludes patients who were inappropriate to contact).

Response rates and returning to work

There were 133 individuals who had worked prior to their arrest. Of these, 72% (n=96) returned to work after their arrest. Of those returning to work, 79% (n=76) returned to work in the same role. VACAR have previously conducted more detailed research regarding drivers of returning to work for OHCA survivors (Kearney 2020). Factors which were positively associated with returning to work included male gender (odds ratio (OR) 4.13; 95% CI 2.38-7.18), arrests witnessed by EMS (OR 2.72; 95% CI 1.50-9.25), discharge from hospital directly to home (OR 4.13; 95% CI 0.95-0.98) and favourable QoL (on EQ-5D).

SF-12 Health Survey

The twelve-item Short Form health survey (SF-12), a generic HRQoL instrument measuring physical and mental status, is used during these interviews. The SF-12 consists of the Physical Component Summary (PCS) and Mental Component Summary (MCS). Each scale is rated 0–100 (full health; Ware 1996). SF-12 data was available for n=222 patients.

For the second year in a row, we observed reduced physical and mental component outcomes relative to Australian population norms. The PCS standardised mean differences was -0.363 (95% CI -0.517 to -0.209). The standardised mean differences for the MCS of the SF-12 was -0.276 (95% CI -0.416 to -0.136, see **Figure 24**). Given that the population norms were derived in 2003, it is possible that our findings are related to the COVID-19 pandemic. Existing evidence suggests that the life satisfaction and mental health of Victorians worsened during periods of COVID-19 lockdown. COVID-19 has also generally been associated with high rates of anxiety, depression, and psychological distress.

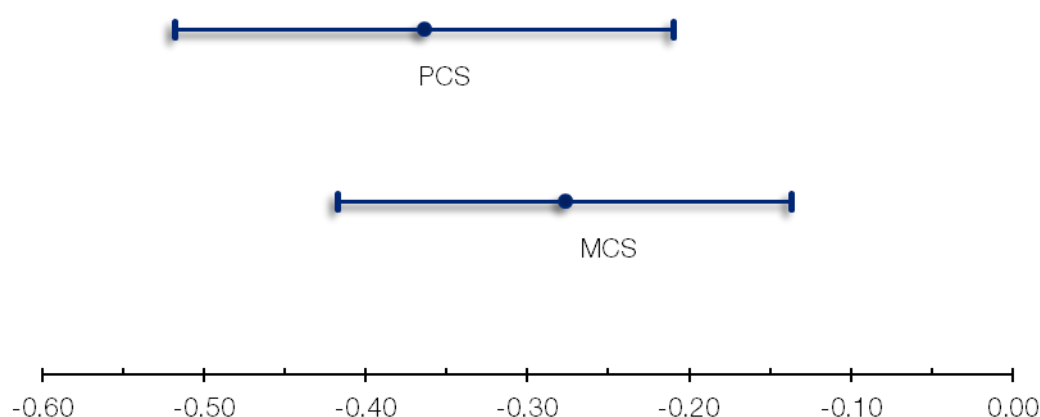


Figure 24: Standardised mean differences for SF-12 scores of OHCA survivors 12 months post-arrest versus the Australian population (patients who arrested in 2020-2021).

GOS-E

According to the Glasgow Outcome Scale – Extended (GOS-E), a global measure of function on an eight level scale from death to upper good recovery where scores ≥ 7 equate to good recovery (Wilson 1998), 83% of survivors who arrested during 2020-2021 reported having lower or upper good functional recovery 12 months after their arrest (see **Figure 25**). An additional 10% reported recovery with only moderate disability.

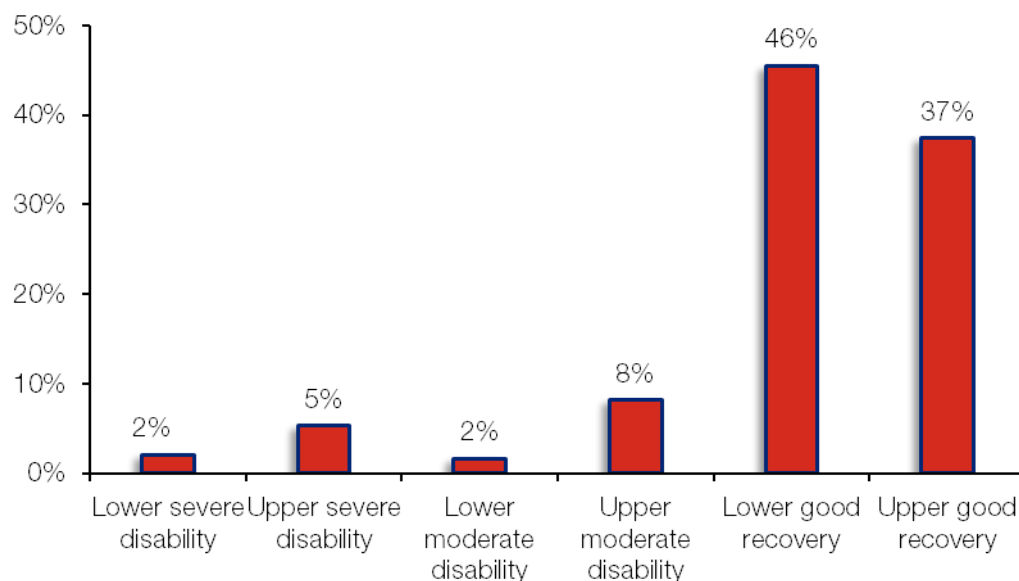


Figure 25: Disability or recovery status according to the GOS-E for OHCA survivors at 12 months post-arrest (patients who arrested in 2020-2021).



EQ-5D

The EuroQol 5 dimension (EQ-5D) questionnaire, a validated instrument to measure HRQoL, is used during these interviews (Rabin 2001). EQ-5D data was available for 247 patients who arrested in 2020-2021. The proportion of responders who reported 'No Problems' in each of the five EQ-5D domains in 2020-2021 are presented in **Figure 26** below. Respondents were most likely to report 'No Problems' in the domain of self-care, followed by mobility and daily activities. This data is similar to last year's report (for patients whose arrest occurred between 2019 and 2020) where 53% reported 'No Problems' in the anxiety domain, 63% in pain, 65% in daily activities, 81% in self-care and 65% in mobility.

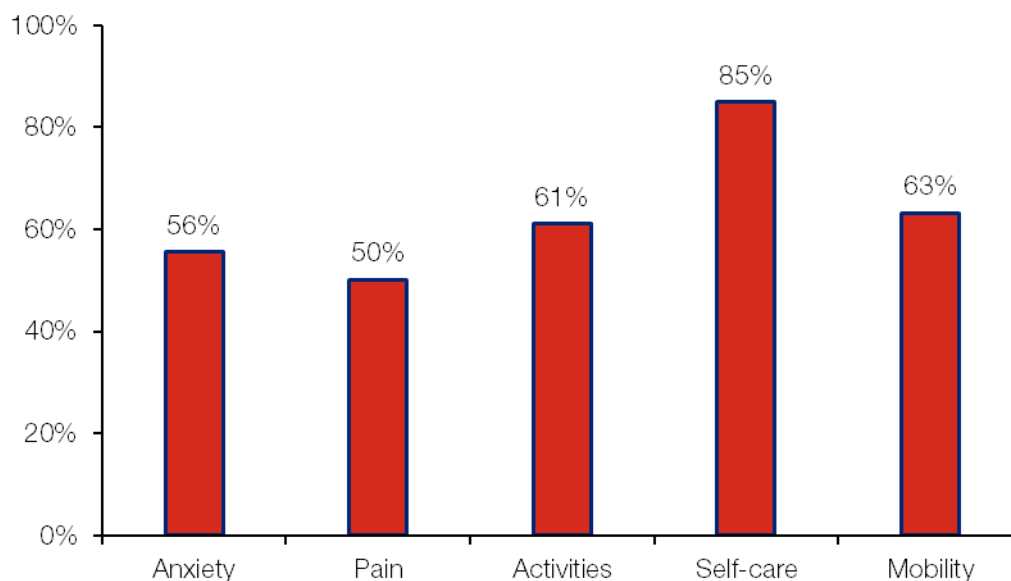


Figure 26: Proportion of responders reporting 'No Problems' across EQ-5D Domains (patients who arrested in 2020-2021).

HADS

The Hospital Anxiety and Depression Scale (HADS) is a validated instrument consisting of 14 questions, half of which assess anxiety and the other half assess depression. Total anxiety/depression scores of between 0 and 7 are considered normal, while scores between 8 and 10 indicate borderline abnormality, and scores between 11 and 21 indicate an abnormal state (Zigmond 1983). We added the HADS scale to our 12-month HRQoL interviews in 2020-2021. The vast majority of responders reported no problems with anxiety (n= 241; 75%) or depression (n= 242; 77%; see **Figure 27**).

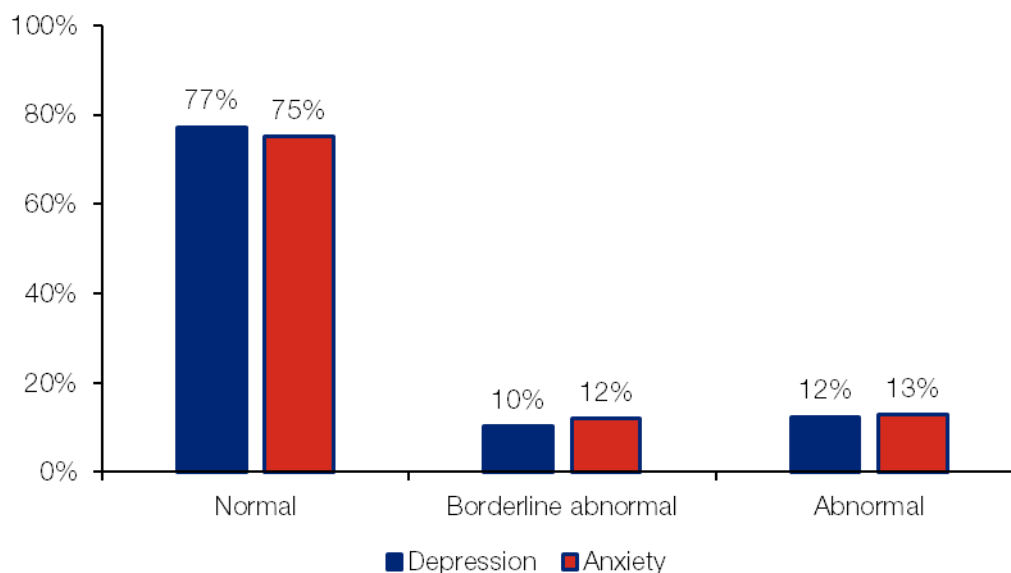



Figure 27: Anxiety and depression outcomes according to the HADS (patients who arrested in 2020-2021).



Research

Research is an important component of AV's vision to improve the health of our community. AV's Research and Evaluation team, which manages VACAR, oversees numerous clinical trials and other research studies in the pre-clinical space, including research into ways to improve OHCA management and patient outcomes.

AV runs several cardiac arrest improvement strategies, which align with the Global Resuscitation Alliance (GRA) 10 steps to improve cardiac arrest survival. GRA is an international collaboration which aims to increase OHCA survival by at least 50% through the promotion of evidence-based best practice OHCA management. The ten steps are listed below.

- | | | |
|---|-----------|---|
|  | 01 | Establish a cardiac arrest registry |
|  | 02 | Begin telephone CPR with ongoing training and Quality Improvement |
|  | 03 | Begin high performing EMS CPR with ongoing training and quality improvement |
|  | 04 | Begin rapid dispatch |
|  | 05 | Measure professional resuscitation using the defibrillator recording (and voice if possible) |
|  | 06 | Begin an AED program for first responders, including police officers, guards, and other security personnel |
|  | 07 | Use smart technologies to extend CPR and public access defibrillation programs to notify volunteer bystanders who can respond to nearby arrest to provide early CPR and defibrillation |
|  | 08 | Make CPR and AED training mandatory in schools and in the community |
|  | 09 | Work towards accountability – submit annual reports to the community |
|  | 10 | Work towards a culture of excellence |



To learn more about research at Ambulance Victoria use the QR code or visit <https://www.ambulance.vic.gov.au/about-us/research/>



To learn more about the Global Resuscitation Alliance, use the QR code or visit <https://www.globalresuscitationalliance.org/ten-programs/>

Peer-reviewed publications

1 July 2021– 30 June 2022

Alqudah Z, Smith K, Stephenson M, Walker T, Stub D and Nehme Z. The impact of a high-performance cardiopulmonary resuscitation protocol on survival from out-of-hospital cardiac arrests witnessed by paramedics. *Resusc Plus* 2022;12:100334.

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Definitions

Adults	Patients aged greater than 15 years of age, or where the age is missing/unknown.
Emergency Medical Services	Denotes Ambulance Victoria paramedics or first responders, including fire services, or community emergency response teams.
EMS-attempted resuscitation	Cases where either paramedics or first responders attempted to revive a patient in cardiac arrest using CPR and/or defibrillation, irrespective of duration.
EMS-attended	Cardiac arrest events attended by paramedics or first responders, regardless of whether treatment was provided.
EMS response time	The time from the emergency call being answered by the call-taker to arrival of the first EMS crew on scene.
EMS-treated	Cases involving an EMS-attempted resuscitation.
Event survival	Patients that have a palpable pulse on arrival at hospital as documented on the PCR.
Paediatrics	Patients aged less than 16 years.
PCI-capable hospital	Denotes a hospital with part-time or full-time Percutaneous Coronary Intervention (PCI) capabilities.
Presumed cardiac aetiology	Cases where the cause of arrest is not due to a known precipitator (e.g. trauma, overdose/poisoning etc) as acquired from the PCR.
Return of Spontaneous Circulation (ROSC)	A detectable pulse at any time during the case.
Survival to hospital discharge (or discharged alive)	Patients who are discharged from hospital alive.
Shockable Rhythm	Rhythms which are appropriate to receive defibrillation, including ventricular fibrillation and pulseless ventricular tachycardia, by EMS or a bystander with a public AED
Transported with CPR	Patients who, at the time of scene departure, are administered ongoing CPR.
Transported with ROSC	Patients that, at the time of scene departure, have a ROSC (i.e. detectable pulse).
Utstein patient group	Patients who are witnessed to arrest by a bystander, present in a shockable rhythm and an attempt at resuscitation was made by EMS.

Abbreviations

ABS	Australian Bureau of Statistics	OHCA	Out-of-Hospital Cardiac Arrest
AED	Automated External Defibrillator	OR	Odds Ratio
ALS	Advanced Life Support	PCR	Patient Care Record
AV	Ambulance Victoria	PCI	Percutaneous Coronary Intervention
CI	Confidence Interval	PCS	Physical Component Summary of the SF-12
CPR	Cardiopulmonary Resuscitation	PEA	Pulseless Electrical Activity
EMS	Emergency Medical Services	QOL	Quality of Life
EMR	Emergency Medical Responders	ROSC	Return of Spontaneous Circulation
EQ-5D	EuroQoL 5 Dimension questionnaire	SF-12	Twelve-item Short Form health survey
GOS-E	Glasgow Outcome Scale—Extended	SD	Standard deviation
HADS	Hospital Anxiety and Depression Scale	SIDS	Sudden Infant Death Syndrome
HP-CPR	High Performance CPR	TPR	Team Performance Report
HRQoL	Health-Related Quality Of Life	VACAR	Victorian Ambulance Cardiac Arrest Registry
MCS	Mental Component Summary of the SF-12	VF	Ventricular Fibrillation
MICA	Mobile Intensive Care Ambulance	VT	Ventricular Tachycardia



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