Ambulance Victoria

Victorian Ambulance Cardiac Arrest Registry

2019-2020 Annual Report

Victorian Ambulance Cardiac Arrest Registry

2019-2020 Annual Report

The VACAR Annual Report 2019-2020 is a publication produced by the Centre for Research & Evaluation, Ambulance Victoria.

Director Professor Karen Smith

Authors Dr Jocasta Ball, Dr Resmi Nair, Ms Kavitha Sathish-Kumar

If you would like to receive this publication in an accessible format please contact the Director, Centre for Research and Evaluation, Ambulance Victoria: karen.smith@ambulance.vic.gov.au.

Disclaimer and Copyright

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.

Ambulance Victoria
375 Manningham Road
Doncaster VIC 3108

Postal Address
PO Box 2000
Doncaster VIC 3108

Email karen.smith@ambulance.vic.gov.au
Website www.ambulance.vic.gov.au
Phone 03 9896 6083
Facsimile 03 9011 7739

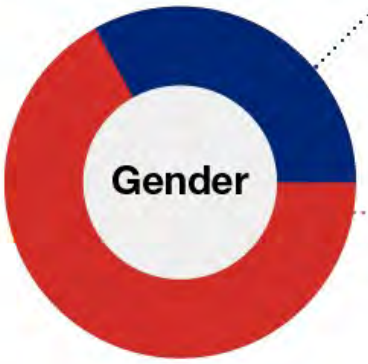
January 2021

Contents

Demographics

This year we treated more Cardiac Arrest Patients than ever before

We attended 6,761 cardiac arrest patients across Victoria - the most cardiac arrest cases ever



33% Female
73 years

67% Male
66 years

76% of cases occured in private residences

9% in a public place

9% in aged care facilities

Bystander Involvement

More of the Community are stepping in to help Cardiac Arrest Emergencies

Patients who received bystander CPR had a higher survival rate (12%) compared with those with no bystander CPR (7%)

80%

of bystander witnessed, EMS treated arrests received bystander CPR, the **highest ever recorded**

Public AED usage has **tripled** in the past decade

92 patients were defibrillated by a public AED

Survival was significantly higher when shocked first by public AED compared to paramedics (56% versus 30%)

Response

More Cardiac Arrest Patients are receiving the care they need, quicker

7.7 min We recorded a **Fast** response time

92% of bystanders correctly directed their call for help to Triple Zero (000) ambulance

87% Cardiac Arrests were correctly identified by ESTA Triple Zero (000) call takers

Most patients were defibrillated within **10 minutes**

Consistent with recent years

Post Cardiac Arrest Outcomes

Cardiac Arrest Patients are returning home to their families

397 Patients were discharged alive from hospital

37% We recorded a **High Utstein Survival Rate**

85% of survivors were able to return home to their families

80% of patients were able to return to work (if working prior)

Survivors were recorded to be **as happy** as the average Australian population (age matched)

34

VACAR data has been used to inform a large research program to improve patient care, including 34 new research papers

When neighbours become lifesavers

Bill Stavretis' life could have ended in 2020 if all the stars hadn't aligned.

The 63-year-old suffered a cardiac arrest while mowing his lawn at his holiday home in Clunes on May 9. Without warning and to the horror of his wife, Faye, Bill's heart suddenly stopped beating.

"I rushed over and found him unconscious," Faye said. She immediately called Triple Zero (000) and was directed to start CPR – something she had never done.

"I wasn't going to let him die, so I had to do something," she said.

Hearing screams, neighbours Ashley Gillespie, Barb Merrifield and Chris Durek raced over to help.

Assisting with compressions and retrieving the nearest Automated External Defibrillator (AED) from the wall of the town's supermarket, the trio kept Bill alive while paramedics travelled to the scene.

"I can't thank those who saved me enough. I wouldn't be here without them," Bill said.

After receiving three shocks from a defibrillator and spending six weeks in hospital, including having quadruple bypass surgery, the Melbourne-based man said it was nothing short of a miracle that he lived to tell the tale.

Attending paramedic Mark Rewi praised the group's efforts and said anyone could make a difference by following the three simple steps – Call, Push, Shock. CALL Triple Zero (000), PUSH hard and fast on the middle of the chest, and SHOCK using an AED (if available).

"Minutes matter and the sooner a person receives CPR and defibrillation, the better their chances of survival," Mark said.

Bill said his story was a great example of the importance of education and knowing what to do in an emergency – how to perform CPR and where to find the nearest AED.

"Doing nothing won't save a life," he said.

Quick thinking saves Corben's life

May 26 2020 started out like any other work day for Mildura man Corben Quick.

The 22-year-old apprentice fitter and turner was using a forklift when he suddenly slumped over unconscious after suffering a cardiac arrest.

Thankfully his manager and workmates called triple zero and quickly commenced CPR.

An ambulance arrived five minutes after the call, with paramedics delivering a shock less than two minutes after arrival.

Corben was stabilised and transported to Mildura Base Hospital, before being flown to Melbourne for further treatment.

He's since made a good recovery and has returned to work.

Mr Quick said he never expected he would suffer a cardiac arrest.

"I'm not going to let it rule my life, it happened and I need to get on with things," he said.

"But I do feel lucky to be here."

The incident prompted Mr Quick's workplace to install an AED, a decision that's been praised by local paramedics.

"With 70% of cardiac arrests occurring at work or home, it's vital that everyone learns CPR and has access to an AED", MICA paramedic Dennis Homfray said.

"The real heroes of this case are Corbin's workmates who called Triple zero (000) and started CPR."


Full-page photo to be supplied
EMERGENCY
AMBULANCE
KEEP

Introduction

Out-of-hospital cardiac arrest (OHCA) is one of the leading causes of death worldwide and a significant public health issue in Australia. Every year, as many as six million OHCAs occur around the globe with 30,000 of these occurring in Australia. Although survival rates from OHCA are reported to be low across developed countries (as low as 5%), many emergency medical services (EMS) have reported a doubling or tripling of survival rates following improvements to systems-of-care for OHCA patients.

Survival from OHCA is determined by the provision of quality and timely pre-hospital interventions, known as the 'Chain of Survival'. Early access and recognition, quality cardiopulmonary resuscitation (CPR), timely defibrillation and early advanced care are the four hallmark components of the Chain of Survival which are being monitored by EMS globally. More recently, a fifth link '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.

The Victorian Ambulance Cardiac Arrest Registry (VACAR) has been monitoring and improving the journey of OHCA patients from the roadside to recovery for more than two decades. In that time we have achieved substantial improvements in the care of OHCA patients, through developments in pre-hospital care, better call-handling and dispatch, telecommunicator CPR, community engagement in CPR programs, the launch of the smartphone CPR crowdsourcing app, GoodSAM®, and an enormous investment in resuscitation research. In 2010, we also become one of the first registries in the world to routinely measure the quality-of-life of adult OHCA survivors, highlighting our vision to improve the outcomes that are most important to our patients.

Every year, we strive to build on these investments. This year, and as a result of improved functionality built into our registry, we saw the launch of our OHCA Team Performance Debriefing Reports – a powerful mechanism to help provide paramedics with objective feedback relating to their resuscitation performance. The reports consist of 19 key metrics which align with international treatment guidelines and include the timeliness of compressions and defibrillation, initial rhythm recognition, quality of external chest compressions, performance of advanced interventions and post resuscitation care. The reports are supported by the collection of real-time monitoring of CPR quality which is now routinely collected and validate following every resuscitation attempt. Over 200 reports every month are now provided to over 700 paramedics and their team mangers, demonstrating the value of VACAR in helping to create a 'measure and improve' culture within Ambulance Victoria.

However, 2019-20 has been a year like no other, and the impact of the COVID-19 pandemic has been felt across a number of urgent health conditions. For OHCA systems-of-care, there have been a number of direct impacts. Paramedic and first-responder donning of personal protective equipment has led to delays in the commencement of resuscitation and key interventions, such as CPR and defibrillation. Critical changes to clinical practice guidelines aiming to minimise the aerosol risk associated with OHCA interventions has also impacted the quality of resuscitation provided. In addition, social restrictions have led to fewer people experiencing an OHCA in public, which significantly reduces the utility of public access defibrillators to improve survival outcomes. Furthermore, due to the potential risk of infection to bystanders, we also made the difficult decision to limit the dispatch of GoodSAM® first responders to only paramedics with an adequate supply of personal protective equipment.

Our national-first investigation into the impact of these changes on OHCA outcomes was published in Resuscitation earlier this year, and shows a considerable decline in the number of OHCA patients surviving to hospital and being discharged alive during the first wave of the pandemic. These findings are also reflected in the 2019-2020 VACAR Annual Report, which shows a small reduction in survival outcomes compared to the results achieved in 2018-19 (our best ever).

Our ongoing commitment is to find new ways to strengthen the Chain of Survival as we approach a 'COVID-19 normal' environment. This includes the safe but reduced use of personal protective equipment to improve the early commencement of resuscitation attempts, and the re-launching of the GoodSAM® app to crowdsource bystanders and public access defibrillators to OHCA events. It also requires us, more than ever, to increase the monitoring activities of the VACAR, to better understand the barriers to providing optimal care and find novel opportunities to increase the provision of early bystander actions which are so critical for survival.

To that end, it is a pleasure to present to you the findings of the 2019-2020 VACAR Annual Report.

Professor Karen Smith
Director, Centre for Research and Evaluation
Ambulance Victoria

List of Tables

List of Figures


AMBULANCE

The Emergency Medical Service

The state of Victoria, Australia has an estimated population of 6.6 million spread over almost 227,500km^2, with over 5.0 million people living in the state's capital city of Melbourne. Almost fifteen per cent of the population are aged 65 years and over. The emergency medical service (EMS) comprises ambulance paramedics who have advanced life support skills (e.g. laryngeal mask airway, intravenous epinephrine) and 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 a 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 (AHPRA) 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 (MPDS). Unless circumstances suggest ventilations first (e.g. drowning), suspected cardiac arrest events identified in-call receive further call-taker instruction (telephone CPR) recommending 600 chest compressions, before two mouth-to-mouth breaths, and a subsequent ratio of 100 compressions to two breaths 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.

The AV cardiac arrest protocols follow the recommendations of the Australian Resuscitation Council (ARC). 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 return of spontaneous circulation (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 (http://registermyaed.ambulance.vic.gov.au). As at October 2020, there were over 6,500 AEDs in the AV AED Registry. During a Triple Zero (000) call, the emergency call taker may identify an AED close to the event which is available for use.

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.

Victorian Ambulance Cardiac Arrest Registry

The Victorian Ambulance Cardiac Arrest Registry (VACAR) was established in 1999 and represents an internationally recognised standard of OHCA monitoring and reporting. The VACAR is managed by AV, the sole EMS provider in Victoria, Australia and is overseen by a multidisciplinary Steering Committee, chaired by Professor Karen Smith (Director, Centre for Research and Evaluation, Ambulance Victoria).

The VACAR is a clinical quality registry (CQR), incorporating both prehospital clinical and operational data and hospital follow-up data from all OHCA events in Victoria where AV are in attendance. The VACAR collects data from Communication Centre dispatch records, EMS patient care records, hospital medical records and from a telephone interview of adult survivors 12 months post-cardiac arrest (commenced January 2010). Hospital outcome data is supplemented by death records from the Victorian Registry of Births, Deaths and Marriages.

Data for all cardiac arrest patients attended by AV since October 1999 has been successfully captured for over 110,000 patients. The data is collated in the registry based on an internationally agreed template. The integrity and reputation of the registry relies on complete and accurate data collection, including hospital discharge data.

The 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.

The 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 Access Defibrillation (for more information, see www.ambulance.vic.gov.au). In addition, the VACAR has successfully established an internationally recognised research program, with the publication of scientific literature in key medical journals (see **2019-2020 Peer-reviewed Publications**, page 65). 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 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 the VACAR provides a robust framework for the measurement of immediate, early and long term quality clinical outcomes following OHCA in Victoria. In 2020, we have further expanded the collection of quality-of-life data in VACAR. We have now included validated questionnaires to assess anxiety and depression (Hospital Anxiety and Depression Scale [HADS]) in addition to the impact of fatigue via the Modified Fatigue Impact Scale (MFIS).

The VACAR contributes to the Australian Resuscitation Outcomes Consortium (Aus-ROC) Epistry, which is an OHCA epidemiologic registry (Beck 2016). 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 VACAR contributes the highest number of cases to the Epistry. 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 A/Prof Andre La Gerche from 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. VACAR provides event and outcome data for all AV attended sudden cardiac arrests in individuals aged 1-50 years. The EndUCD Registry will provide insight into the causes of sudden cardiac arrest in younger individuals based on clinical, demographic, and genetic analyses.


PARAMEDIC

How does VACAR operate?

Eligibility

The 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 (see **Table 1**). The VACAR defines the state of cardiac arrest as the cessation of cardiac mechanical activity as confirmed by 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 the VACAR are described below (see **Tables 2** and **3**).

Data capture

The registry is based on the internationally recognised Utstein template and definitions (Perkins 2015). Ambulance Victoria's in-field recording of patient data is performed electronically using the Victorian Ambulance Clinical Information System (VACIS), an electronic data capture system. All electronic patient care records (PCRs) are synchronised daily with organisational databases, providing an effective medium of clinical and administrative data capture. To ensure the capture of all OHCA events attended by AV, a broad electronic search is conducted of clinical databases utilising specific search criteria. This search strategy is focused at identifying potential cardiac arrest cases, which may be eligible for review. Paper PCRs are used in cases where in-field electronic data capture is not possible. In these instances, paramedic team managers are required to 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 hospital discharge. The interview questionnaires used include: the Extended Glasgow Outcome Scale (GOS-E), 12-item Short Form (SF-12) health survey and EuroQol 5 Dimension (EQ-5D) validated questionnaires, in addition to general questions relating to residential status, work status and level of education.

Table 1: Participating first responders dispatched to cardiac arrest events in Victoria.

1. Metropolitan Fire Brigade
2. Country Fire Authority (selected areas)

Table 2: VACAR 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.

Table 3: VACAR 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 prior to arrival, or no other evidence verifying a cardiac arrest state is present.

Data quality

The 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 the accuracy of data coding by the VACAR data entry team. 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 two independent external audits over the last decade, including an audit by the Victorian Auditor-General's Office. Cardiac arrest cases also undergo clinical auditing by senior paramedics. All cases where a patient requires defibrillation or where a death occurs in AV care undergo audit.

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 the integrity of the data with time. As such, data presented in this report may differ slightly from previously published data. Previous years' data 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) and maintains ethical review as a quality assurance initiative from the Human Research Ethics Committee of the Victorian Department of Health and Human Services. The 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 almost 99% of all out-of-hospital cardiac arrests 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 4). Periodic quality control checks and data verification activities ensure the long-term validity of registry data.

Table 4: Number and proportion of missing data for select registry variables, 2019-2020 (n=6,761).

Patient age	57 (1%)
Patient sex	20 (0%)
Arrest location	0 (0%)
Witnessed status	62 (1%)
Bystander CPR	0 (0%)
Rhythm on arrival	23 (0%)
EMS response time	0 (0%)
Defibrillation time	28 (0%)
Outcome at scene	1 (0%)
Event survival	2 (0%)
Hospital discharge status	36 (1%)
Hospital discharge direction	2 (0%)


M.I.C.A.
PARAMEDIC
AMBULANCE VICTORIA

About this Report

The American Heart Association states that monitoring the treatment of out-of-hospital cardiac arrest by EMS agencies should be the sentinel measure of the quality of EMS care in our communities.

Despite recent advances in resuscitation and post-arrest treatment strategies for OHCA patients, survival to hospital discharge rates remain low (approximately 10%) (Dyson 2019). OHCA is a significant cause of disability and death in Australia, with a reported incidence of an average of 100 events per 100,000 peoples (Beck 2017). Much of the burden associated with OHCA, sometimes referred to as sudden cardiac death, occurs before a patient reaches hospital, therefore EMS has a crucial role in reducing the burden of illness in our communities. The American Heart Association states that monitoring treatment of OHCA by EMS agencies should be a sentinel measure of the quality of EMS care in our communities (Nichol 2008).

This report describes data from the VACAR for all OHCA events attended by AV. The main focus of this report is to summarise data pertaining to adult and paediatric OHCA in Victoria within the most recent fiscal year, 1 July 2019 to 30 June 2020. Final data for this report was extracted on 18 November 2020, with pending hospital follow-up remaining in a small proportion of events.

Analyses in this report are described across two predominant populations. The 'EMS attended' population is used for all cardiac arrest patients where AV is in attendance, regardless of whether emergency treatment is provided. The 'EMS treated' population specifically refers to patients who receive an attempted resuscitation by EMS, including eligible first responders. Our outcomes are defined by two major endpoints 'event survival' and 'survival to discharge'. These endpoints define patients with sustained return of spontaneous circulation on arrival at hospital and those discharged alive from hospital, respectively. All definitions used in this report have been described in detail on page 72.

Descriptive statistics in this report are presented as frequencies and proportions for categorical data and median and interquartile ranges 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 and Human Services regions (according to the following website https://www2.health.vic.gov.au/about/publications/formsandtemplates/Department-of-Health-regional-boundaries-and-local-government-areas-map). 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 and Human Services region.

Regional data for this report was sourced from the Regional Population Growth report (published 25 March 2020, Australian Bureau of Statistics (ABS)). The estimated Victorian population as at 30 June 2019 was 6,596,467 persons. Annual Victorian data by age was sourced from the National, State and Territory Population report (published 24 September 2020, ABS). This report also specifies the 2001 Australian Standard Population for use in age-standardisation.

Patients who suffer a cardiac arrest in the presence of paramedics represent a unique sub-group of patients. These patients differ considerably in survival factors (eg. time to defibrillation, presenting rhythm etc.). This may skew analyses. As such, data relating to paramedic or EMS witnessed OHCA have been analysed and depicted separately to those which are unwitnessed by paramedics in this report. Unless specifically stated, all analyses should be assumed to exclude EMS witnessed events.

Executive Summary

Over the last decade, rates of bystander CPR in the community have steadily risen and the odds of an out-of-hospital cardiac arrest patient surviving to hospital discharge has more than doubled.

1. Ambulance Victoria attended 6,761 OHCA events in the period between 1 July 2019 and 30 June 2020, with 99% involving adults. The proportion of all adult OHCA patients receiving emergency treatment by EMS was 44%; when excluding EMS witnessed arrests, 41% of adult EMS attended arrests received attempted resuscitation by EMS. The crude incidence of OHCA was higher in the rural region than in the metropolitan region: 136 versus 92 events per 100,000 population. The Gippsland region recorded the highest crude incidence rate of OHCA. The age adjusted state-wide incidence of OHCA in 2019-2020 was 91 events per 100,000 population; age-adjusted OHCA incidence in males was 118 events per 100,000 and in females was 69 events per 100,000 (see **Incidence & Demographics**, pages 23-29).

2. The demographic profile of patients in 2019-2020 was similar to those observed over the last decade. OHCA due to a presumed cardiac cause accounted for 72% of adult EMS attended patients. Twenty nine percent of paediatric arrests were due to a presumed cardiac cause. Sudden infant death syndrome (SIDS) remained a leading cause of OHCA in paediatrics (20%). Patients who arrested in a public location had significantly better survival outcomes than those who arrested in the home or in an aged care facility (see **Incidence & Demographics**, pages 23-29).

3. Most bystander calls for help following OHCA were appropriately directed to Triple Zero (000) (92%). Emergency call-takers were effective at identifying cardiac arrest events during the emergency call; 87% of all EMS attended arrests were correctly identified (see **Chain of Survival**, pages 30-41).

4. The median state-wide response time to EMS treated events in 2019-2020 was 7.7 minutes (90th percentile time 15.2 minutes), slightly longer than the previous year. The median EMS response time to EMS treated patients in the metropolitan region (median 7.3 minutes, 90th percentile 11.8 minutes) was slightly longer than the previous year. The median EMS response time to EMS treated patients in the rural regions (median 9.3 minutes; 90th percentile time 23.1 minutes) was the same as the previous year (see **Chain of Survival**, pages 30-42).

5. The rate of bystander CPR for bystander witnessed OHCA events in 2019-2020 remained high (65%), compared to 51% in 2010-2011. Also, the rate of bystander CPR amongst bystander witnessed OHCA patients receiving EMS attempted resuscitation in 2019-2020 was the highest ever recorded (80%). Use of public automated external defibrillators has increased three-fold over the last decade for patients presenting in a shockable rhythm (see **Chain of Survival**, pages 30-42).

6. In 2019-2020, when an arrest was witnessed by a bystander, the proportion of patients who survived the event was higher than that observed for all OHCA events combined (38% vs 27%, respectively) (see **Chain of Survival**, pages 30-42).

7. The state-wide rate of return of spontaneous circulation (ROSC) in adult EMS treated patients during 2019-2020 was 36%. The rate of event survival for all-cause adult OHCA in the EMS treated population during this period was 28%. Meanwhile, the rate of survival to hospital discharge was 10% which was comparable to recent years (see **Survival Outcomes**, pages 46-53).

8. The rate of event survival for adult EMS treated patients presenting in a shockable rhythm was 54%, with 34% surviving to hospital discharge. This is consistent with recent observations. For adult EMS treated patients presenting in a shockable rhythm and witnessed to arrest by EMS, event survival was 80% and survival to hospital discharge was also 80%, the highest ever recorded. Adults presenting in asystole or pulseless electrical activity experienced the poorest survival outcomes, with 0.6% and 9% surviving to hospital discharge, respectively (see **Survival Outcomes**, pages 46-53).

9. Despite the significant impact of the COVID-19 pandemic, survival of 37% was recorded for the Victorian Utstein patient subgroup in 2019-2020. Victorian patients have comparable discharged alive rates to a number of international agencies (see **Survival Outcomes**, pages 44-51). Survival for Inner Melbourne was 55% which equals the survival demonstrated by the world leaders in cardiac arrest survival, King County (USA).

10. The risk-adjusted odds of survival to hospital discharge have improved significantly over time. The odds of survival to hospital discharge for OHCA patients in 2019-2020 was over 2.0 times higher than for OHCA patients in 2004-2005 (adjusted odds ratio 2.1, 95% CI 1.6-2.7, $p<0.001$). A significant improvement was also observed for patients who presented in a shockable rhythm over the same period (adjusted odds ratio 2.4, 95% CI 1.8-3.2, $p<0.001$) (see **Survival Outcomes**, pages 46-53).

11. Most OHCA patients with known survival to hospital discharge were discharged home (85% in 2019-2020). Phone interviews with adult survivors showed that most survivors maintained their independence and had a good quality of life 12 months after their arrest. Of those who had worked before their arrest, 80% had returned to work 12 months after their arrest (see **Long-term Functional Outcomes**, pages 58-62).


PARAMEDIC

Incidence & Demographics

Incidence of all adult & paediatric events†

In 2019-2020, Ambulance Victoria attended 6,761 OHCA events, of which 6,673 (99%) were defined as adults aged greater than 15 years. This number of adult cases represents the highest number of annual events ever recorded in Victoria. The number of paediatric events attended by paramedics was slightly higher than the previous year (88 cases in 2019-2020 vs 86 cases in 2018-2019), and is within normal yearly fluctuations.

Of all adult OHCA events attended in 2019-2020, 44% received an emergency resuscitation attempt by paramedics and/or first-responders (includes EMS witnessed events; in the previous year, this was 46%). The rate of EMS attempted resuscitation for adult attended OHCA has remained steady

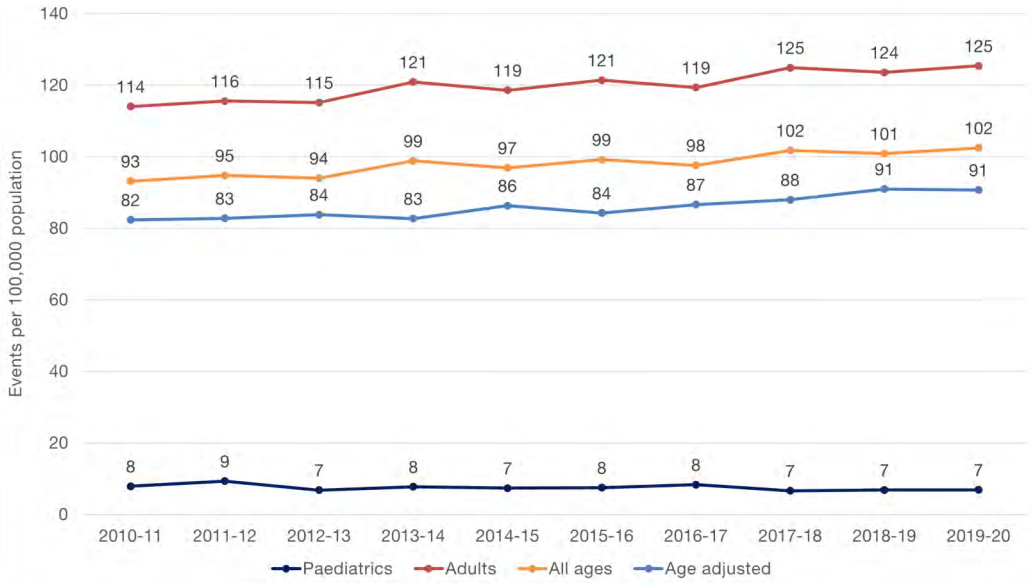


Figure 1: Crude incidence of all ages, adult and paediatric EMS attended OHCA in Victoria and age-adjusted incidence rate of EMS attended events (includes EMS witnessed events).

The crude incidence of OHCA has slowly increased over the last decade. In 2019-2020, the unadjusted incidence of all OHCA in Victoria was 102 events per 100,000 population, higher than the rate of 93 events per 100,000 population observed in 2010-2011 (see **Figure 1**). However, age standardisation gives rise to an adjusted OHCA incidence rate of 91 events per 100,000 population during 2019-2020. Age standardisation is a technique for comparing populations where the age profiles are different. Age-adjusted rates are rates that would exist if the population in a given year had the same age distribution as the standard population. In this case we have used the age profile of the 2001 Australian population as our standard population.

Age-adjusted incidence rates over the last 10 years have also been slowly increasing. The age-adjusted OHCA incidence rates for males and females during 2019-2020 was 118 events and 69 events per 100,000 population, respectively.

The incidence of adult events has slowly been increasing over time and paediatric events remained within recent observations. The numbers for 2019-2020 were 125 and 7 events per 100,000 population for adults and paediatrics, respectively. While variation in OHCA incidence across continents and regions are well established, these figures are within previously reported incidence rates.

over the last 10 year period (46% in 2010-2011; 46% vs 44%, p=0.325).

Lack of bystander witnesses and prolonged downtime are the major reasons for EMS withholding resuscitation efforts in adult patients. The crude incidence of adult EMS treated events was 56 events per 100,000 population.

In paediatric patients, the proportion of EMS treated events is higher than in adults. The majority of paediatric patients (78%) received an attempted resuscitation by EMS during 2019-2020 (includes EMS witnessed events; in the previous year, this was 81%). The rate of EMS attempted resuscitation for paediatric events over the last 10 years has been quite variable; this rate was 56% in 2010-2011. The crude incidence of paediatric EMS treated events was seven events per 100,000 population.

† All results in this section include EMS witnessed events.

In 2019-2020, Ambulance Victoria attended 6,761 OHCA events, the highest number of events ever recorded. The rate of attempted resuscitation by EMS for all arrests was 44%.

Incidence across regions of Victoria†

In 2019-2020, the highest number of OHCA events in the last 10 years was observed for the metropolitan regions of Victoria: Eastern Metropolitan, North and Western Metropolitan and Southern Metropolitan (4,594 cases, representing 68% of the total number of cardiac arrest events attended by AV). The second highest number of events for the last decade were observed in rural Victoria in 2019-2020 (2,167 events, a 37% increase since 2010-2011).

Despite more arrests occurring in the metropolitan region, the crude incidence of OHCA is significantly higher in the rural regions (136 vs. 92 events per 100,000 population, p<0.001) (see Figure 2).

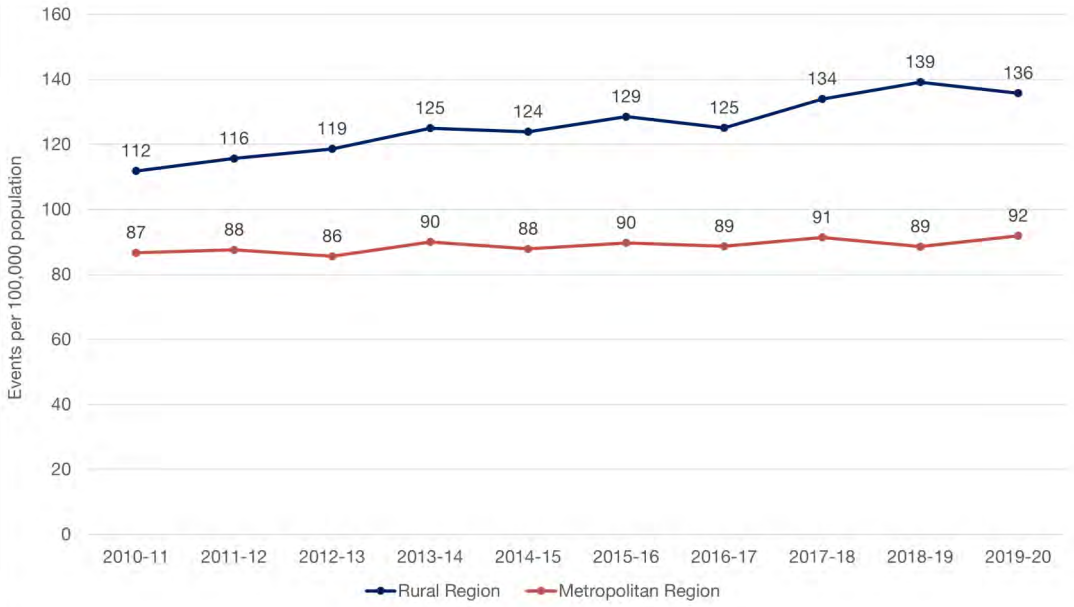


Figure 2: Yearly crude incidence of EMS attended events across metropolitan and rural regions of Victoria (includes EMS witnessed events).

The crude incidence of OHCA has increased over the last 10 years in rural Victoria, rising from 112 events in 2010-2011 to 136 events per 100,000 population in 2019-2020. As noted previously, this observation may reflect better case capture since the 2010-2011 period, which coincided with the completion of the roll-out of VACIS in the rural area. Unadjusted incidence in the metropolitan region has remained relatively unchanged during the same period.

There is regional variability in OHCA incidence across Department of Health and Human Services regions (see Figure 3). The lowest crude incidence during 2019-2020 was observed in the Eastern Metropolitan and North and West Metropolitan regions (both 88 events per 100,000 population) and the highest incidence was in the Gippsland region (159 events per 100,000 population).

The proportion of events receiving an attempted resuscitation by EMS varies considerably across regions. The highest proportion of EMS treated events during 2019-2020 occurred in the North and West Metropolitan region (48%) and the lowest in the Hume region (39%).

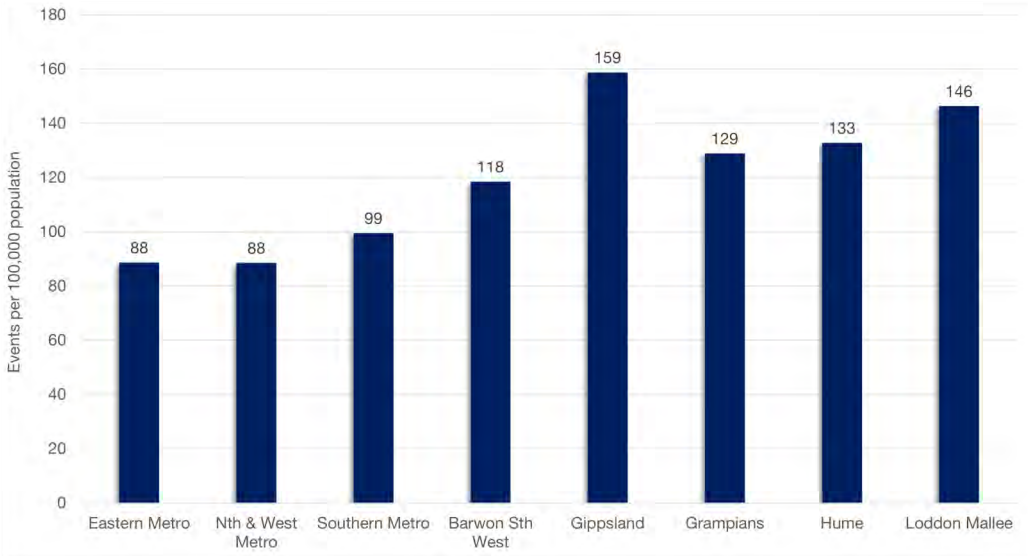


Figure 3: Crude incidence of EMS attended events across Department of Health and Human Services regions, 2019-2020.

† All results in this section include EMS witnessed events.

Demographics of adults

The demographic profile of adult OHCA events (excluding EMS witnessed arrests) has been consistent over the last decade. In 2019-2020, EMS-attended adult events were predominately male patients (67%). The median age of OHCA patients was 69 years. The age distribution varied significantly across the sexes (see **Figure 4**), with females having a higher median age of arrest (73 vs. 66 years, p<0.001). The proportion of cases witnessed to arrest by a bystander was 29% and the proportion occurring in a public location was 9%. Notably in 2019-2020, the proportion of adult patients receiving bystander CPR (40%), was one fifth higher than in 2010-2011 (32%), although this did not reach statistical significance (p=0.17). In 2019-2020, 10% of adult OHCA patients presented in a shockable rhythm (VF or pulseless VT) to either EMS or a bystander who made use of an automated external defibrillator (AED).

Paramedics attempted resuscitation in 41% of all EMS attended adult OHCA events. The demographic profile of patients receiving EMS attempted resuscitation varied significantly from the overall population, with more male patients (68%), a lower median age (66 years), more events occurring in a public location (15%), more events witnessed by a bystander (49%) and a high rate of bystander CPR (74%).

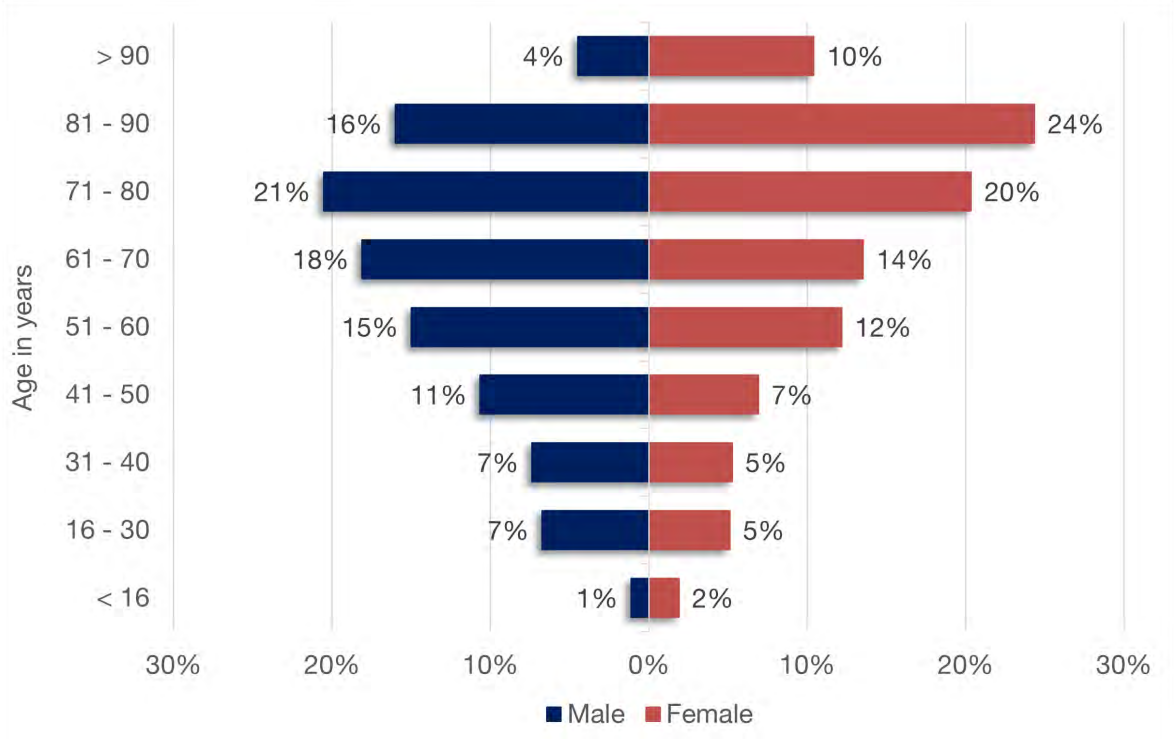


Figure 4: Age distribution of EMS attended OHCA events, 2019-2020.

Demographics of paediatrics

The frequency of EMS attended paediatric events (excluding EMS witnessed arrests) has remained relatively low over the last decade, with fewer than 100 events per year (84 in 2019-2020). The median age of arrest in 2019-2020 was three years, which is consistent with the past decade. The dominant precipitating factors in this population are described in a later section (see **Figure 7**, page 27).

The demographic profile of paediatric OHCA varies significantly across reporting years and is impacted by smaller samples sizes. In 2019-2020, EMS attended paediatric events were predominantly males (54%). Within the paediatric OHCA population, 14% of events during 2019-2020 occurred in a public location. Significantly more paediatric patients received bystander CPR than adult patients during 2019-2020 (74% vs. 40%, respectively; p<0.001).

The majority of paediatric patients during 2019-2020 presented to EMS in an asystolic rhythm (77%). In 2019-2020, one paediatric patient was defibrillated prior to the arrival of EMS with a public automated external defibrillator, compared to three patients in 2018-2019. This patient survived their arrest and was discharged home.

The rate of EMS attempted resuscitation amongst paediatric patients during 2019-2020 remained high (80%). Significantly more paediatric cases received an attempted resuscitation by paramedics than adults during 2019-2020 (80% vs. 41%, respectively; p<0.001).

In 2019-2020, Ambulance Victoria attended 84 paediatric events. The median age was three years.

Precipitating events for adults

The precipitating causes of OHCA events are defined by paramedics and recorded directly from the patient care record. Unless the cause of arrest is clearly described (e.g. trauma, submersion, overdose/poisoning, hanging etc.), the aetiology of arrest is presumed to be of cardiac origin, as per Utstein definitions (Perkins 2015). In total, VACAR records 13 precipitating events for adults.

In 2019-2020, 72% of EMS attended adult OHCA were presumed to be of a cardiac cause. Other frequent causes of OHCA during 2019-2020 were: terminal illness (7%), trauma (6%), hanging (6%), overdose/poisoning (5%), and respiratory causes (3%), (see **Figure 5**).

For adult patients receiving an attempted resuscitation by EMS during 2019-2020, most cases were due to a presumed cardiac cause (75%).

The rate of EMS attempted resuscitation differed amongst patients according to the precipitating cause of the event. During 2019-2020, the rate of EMS attempted resuscitation for arrests due to overdose/poisoning was 45%. Rates of EMS attempted resuscitation during 2019-2020 were lower for arrests due to presumed cardiac causes (44%), trauma (38%), hanging (31%) and terminal illness (17%). In contrast, most OHCA events due to a respiratory cause received EMS attempted resuscitation (65%).

The precipitating event for arrests across age groups in the EMS attended adult population is presented in **Figure 6**. This graph highlights the relationship between arrest aetiology and patient age. A presumed cardiac cause was the predominant precipitating factor for most age groups: 36-50 years (53%), 51-75 years (78%) and >75 years of age (85%).

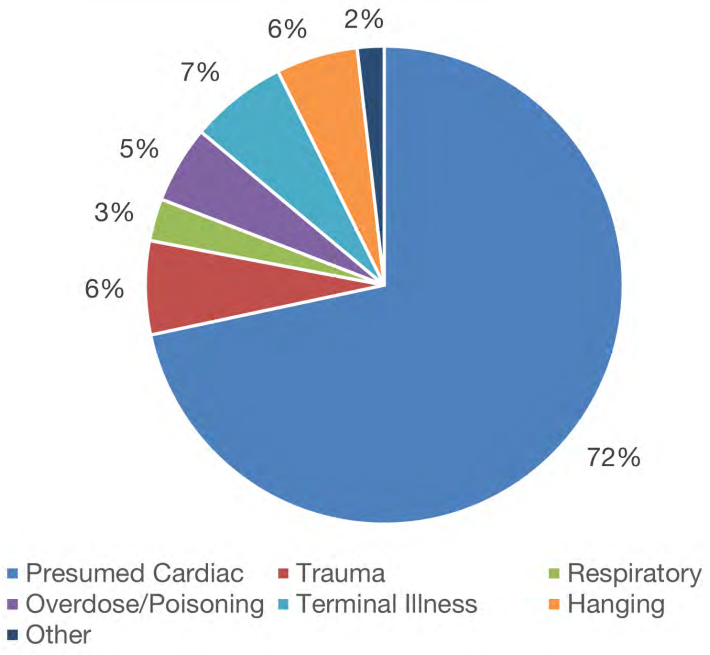


Figure 5: Adult precipitating events for EMS attended events, 2019-2020.

Meanwhile, in the 16-35 years age group during 2019-2020, the predominant precipitating factor was the combined causes of trauma and hanging (44%). In this young adult age group in 2019-2020, a presumed cardiac cause was the precipitating factor for 32% of OHCA events. There were few OHCA events due to trauma and hanging in the oldest age group of >75 years (2%) and also few cases of overdose/poisoning in 2019-2020 (1%).

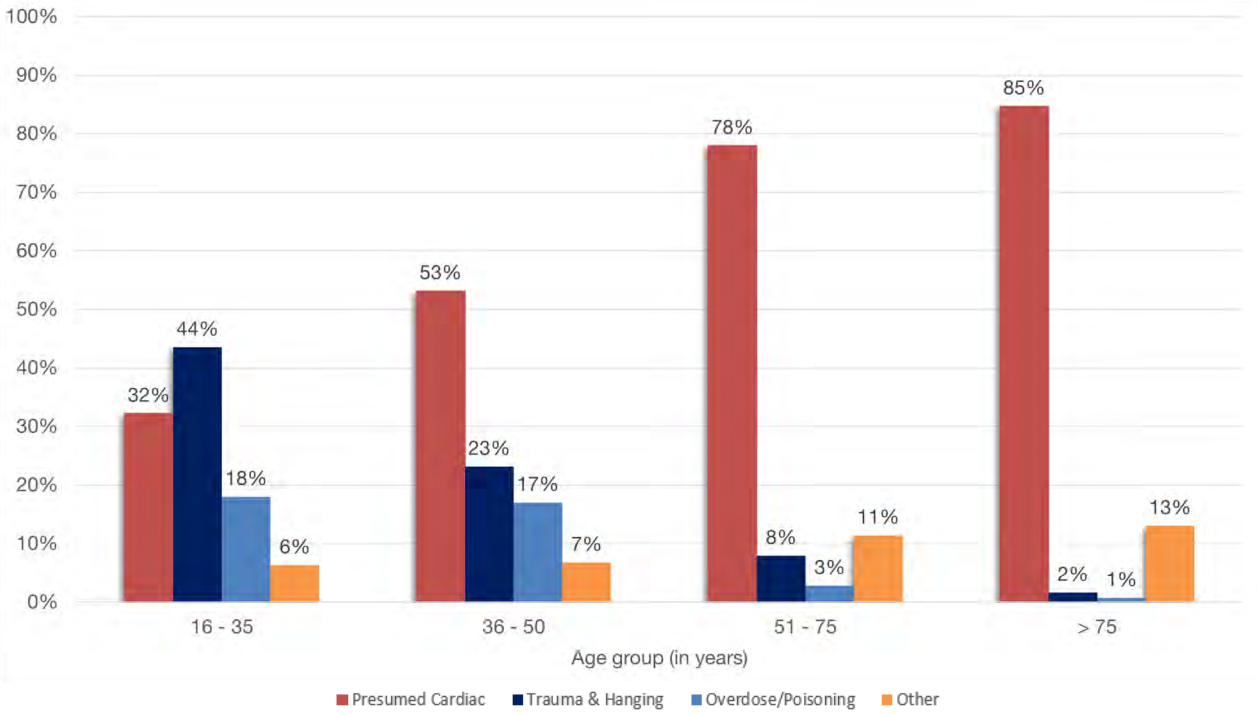


Figure 6: Adult precipitating events across age groups for EMS attended events, 2019-2020.

Presumed cardiac causes were the most common precipitating event for both adult and paediatric OHCA cases in 2019-2020.

Precipitating events for paediatrics

Precipitating events for paediatrics who suffer OHCA vary considerably in comparison to adults. In 2019-2020, 29% of EMS attended paediatric events were due to a presumed cardiac cause (see **Figure 7**). Sudden infant death syndrome (SIDS) is still a dominant cause of paediatric OHCA (20% in 2019-2020). During 2019-2020, less common causes of paediatric OHCA included trauma (14%), respiratory causes (11%), terminal illness (7%) and drowning (1%). Previous research conducted using VACAR data from paediatric OHCA events where trauma was the precipitating factor showed that resuscitation efforts were rarely effective and were associated with poor neurological outcome for the patient (Nehme 2018). The distribution of precipitating events in the EMS treated paediatric OHCA population mirrors the overall paediatric OHCA population data presented in **Figure 7**.

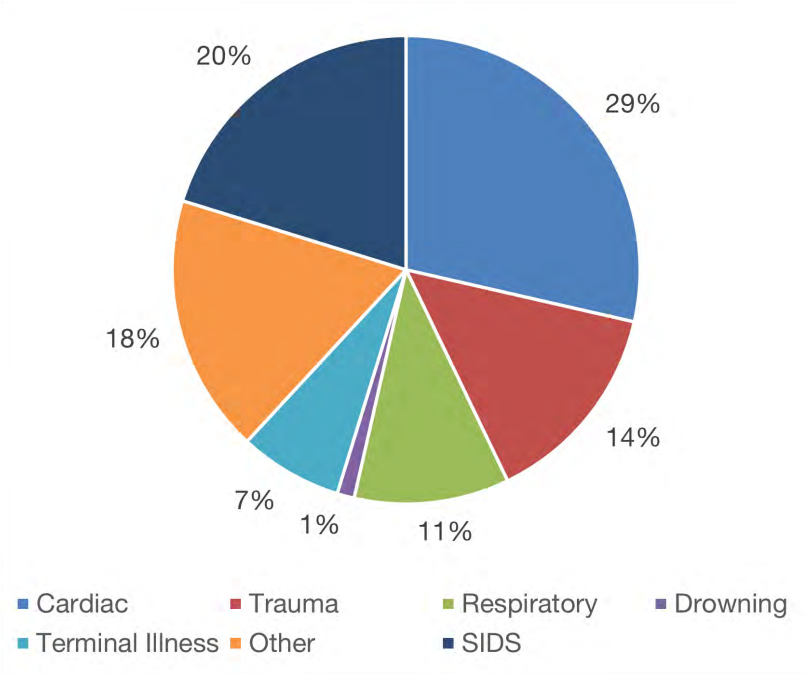


Figure 7: Paediatric precipitating events for EMS attended events, 2019-2020.

Mechanism of arrest in the traumatic sub-group*

Cardiac arrests secondary to major trauma are an important, potentially-preventable patient subgroup. During 2019-2020, arrests secondary to road trauma were responsible for 56% of events, while arrests following falls accounted for 12%, and ballistic trauma and stabbings accounted for 8%, see **Figure 8**.

The following vehicles were the mode of transport associated with road trauma incidents during 2019-2020: a car or light vehicle (58%), train (15%), motorcycle (15%), truck (8%) and bicycle (3%). During 2019-2020, the role of the OHCA patient in these vehicles was as the vehicle driver (55%), pedestrian (30%) and passenger (11%).

* 'Other trauma' refers to any of the following: chemical exposure, environmental exposure, fire/smoke exposure, sting/bite/envenomation, animal related injury, electrical contact, sporting injury, assaults (excluding shooting/stabbing), crush injury or trauma due to an unknown reason. 'Other trauma' causes were responsible for 24% of trauma-related OHCA in 2019-2020.

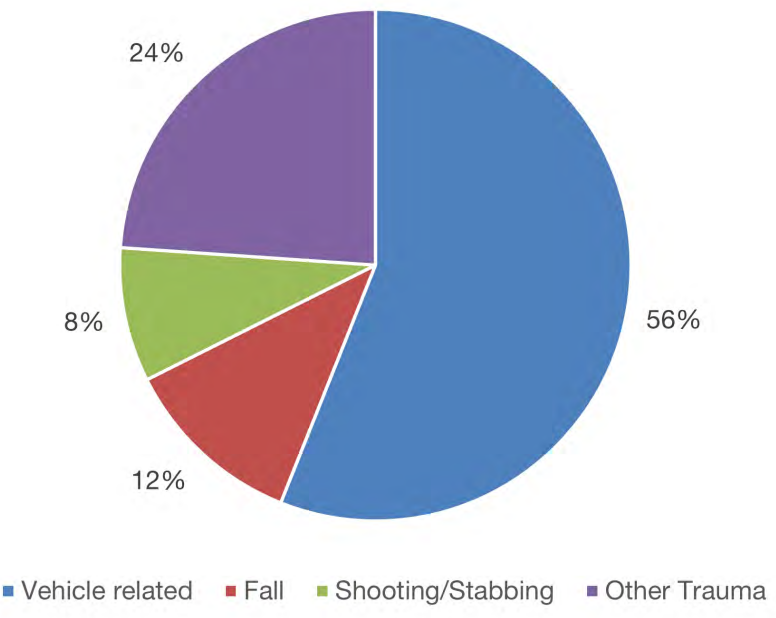


Figure 8: Sources of trauma in EMS attended traumatic OHCA sub-group, 2019-2020.


DUTY TEAM MANAGER
PARAMEDIC
PARAMEDIC

Arrest location for adults and paediatrics

The location of the OHCA has important implications on OHCA outcome. The VACAR records over 20 cardiac arrest locations, the most common of which are presented in **Figures 9 and 10**. Public places include places of work, streets or roads, shops, vehicles and sporting/recreational facilities. In 2019-2020, most (76%) of EMS attended adult OHCA events occurred within a private residence. Other common arrest locations were a public place (9%) and aged care facility (9%) (see **Figure 9**).

Similar to EMS attended adult OHCA events, amongst adult patients who received an attempted resuscitation by EMS during 2019-2020, the most common site of an arrest was a private residence (70%), followed by arrests in a public place (15%) and aged care facility (8%). 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 10**).

The presence of bystanders witnessing the arrest and/or providing CPR in public places has an important contribution to survival for adult events occurring in these locations (see **Figure 10**). In 2019-2020, the unadjusted rates of adult survival to hospital discharge were highest in public places (29%) and medical facilities (29%). Unadjusted adult survival to hospital discharge in a private residence (7%) and aged care facilities (1%) remained relatively low. Unadjusted adult survival to hospital discharge varied significantly between private residences and public places (7% vs. 29%, respectively; p<0.001).

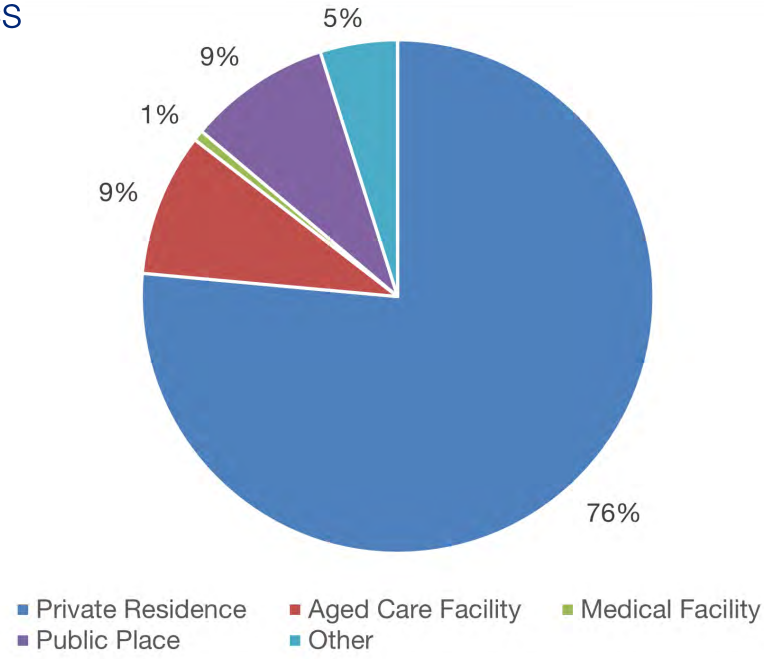


Figure 9: Location of arrest for EMS attended adult events, 2019-2020.

The locations of arrest for paediatric events were similar to those in adults. In 2019-2020, 77% of EMS attended paediatric events occurred in a private residence and 16% occurred in a public place.

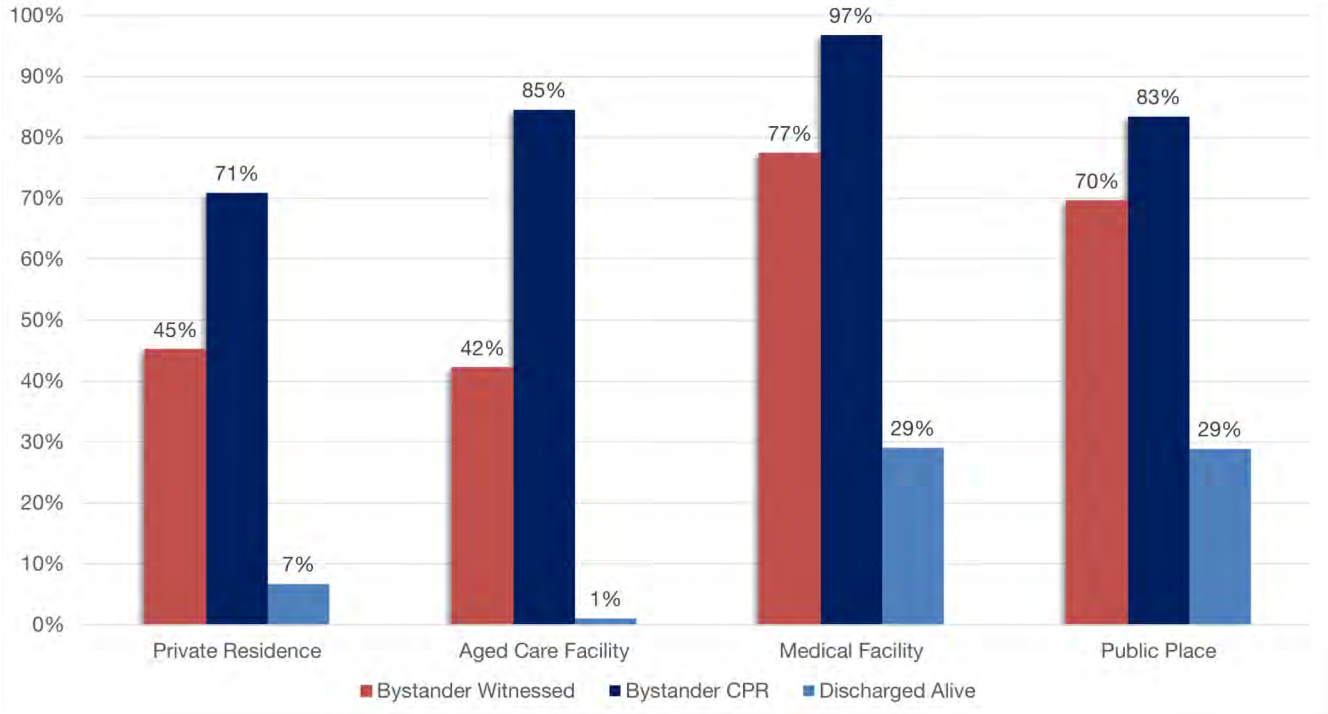


Figure 10: Proportion of EMS treated adult events that are bystander witnessed, receive bystander CPR and are discharged alive across arrest locations, 2019-2020.

Bystander action in public places, including performing cardiopulmonary resuscitation, has a significant influence on overall survival following OHCA.

Chain of Survival

The chain of survival is an internationally recognised initiative aimed at maximising survival following out-of-hospital cardiac arrest. The four key links in the chain involve correct identification and early access to help, early CPR, early defibrillation and early access to advanced cardiac life support.

Bystander call for help

In 2019-2020, the first bystander call for help was correctly directed to ambulance in the majority of cases (92%). However, emergency call delays continue to exist for a small subset of attended OHCA events, where the first call for help is directed to a relative/friend (2%), neighbour (2%), police (3%) or another person (1%) rather than to emergency medical services. Previously published work by VACAR researchers has shown that bystanders inappropriately directing their first phone call to neighbours, relatives or others is associated with significantly poorer survival outcomes following OHCA (Nehme 2014). This is because misdirection of the call for help can significantly impact the timely delivery of CPR and defibrillation to the patient.

Emergency response to the incident

The distribution of response times for the EMS treated population across regions in 2019-2020 is presented in **Figure 11**. EMS response time, or the time from the beginning of the emergency call to the arrival of EMS at the scene, is an important measure of time to definitive resuscitation treatment by EMS. Some OHCA events may occur after the Triple Zero (000) call is made, such as those arrests which are witnessed by a paramedic. These cases may not be dispatched as a high priority as the initial event was not a cardiac arrest; including these cases in OHCA response time analyses can give rise to misleading results. As such, EMS witnessed arrests are excluded from the following response time analyses.

In 2019-2020, state-wide, median response time to EMS treated events was 7.7 minutes (90th percentile time 15.2 minutes). This was slightly longer than the response time noted in the previous year (median time 7.5 minutes; 90th percentile time 16.4 minutes). In 2019-2020, median response time to EMS treated events in metropolitan regions was 7.3 minutes (90th percentile time 11.8 minutes) compared to 7.1 minutes (90th percentile time 12.0 minutes) in the previous year. Median response time in rural areas in 2019-2020 was 9.3 minutes (90th percentile time 23.1 minutes), the same as in the previous year (median time 9.3 minutes; 90th percentile time 24.6 minutes).

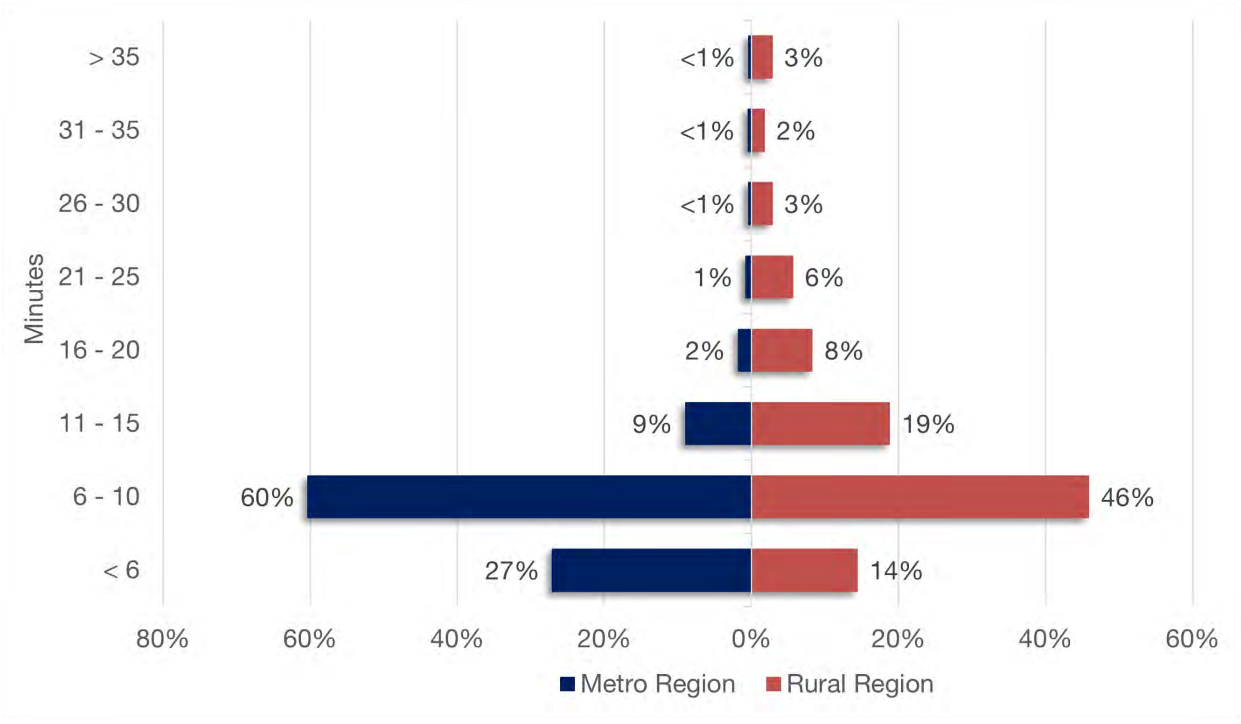


Figure 11: Distribution of time from call to arrival of EMS on scene in the EMS treated population, 2019-2020.

Bystander cardiopulmonary resuscitation

Over the last decade in Victoria, there have been substantial increases in rates of bystander CPR (see **Figure 12**). Of all OHCA events in 2019-2020, 41% of patients received CPR performed by bystanders, compared to 33% of patients receiving bystander CPR 10 years ago (p=0.173). Of OHCA events witnessed to collapse by bystanders in 2019-2020, 65% of patients received bystander CPR, in comparison to 51% of patients in 2010-2011 (p=0.003). Of bystander witnessed OHCA events receiving an attempted resuscitation by EMS, 80% received bystander CPR in 2019-2020, compared to 64% in 2010-2011 (p=0.004). The rate of bystander CPR amongst bystander witnessed OHCA cases which received EMS attempted resuscitation has been over 70% for the past eight years.

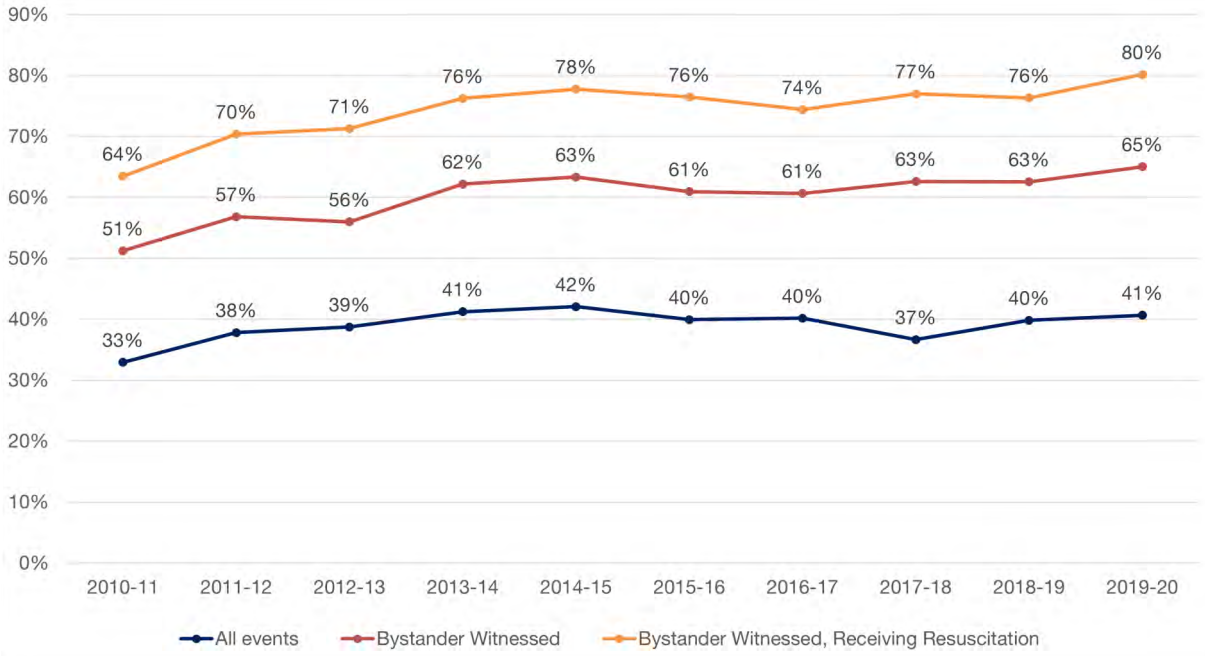


Figure 12: Bystander CPR rates.

These improvements 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 shows early, effective bystander CPR increases the likelihood of an initial shockable rhythm and improves the chances of survival following OHCA (Fridman 2007).

Unadjusted survival was strongly associated with the presence of bystander CPR (see **Figure 13**). In 2019-2020, for EMS treated OHCA events, the rate of event survival for patients receiving bystander CPR (29%) was significantly higher than for patients not receiving bystander CPR (24%), p=0.019.

In 2019-2020, survival to hospital discharge was significantly higher for patients receiving bystander CPR (12%) versus no bystander CPR (7%), p<0.001.

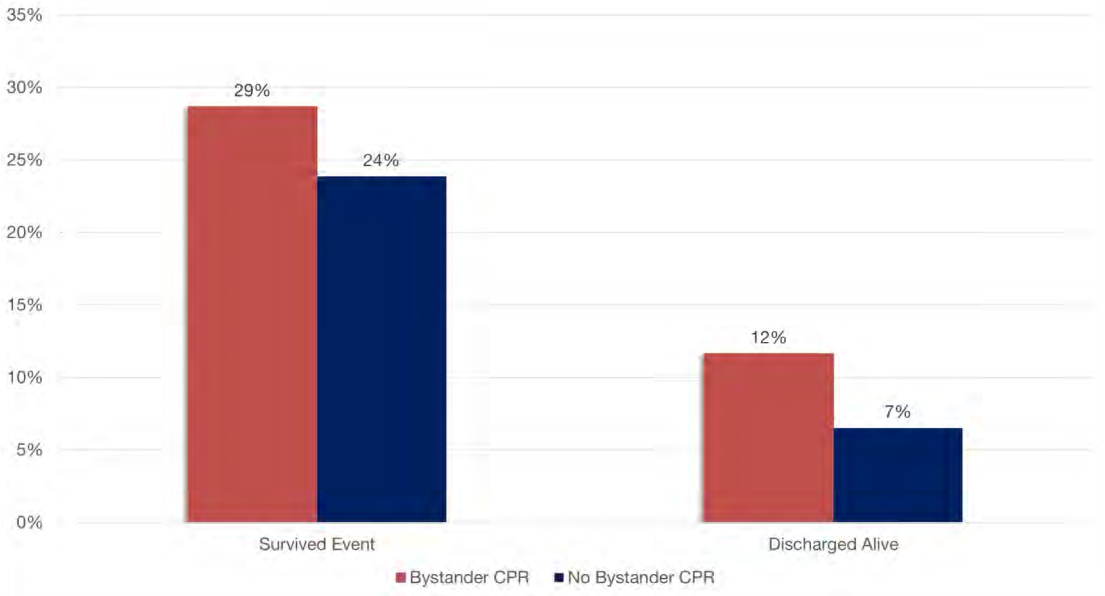


Figure 13: Unadjusted survival outcomes after bystander CPR in the EMS treated population, 2019-2020.

When you call Triple Zero (000), the call-taker can help you do CPR even if you have never done it before. Any CPR is better than no CPR.

Alert and dispatch of community responders via the GoodSAM app

Cardiac arrest is often unexpected and for every minute a patient doesn't get CPR/defibrillation, their chance of survival falls by 10%. This highlights the importance of early bystander intervention and the significant role that crowdsourcing mobile device applications have to facilitate bystander involvement in resuscitation efforts. The benefits of using crowdsourcing technologies in the emergency response to OHCA are becoming clearer and may soon demonstrate significant impact on patient outcomes (Valeriano A et al, 2021; Blewer et al, 2020). The use of crowdsourcing apps is recommended in treatment guidelines for OHCA (Semeraro et al, 2020; Rumsfeld et al, 2016).

This is why AV introduced the GoodSAM (Smartphone Activated Medic) app on 28th January 2018. GoodSAM is a free global smartphone app that connects responders to patient in those first critical minutes of cardiac arrest while paramedics are on the way. GoodSAM is linked to the Triple Zero (000) communications centre, so as soon as an ambulance is dispatched, a GoodSAM alert will be sent in parallel.

Key media coverage saw an increase in the number of individuals and businesses that registered their AED via the GoodSAM app, meaning more community members have access to an AED when needed. Through the implementation of GoodSAM, the AED registry grew and there are now over 4,200 Victorian AED's registered with GoodSAM.

GoodSAM eligible cases are based on dispatch events identified as the most commonly occurring OHCA events that include suspected OHCAs, apnoeic seizures and drownings. GoodSAM notifications, sent via an alert message to a person's smartphone, highlight the sophistication of this advanced emergency alerting technology. VACAR is pivotal in monitoring the impact of GoodSAM in Victoria on OHCA patient survival.

Establishing successful partnerships with five key community responder agencies led to an initial pool of trained responders in the Victorian community. Partner organisations include: St John Ambulance, Surf Life Saving Victoria, Country Fire Authority, Chevrah Hatzolah, Australian Volunteer Coast Guard and the Australian Health Practitioner Regulation Agency (AHPRA). The program was expanded to the general public on 4th July 2019 to include those holding first aid/CPR certification.

We are calling on all members of the Victorian community to join up to GoodSAM and save lives. As of 30th November 2020, there were over 12,200 registered GoodSAM responders.

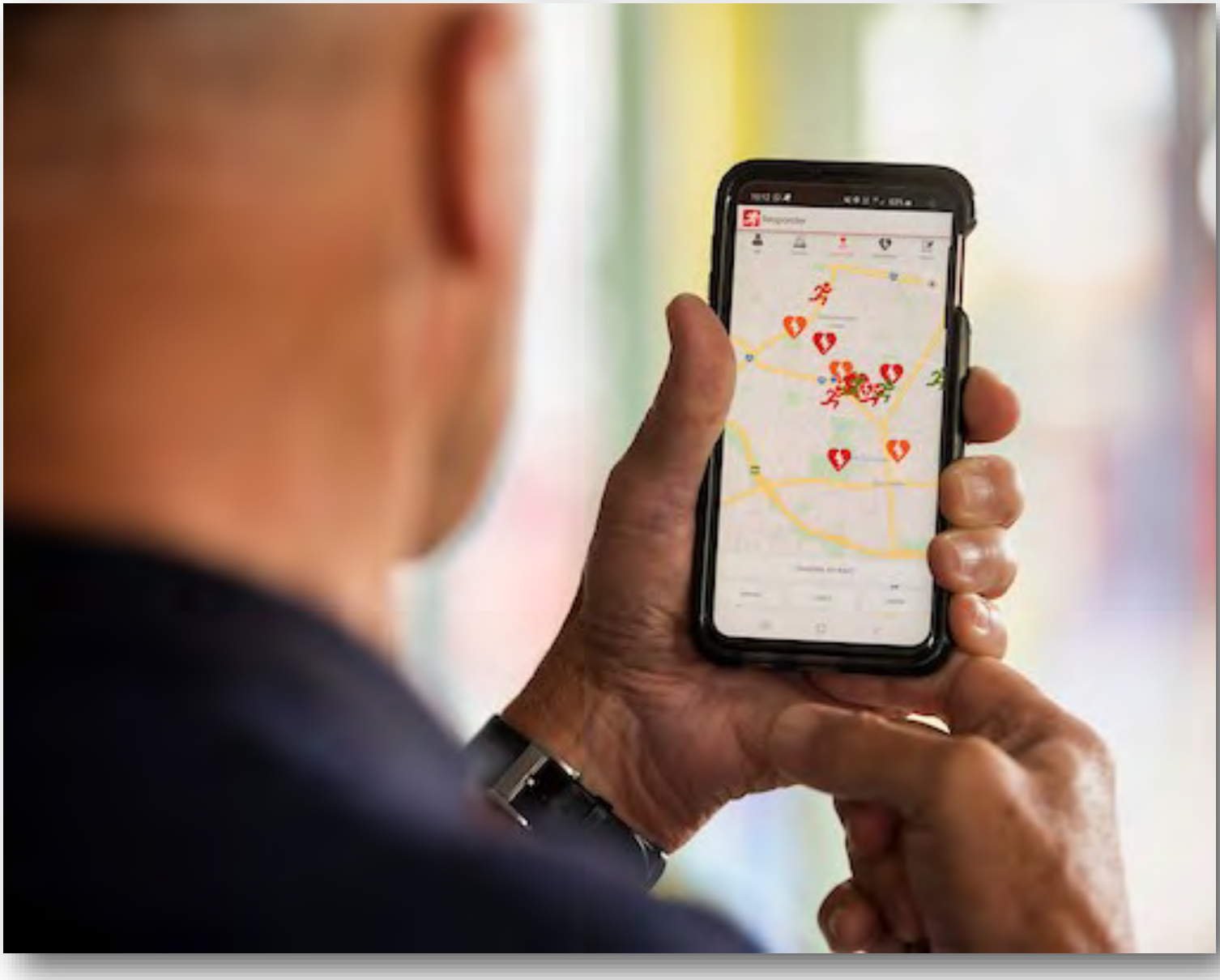
GoodSAM was suspended during the peak of the COVID-19 pandemic in Victoria for the safety of responders. The program was re-instated in October 2020 for those living in Rural Victoria, and in November 2020 for responders residing in Metropolitan Melbourne.

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 simultaneously 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.

Anyone who wants to save lives can now register with GoodSAM

Become a GoodSAM Responder by registering at ambulance.vic.gov.au/goodsam/ today.



High-performance cardiopulmonary resuscitation (HP CPR)

The quality of CPR is significantly associated with OHCA survival (Soreide et al, 2013; Hopkins et al, 2016; Pearson et al, 2016; Bobrow et al, 2013). High-performance CPR (HP CPR) uses targeted metrics that are known to increase survival (Eisenberg et al, 2018). The main components of high -performance CPR are high chest compression fraction, targeted chest compression rate and depth, allowing full chest recoil, and avoidance of over-ventilation. HP CPR involves the delivery of high-quality CPR which meets international standards and a well-practised choreography (the "pit-crew" approach) aimed to minimise interruptions to resuscitation. In February 2019, AV transitioned to a HP CPR model with training provided to all First Responders, ALS and MICA paramedics. State-wide, EMR partners were also trained in an integration model of HP CPR.

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 ECC recommend minimising pauses in chest compressions. Lower chest compression fraction (CCF; i.e. longer pauses and lower proportion of time with CPR being performed) during resuscitation is associated with decreased likelihood of ROSC and survival. Interruptions in ECC 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.

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 CCF, has been demonstrated in Victoria. In addition, significant changes in pre and post-shock pauses have been demonstrated.

Dr Ziad Nehme (Senior Research Fellow, Centre for Research and Evaluation) is currently leading research to examine the impact of introducing HP CPR. Preliminary results indicate that implementing the resuscitation quality improvement programme targeting CPR performance was associated with a 29% improvement in the odds of survival to hospital discharge during the first 12 months of the programme.

Team performance report (TPR)

One of our ongoing quality improvement initiatives this year was the introduction of the Team Performance Report (TPR) in August 2020. The TPR contains timely, objective clinical feedback on paramedic performance for every adult medical cardiac arrest attended. A TPR is sent to all paramedics present at a cardiac arrest case and their associated Team Managers. The TPRs provide an opportunity to recognise and celebrate good performance, identify areas for improvement and facilitate discussion between paramedics, their manager, and clinical leaders.

The TPRs use the technology of the chest compression sensor and collate it with other routinely collected data into a standardised report. The TPR includes 19 key performance metrics which are both measurable and evidence based. The 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. The metrics are summarised by five key components; 1) early recognition (including the timing and placement of defibrillation pads and commencement of CPR); 2) quality CPR (including compression depth, rate, recoil and chest compression fraction); 3) timely defibrillation (including 'pre-shock' and 'post-shock' pauses); 4) advance interventions (including early placement of a laryngeal mask airway, administration of adrenaline and amiodarone) and 5) post resuscitation care (including 12 lead ECG acquisition, blood pressure targets and transport to an appropriate hospital for definitive care).

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. To date, there is very little literature regarding feedback to paramedics and the CRE plans to publish this methodology to allow other services access to the approach.

Following on from establishing the TPR, the Centre for Research and Evaluation aims to develop a Cardiac Arrest Improvement Plan to commence in 2021.


ZOLL
62
111
70
98
SHOCK
PACER
ENERGY SELECT
CHARGE

Time to first defibrillation

The time from emergency call to first defibrillation for patients presenting in a shockable rhythm is a key measure for EMS. Timely response by first responder teams and early intervention by bystanders remains a key factor driving favourable outcomes for patients with a shockable rhythm in Victoria (Lijovic 2014).

The proportion of cases where AV performed the first defibrillation has reduced significantly between 2010-2011 and 2019-2020, from 87% to 75% ($p<0.001$). This decline has been driven by an over three-fold increase in the use of public automated external defibrillators (AED) by bystanders over the same period (5% to 15%, $p<0.001$) and the expansion of EMR over the decade. This year, we have seen the second highest ever proportion of arrests defibrillated by public AEDs (15%) prior to EMS arrival. The proportion of cases first defibrillated by first responders during 2019-2020 was 10% (the same as in 2018-2019).

The time to first defibrillation by EMS is recorded for EMS treated patients whose rhythm is shockable on EMS arrival. In 2019-2020, the state-wide time to defibrillation of 10.0 minutes (90^{th} percentile time 16.3 minutes) was slightly longer that for the previous year (median time 9.6 minutes; 90^{th} percentile time 16.3 minutes; $p=0.15$). The median time to defibrillation in the metropolitan region in 2019-2020 was 9.7 minutes (90^{th} percentile time 15.3 minutes), slightly slower than for the previous year (median time 9.2 minutes; 90^{th} percentile time 14.0 minutes; $p=0.12$). In the rural region in 2019-2020, median time to defibrillation was 11.1 minutes (90^{th} percentile time 17.8 minutes), again slightly longer than for the previous year (median time 10.4 minutes; 90^{th} percentile time 19.4 minutes; $p=0.65$). The COVID-19 pandemic period has significantly impacted the time to first defibrillation due to the requirement of putting on PPE prior to arriving at the patient (Ball et al, 2020).

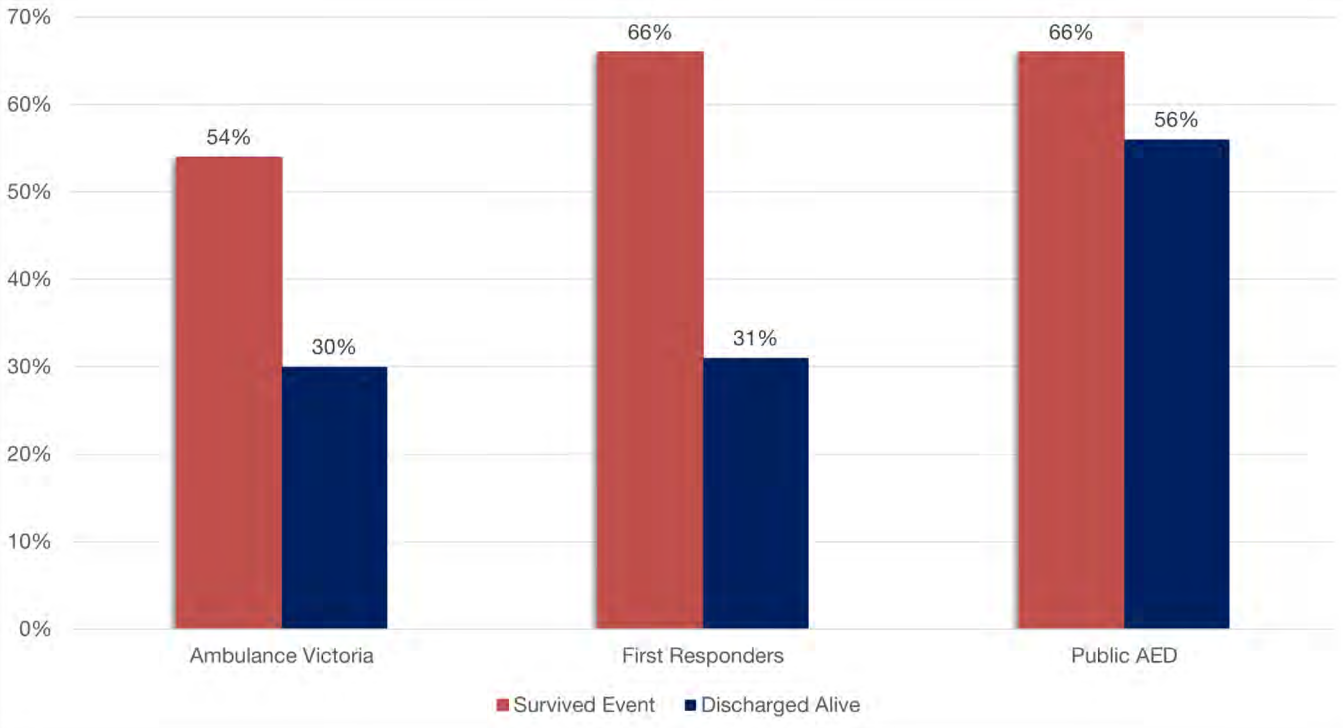


Figure 14: Unadjusted survival outcome according to who shocked first in the EMS treated population with a shockable rhythm on or before EMS arrival, 2019-2020.

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 14). It should be noted that some fluctuations in survival proportions may be observed over time due to small samples sizes.

The proportion of OHCA patients surviving the event when first defibrillated with a public AED was 66%, compared with 66% of patients first shocked by first responders and 54% of patients first shocked by paramedics. The 2019-2020 event survival rates were significantly higher if a public AED was used compared to when patients were shocked first by paramedics ($p<0.001$).

Survival to hospital discharge in 2019-2020 was significantly different according to who provided the first defibrillation. The proportion of patients surviving to hospital discharge when first defibrillated with a public AED was 56%, compared with 31% of patients first shocked by first responders and 30% of patients first shocked by paramedics. The 2019-2020 survival to hospital discharge rates were significantly higher if a public AED was used compared with patients shocked by paramedics ($p<0.001$). The small sample size of these groups should be taken into consideration as this can result in yearly fluctuations in the survival rate.

A discharged alive rate of 56% for patients defibrillated with a public AED during 2019-2020 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.


EMERGENCY
AMBULANCE

The Chain of Survival

Impact of bystanders on OHCA

Bystanders play an important role in improving OHCA survival. Three of the four steps of the OHCA chain of survival can be carried out by bystanders. Typically, bystanders are the first on scene and make the emergency call (early access). With the help of the call-taker, or if skilled through prior CPR training, bystanders can start CPR prior to the arrival of EMS. If an AED is located near the location of the arrest, bystanders have the opportunity to provide vital defibrillation prior to the arrival of EMS. OHCA events witnessed to occur by a bystander have more positive survival outcomes.

Table 5 provides an overview of the impact of bystanders during 2019-2020. Bystander CPR rates were higher amongst OHCA patients witnessed to arrest by a bystander, compared with all OHCA patients (65% vs. 37%, respectively).

In addition, unadjusted likelihood of an OHCA patient presenting in a shockable rhythm in 2019-2020 was eight times higher for patients receiving bystander CPR than those not receiving bystander CPR (excluding EMS witnessed events).

The proportion of patients presenting in a shockable rhythm was higher amongst those who were witnessed to arrest by a bystander as compared to all OHCA patients combined (28% vs 9%, respectively). When an arrest was witnessed by a bystander, the proportion of patients who survived the event was higher than for all OHCA patients combined (38% vs. 27%, respectively). Similarly, when an arrest was witnessed by a bystander, the proportion of patients who were discharged alive was higher than for all OHCA events combined (16% vs. 10%, respectively).

Table 5: Number and proportion of patients receiving bystander CPR or defibrillation and unadjusted survival, for all and bystander witnessed events, 2019-2020.

	All OHCA	Bystander witnessed
Total events	6,761^	1,765
- Bystander CPR	2,503 (37%)	1,148 (65%)
- Bystander AED use	92 (1%)	77 (4%)
- Shockable rhythm	629 (9%)	486 (28%)
EMS treated events	2,564	1,251
- Survived event	689 (27%)	476 (38%)
- Discharged alive	255 (10%)	204 (16%)

^Total OHCA events includes EMS witnessed events; all other data in the table exclude EMS witnessed events.

Bystander CPR improves survival and maintains shockable rhythms for longer

When bystanders perform CPR, the likelihood of survival is significantly increased. Figure 15 shows that, this year, when OHCA patients received bystander CPR prior to EMS arrival, survival to hospital discharge was more than doubled when the EMS response time was <6 minutes and was more than tripled when response time was between 6 and 10 minutes. When it took between 11 and 15 minutes for EMS to arrive, bystander CPR still contributed to a more than doubling of survival. With no bystander CPR, patient survival significantly decreases as response time increases.

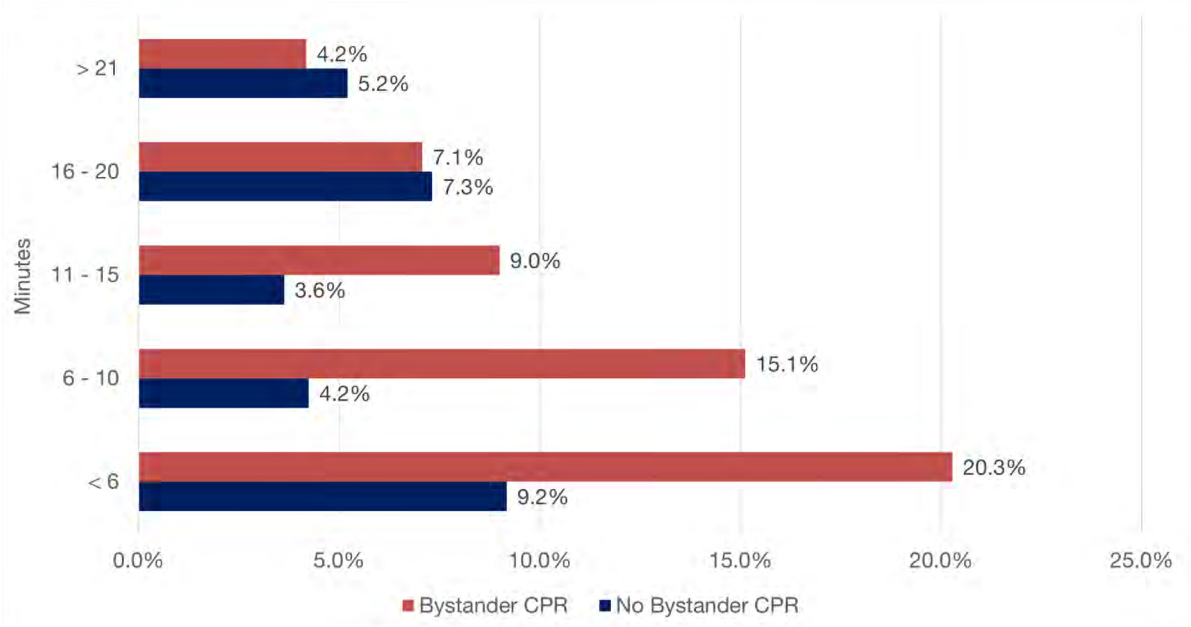


Figure 15: Survival to hospital discharge by EMS response time for adult patients with cardiac arrest due to a presumed cardiac cause where EMS attempted resuscitation (excludes EMS-witnessed events) with and without bystander CPR

Not only does bystander CPR improve survival to hospital discharge but OHCA patients remain in shockable rhythms for longer when bystander CPR is provided. Therefore, upon their arrival, EMS intervention and treatment is more likely to be effective. Figure 16 shows that, this year, for EMS response times between <6 minutes and 20 minutes, consistently almost 40% of patients remained in a shockable rhythm. With no bystander CPR, patients deteriorated into a non-shockable rhythm significantly faster. The proportion of patients in a shockable rhythm decreased by almost 6.0% for every 5 minute increase in response time up to 20 minutes. Figures 15 and 16 demonstrate the significant impact that bystander CPR has on survival from OHCA and the importance of this link in the Chain of Survival.

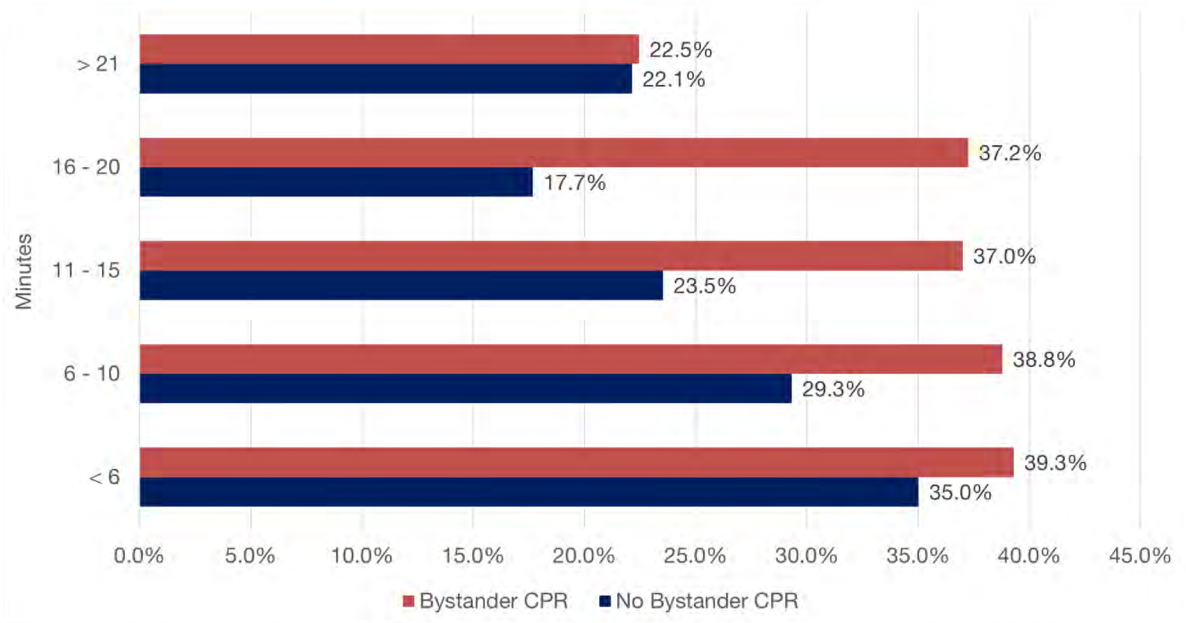


Figure 16: Proportion of adult patients with cardiac arrest due to a presumed cardiac cause presenting in a shockable rhythm by EMS response time where EMS attempted resuscitation (excluding EMS-witnessed events) with and without bystander CPR

Donating AEDs to communities in need, increasing capacity to respond to OHCA

This year, we undertook a novel analysis of Victorian Local Government Areas (LGAs) to understand which communities (including specific towns and suburbs) were in need of increased bystander capacity to allow residents to respond effectively in the event of a cardiac arrest. AV had almost 100 AEDs to donate to communities most in need. Therefore, we developed a score to categorise community need based on OHCA incidence per 1,000 population, median response time to OHCA events, current AED density per 1,000 population and survival to hospital discharge seen in each LGA over the last 5 years combined. The Index of Relative Socio-Economic Disadvantage (IRSD) was also considered following initial scoring. LGA population data was obtained from the Australian Bureau of Statistics as was the IRSD. We used VACAR for the OHCA statistics and AV's AED Register for data on AED density. Areas with the highest need (and, therefore, those to whom AEDs were donated) were those with higher OHCA incidence, slower response times, lower AED density and poorer survival. All donated AEDs are linked to the Victorian cardiac arrest system of care via registration on GoodSAM and the AV AED Registry.

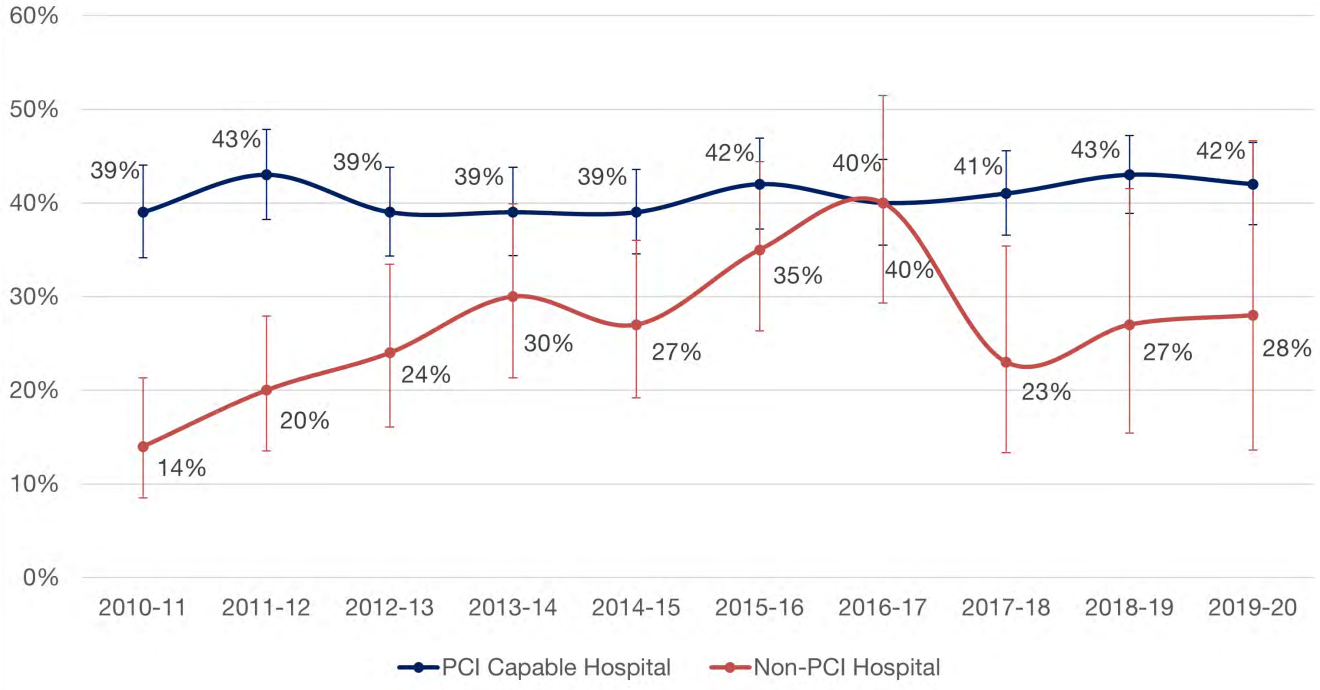
Transport to a cardiac centre

Previous VACAR research demonstrates that transport of OHCA patients to a percutaneous coronary intervention (PCI)-capable hospital is associated with improved survival to hospital discharge (Stub 2011).

State-wide during 2019-2020, 93% of EMS treated arrests due to a presumed cardiac cause were transported to a PCI-capable hospital. Within the metropolitan region during 2019-2020, 98% of arrests due to a presumed cardiac cause were transported to a PCI-capable hospital. This is the highest ever rate of transportation to a PCI-capable hospital.

Within the rural region during 2019-2020, 82% of arrests due to a presumed cardiac cause were transported to a PCI-capable hospital. This represents the highest rate of transportation to PCI-capable hospitals in the rural region in the last 10 years (82% vs 33% in 2010-2011). Rates of transportation to PCI-capable hospitals in rural regions vary due to the location of arrests. Patients are predominantly transported to University Hospital Geelong and Ballarat Hospital, two PCI-capable hospitals.

In 2019-2020, 42% of OHCA patients transported to PCI-capable hospitals survived to hospital discharge (unadjusted survival, see **Figure 17**). Of OHCA patients transported to hospitals without PCI capability during 2019-2020, 28% were discharged alive. This is a slight improvement compared to the previous year (27%) and a significant improvement compared to 10 years ago (14%). It is likely that hospital-based factors contribute to the variation in outcomes observed across hospitals, including optimal post-arrest treatment strategies.



‡ Data in the graph refers to Victorian hospitals with a current process to receive AV emergency patients via a pre-notification system, have full-time PCI-interventional capabilities and was the first hospital that the OHCA patient was transported to. Error bars show the 95% confidence interval around the proportion.

Figure 17: Unadjusted survival to hospital discharge for adult presumed cardiac EMS treated events according to transport to a PCI-capable hospital.


M.I.C.A.
PARAMEDI

Artificial Intelligence in carDiac arrEst (AIDE)

This major project we have been undertaking will improve cardiac arrest identification in the Triple Zero (000) call using AI

Triple Zero (000) call-takers play a pivotal role in the early detection and provision of bystander interventions for out-of-hospital-cardiac arrest (OHCA) patients. When cardiopulmonary resuscitation (CPR) and defibrillation are provided quickly, alongside an effective system of care, the chances of successful resuscitation and a good neurological recovery greatly increase.

When an OHCA is identified in the call, patients receive the highest priority ambulance dispatch (i.e. shorter ambulance response times), dispatch of basic life support-trained first responders, provision of telephone-assisted CPR and defibrillation instructions to bystanders, and activation of GoodSAM responders (crowdsourcing of bystander CPR and defibrillation). However, in Victoria almost 1,000 patients per annum fail to have their OHCA identified during the call. Intervention to improve the early detection of OHCA in the call would improve survival rates and long term patient outcomes.

The AIDE project aims to develop an Artificial Intelligence (AI) framework for Triple Zero (000) call-takers to use as a decision support tool. The tool will recognise potential OHCAs during the Triple Zero call and notify the call-taker of the level of probability of a cardiac arrest at the earliest possible point of recognition. The tool will demonstrate superior accuracy over lay call-takers alone, and aid in improving decision confidence and removing some of the pressure that call-takers experience in the Triple Zero (000) environment.

Even though the proof of concept will be in cardiac arrest patients, given cardiac arrest is the most time-sensitive of all emergency conditions, once established, this methodology has the potential for application in many other patient cohorts (e.g. stroke). This work is a powerful example of how advanced technologies and, in particular, AI can used in the health care setting. In addition, we are demonstrating a new and alternative approach to further improve the OHCA system of care.

This project is a collaboration between Ambulance Victoria, Emergency Services Telecommunications Authority (ESTA) and the Monash University Faculty of Information Technology and is funded by Safer Care Victoria.

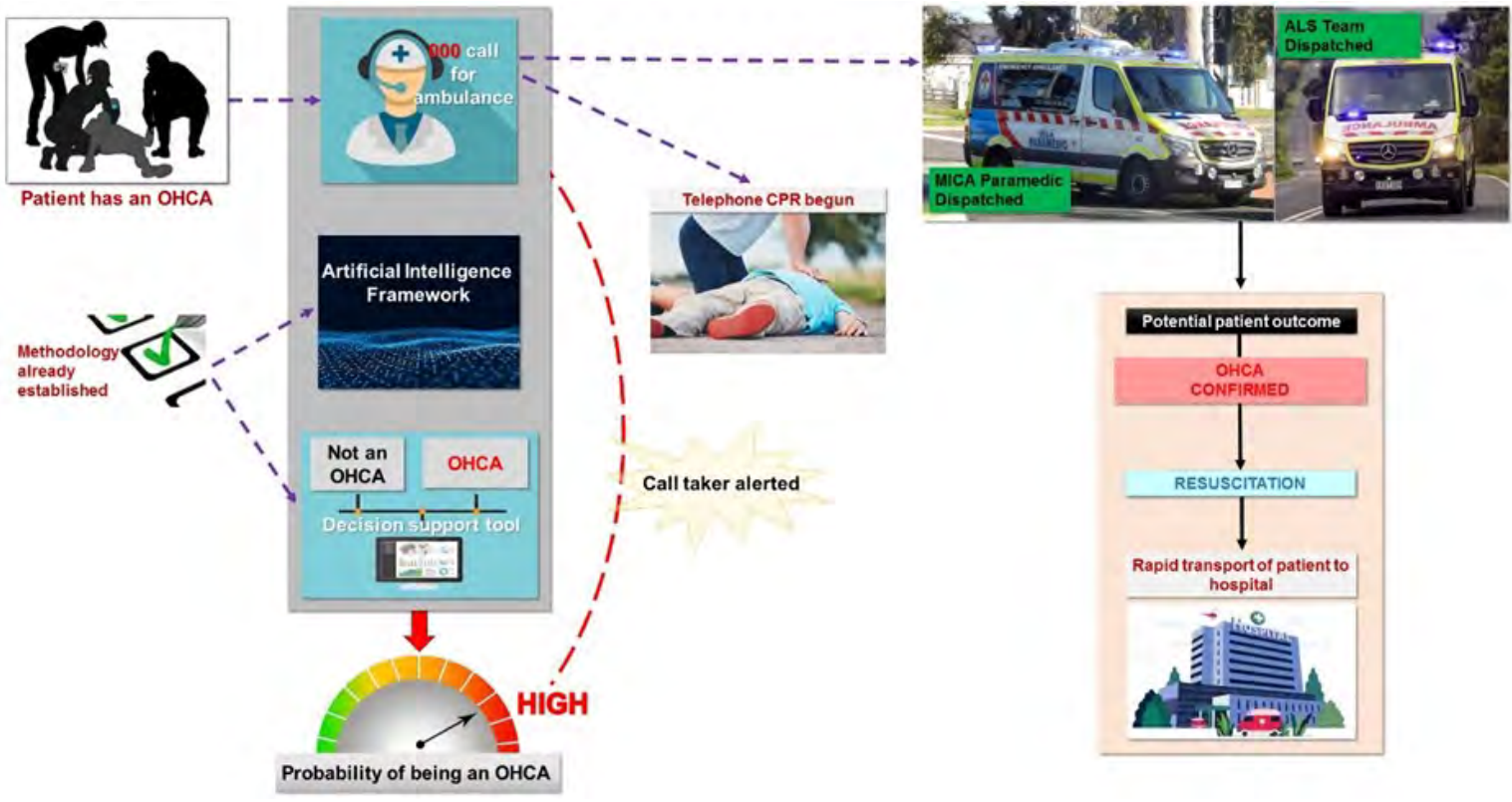


Figure 18: Schema of Triple Zero (000) call & dispatch for OHCA using the AIDE call-taker decision support tool for more efficient cardiac arrest identification


PARAMEDIC

Survival Outcomes

Scene outcomes in adults

Successful attempts at resuscitation following OHCA are often evaluated by the attainment of return of spontaneous circulation (ROSC) in the field and transportation of patients to hospital.

During 2019-2020, the achievement of ROSC was highest amongst adult OHCA patients who arrested in the presence of EMS (56%). Bystander witnessed arrests attained higher rates of ROSC than unwitnessed arrests in 2019-2020 (45% vs. 19%, respectively).

Across the entire state in 2019-2020, ROSC was achieved in 36% of all adult EMS treated events (includes EMS witnessed arrests); slightly less than the previous year (38% in 2018-2019). During 2019-2020, ROSC was achieved in 37% of OHCA events in the metropolitan region (in the previous year, this was 39%) and 33% of OHCA events in the rural region (in the previous year, this was 37%); includes EMS witnessed arrests. There was a significant difference in ROSC outcomes observed in the metropolitan region compared to the rural region (37% vs. 33%, p=0.027).

Over time, there has been an increase in the proportion of OHCA events where resuscitation efforts were ceased at scene, accompanied by a reduction in transportation with ongoing resuscitation efforts (see Figure 19). In 2019-2020, the proportion of adult EMS treated events which were transported from the scene with ROSC was 27%; similar to previous years. Efforts were ceased at scene for 71% of adult EMS treated events and the rate of transportation with CPR was low (2%).

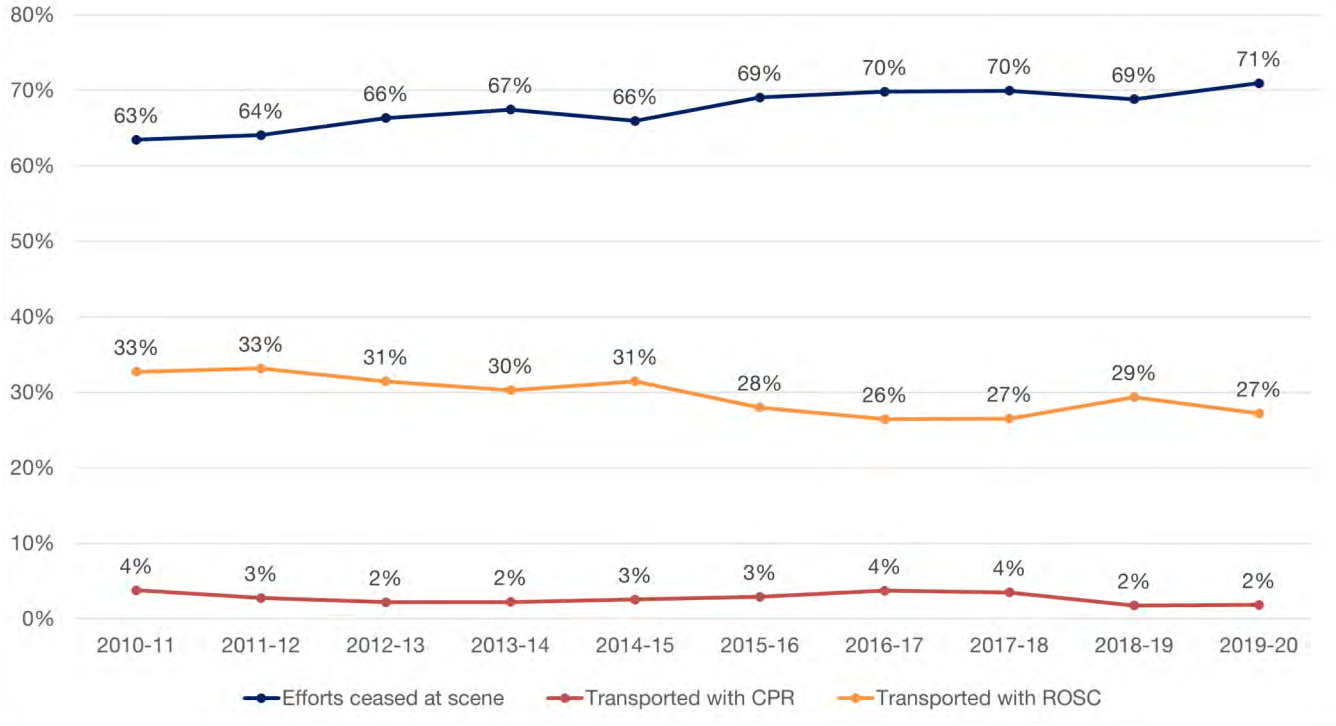


Figure 19: Scene outcomes for adult EMS treated events.

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 no additional treatment options at hospital. In 2020, Ambulance Victoria begun a trial (CHEER3) of in-field advanced life support with extracorporeal membrane oxygenation (ECMO) which involves oxygenation of blood outside the body for patients in a shockable rhythm who don't respond to paramedic treatment. Due to COVID-19, the trial was suspended and will re-start again soon.

Adult survival from all-cause cardiac arrest

Unadjusted adult survival from all-cause OHCA has remained steady over the past 10 years. In 2019-2020, the rate of event survival for adult EMS treated events was 28% and discharged alive rate was 10% (see **Figure 20**). The rate of event survival has declined slightly since 2010-2011, however survival to hospital discharge was consistent with recent observations.

In the metropolitan region during 2019-2020, event survival was 29% and discharged alive rate was 11%. In the rural region during 2019-2020, event survival was 24% and discharged alive rate was 10%.

In 2019-2020, 24% 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 (32% in 2010-2011; 32% vs. 24%, p<0.001; see **Figure 21**), consistent with international trends. As the number of arrests presenting in a shockable rhythm decreases, overall survival is subsequently impacted. Despite this, the rate of patients surviving to hospital discharge has not significantly decreased over the past decade (11% in 2010-2011 vs. 10% in 2018-2019, p=0.846) (see **Figure 20**).

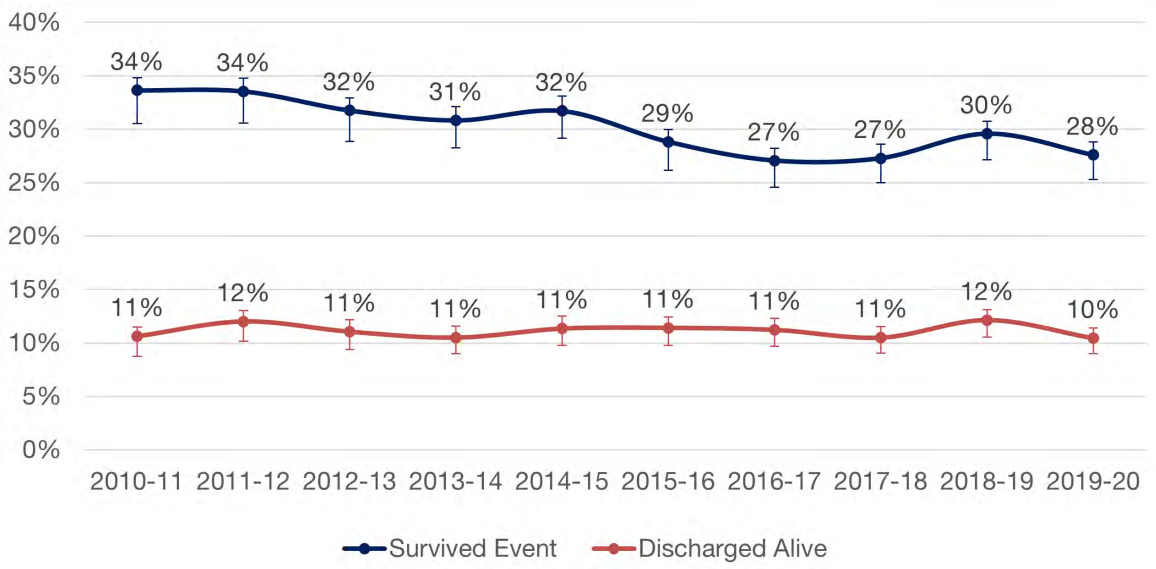


Figure 20: Unadjusted survival outcomes for all-cause adult EMS treated events.

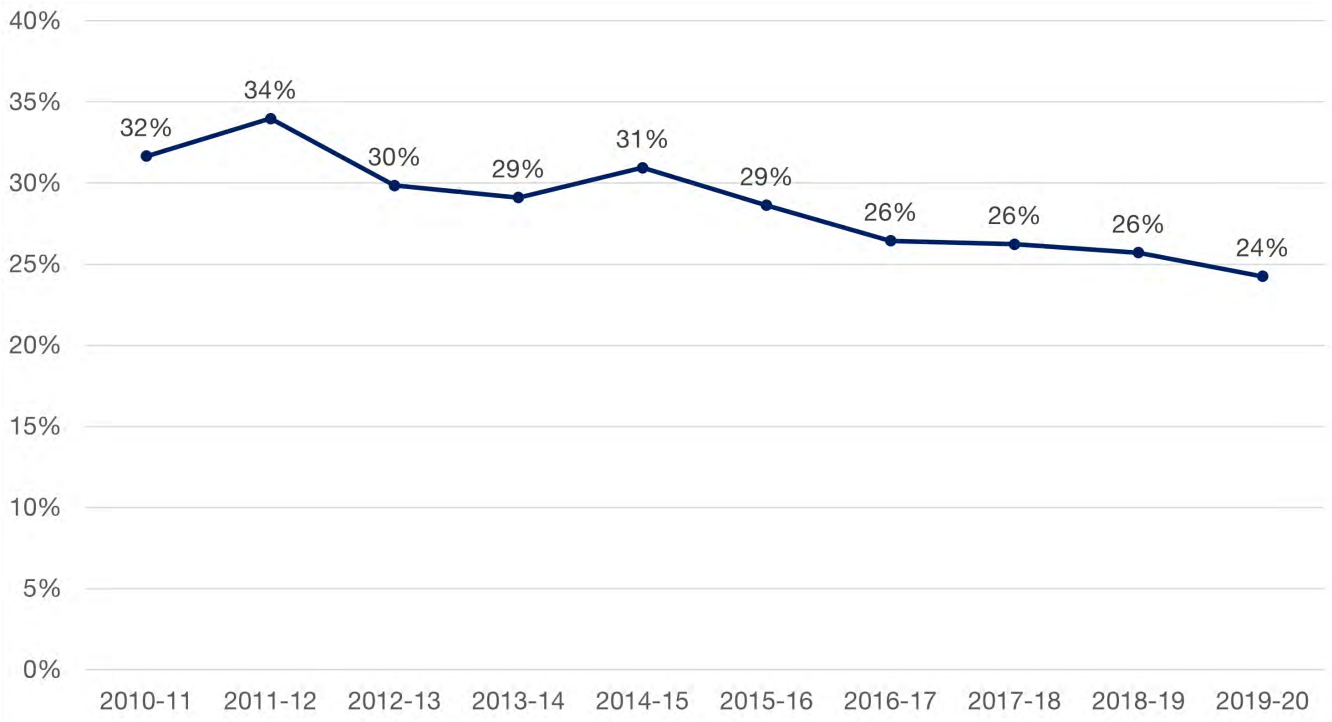


Figure 21: Proportion of adult EMS treated events presenting in a shockable rhythm on arrival.

Adult and all-ages survival from shockable rhythms

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).

For patients of all ages found in a shockable rhythm during 2019-2020, the rate of event survival was 54% (in 2018-2019, this was 55%) and the discharged alive rate was 34% (see **Figure 22**).

In comparison to adult patients presenting in a shockable rhythm during 2019-2020, 9% of adult patients who presented in PEA were discharged alive (in the previous year, this was 10%). Few adults presenting in asystole (0.6%) were discharged alive (in the previous year, no patients presenting in asystole were discharged alive).

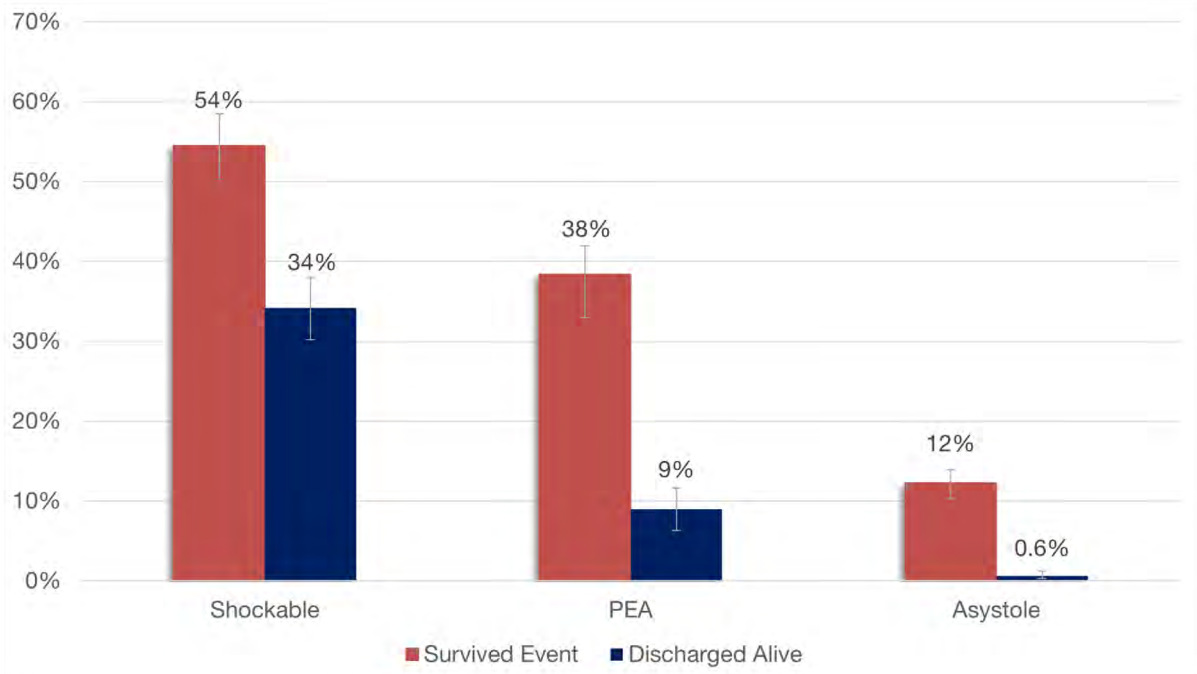


Figure 22: Unadjusted survival outcomes for adult EMS treated events according to presenting rhythm on arrival, 2019-2020.

Outcomes for patients with shockable rhythms have improved slightly over time (see **Figure 23**). In 2019-2020, adult event survival for patients presenting in a shockable rhythm was 54%. The rate of adult survival to hospital discharge was 34%. Both event survival and survival to discharge for adults in shockable rhythms have decreased slightly from the previous year (55% and 36%, respectively).

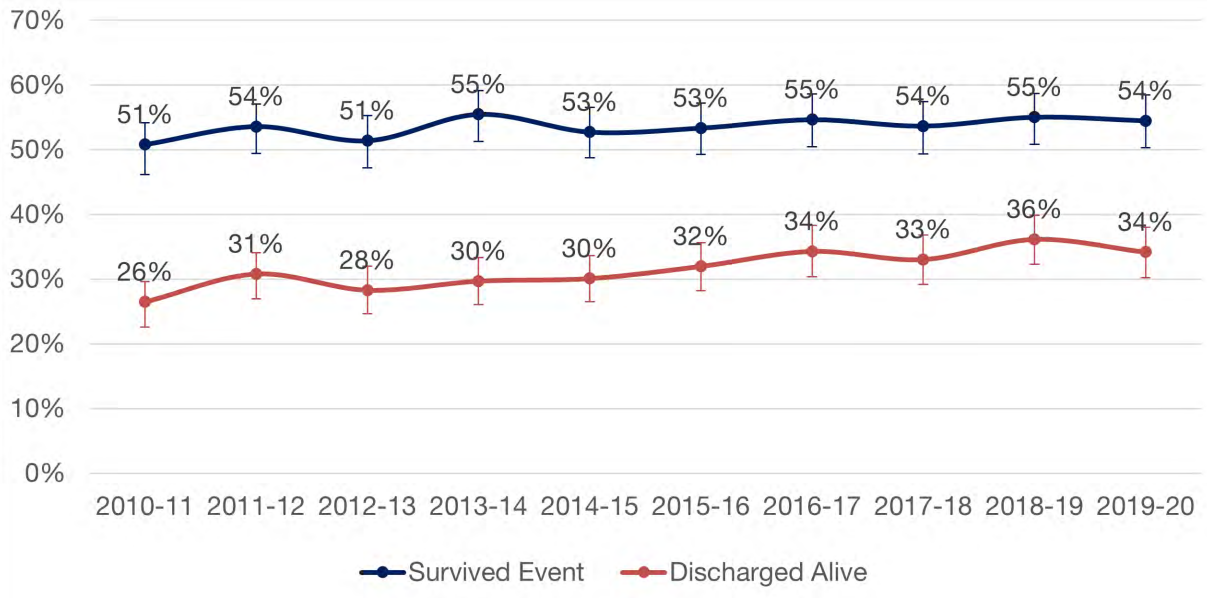


Figure 23: Unadjusted survival outcomes for adult EMS treated events with a shockable rhythm on arrival.

Adult survival from EMS witnessed arrests

In 2019-2020, for adult EMS witnessed events presenting in a shockable rhythm, the rate of event survival was 80% and the rate of survival to hospital discharge was also 80%, the highest ever recorded (see **Figure 24**). When considering all adult EMS witnessed events during 2019-2020, the rate of event survival was 47% (in the previous year, this was 50%) and the discharged alive rate was 31%, higher than the discharged alive rate for 2018-2019 (27%).

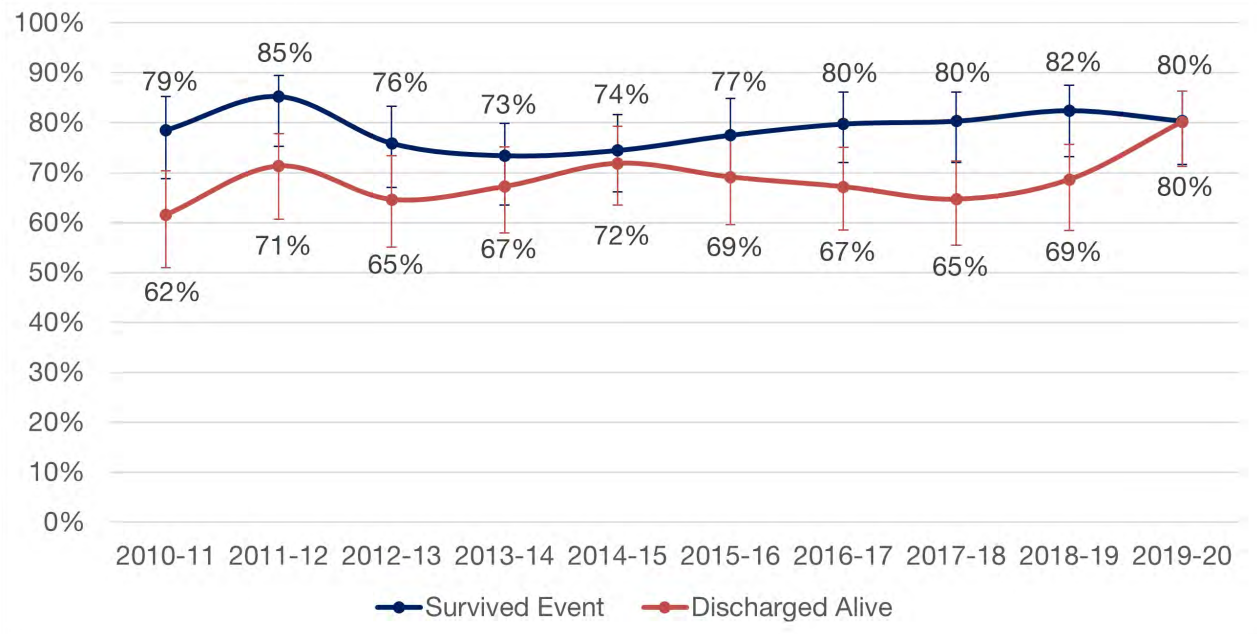


Figure 24: Unadjusted survival outcomes for adult EMS witnessed, EMS treated events with a shockable arrest rhythm.

Paediatric survival from all-cause cardiac arrest

Annual incidence of paediatric OHCA is low, with survival factors and outcomes differing from adults. Notably, paediatric cases rarely present in a shockable rhythm. In 2019-2020, 6% of EMS treated paediatric cases presented in a shockable rhythm (9% in the previous year). Asystole was the most common presenting rhythm (73%).

In 2019-2020, 22% of paediatric EMS treated patients survived the event (25% in the previous year). During 2019-2020, there were four paediatric patients (6%) who were discharged alive (11% in the previous year), relatively consistent over the last 10 years.

There were two EMS witnessed paediatric events in 2019-2020. One patient survived the event, however, this patient was not discharged alive from hospital.

Survival per million population

As shown in **Figure 25**, in 2019-2020, there were 60 OHCA survivors per million population. This is consistent with recent observations. Understanding the number of survivors per million population allows for international comparison and controls for variations within populations that influence absolute case numbers. In 2019-2020, the survivors per million population for the Utstein group (27 survivors per million), cases with an initial rhythm of VF/VT (45 survivors per million), and OHCAs that were witnessed by EMS (21 survivors per million) were consistent with recent observations.

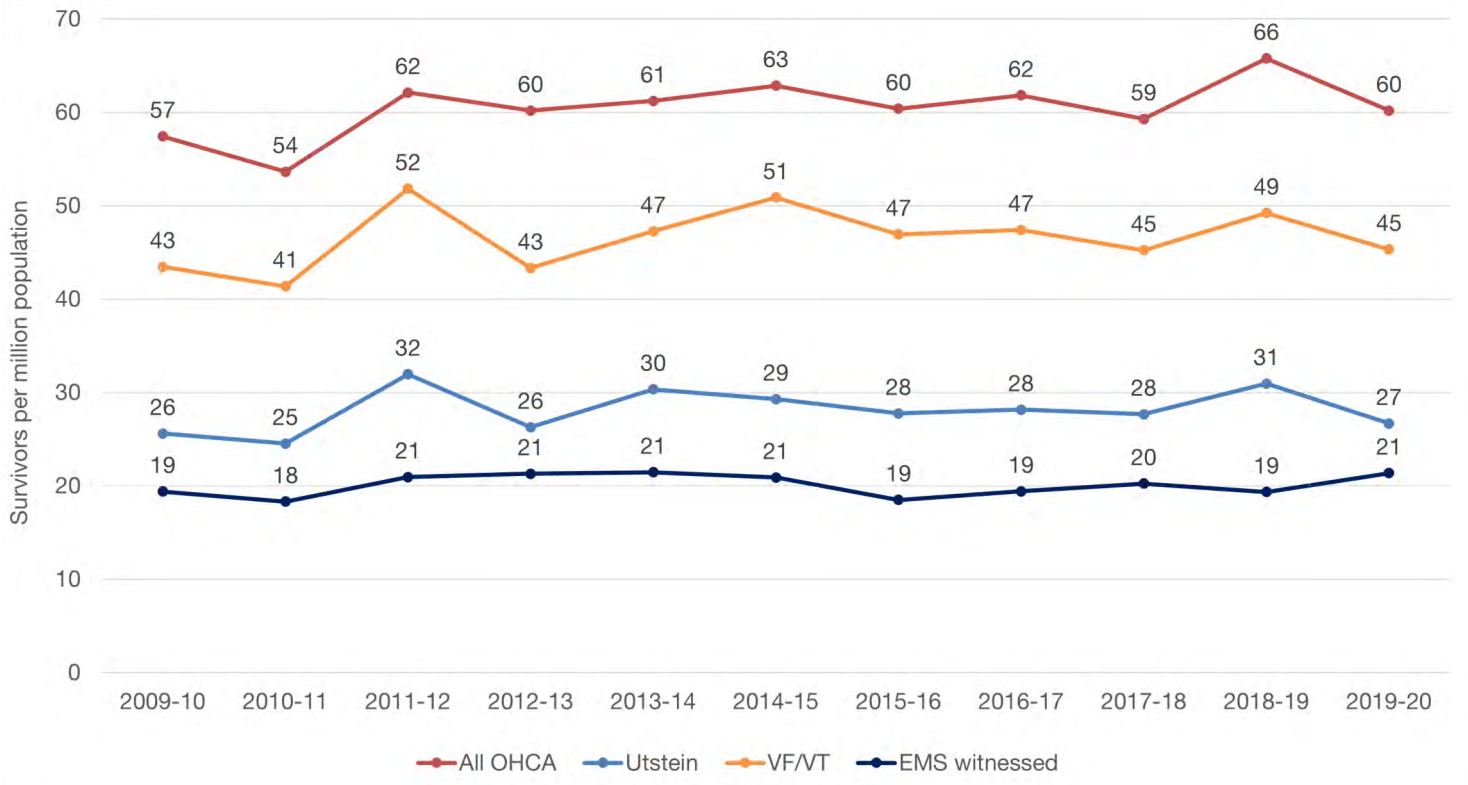


Figure 25: Survival per million population for all OHCA (red), the Utstein patient group (light blue), patients initially in VF/VT (yellow) and EMS witnessed arrests (navy blue).

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.

OHCA patients who are witnessed to arrest and present in a shockable rhythm are the most likely subgroup to survive an arrest. Data presented using the Utstein template focuses on survival within the following patient subgroup: OHCA events where EMS attempted resuscitation, where the arrest was witnessed by a bystander and the presenting cardiac rhythm was shockable (VF or VT).

Figure 26 shows state-wide survival to hospital discharge for the Utstein patient subgroup for the last decade (2011-2020). Utstein survival has gradually increased over time. However, COVID-19 has impacted OHCA survival over the last year.

In 2019-2020, the state-wide rate of survival to hospital discharge for the Utstein patient subgroup presenting in a shockable rhythm was 37%. In the previous year, the state-wide rate of being discharged alive within the Utstein patient subgroup was 39%.

Within the metropolitan and rural regions, the rates of being discharged alive within the Utstein patient subgroup was 39% and 35%, respectively. In the previous year, these rates in the metropolitan and rural regions were 44% and 34%, respectively.

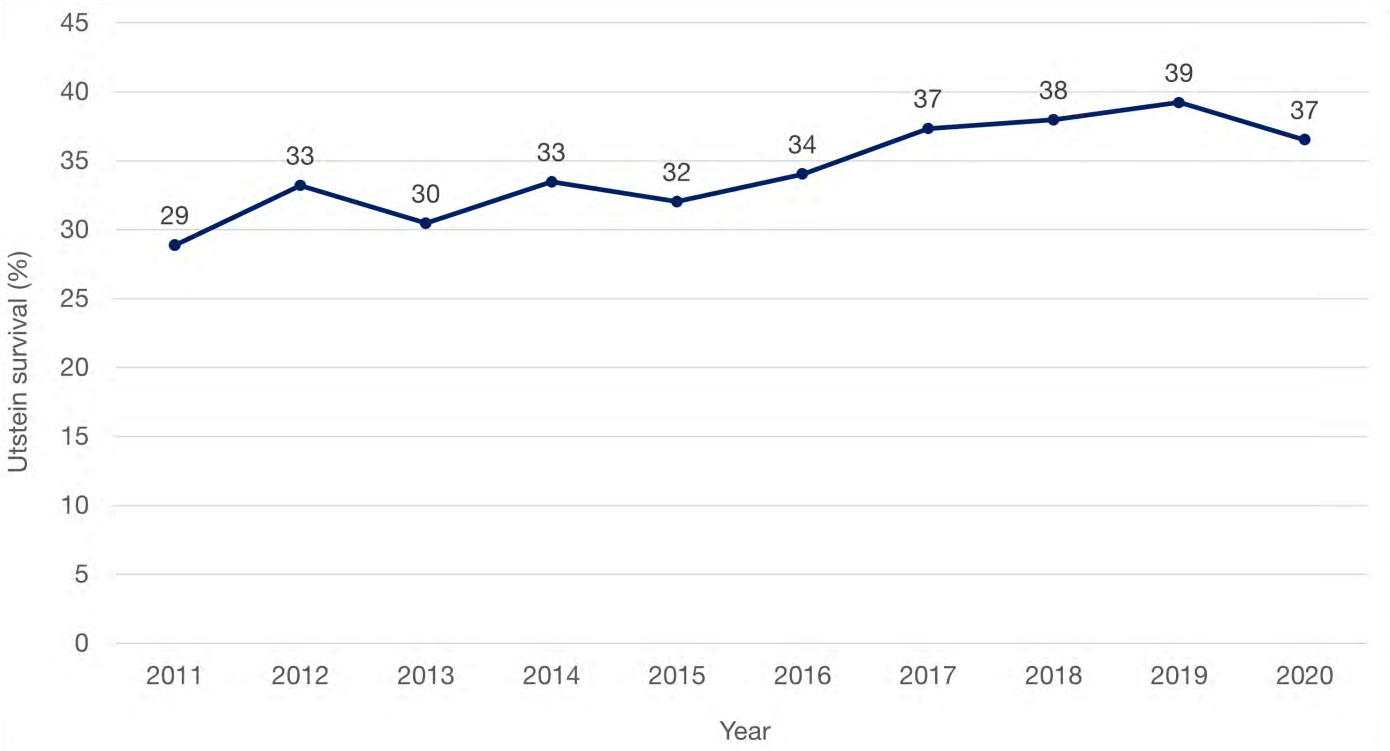


Figure 26: Survival outcomes for the Utstein patient group over the last decade, 2011-2020.

Utstein patient group survival in Victoria compared to international data

Table 6 compares survival to hospital discharge for the Utstein patient group in Victoria to other international data for this patient subgroup, a useful benchmarking patient group.

It should be noted that there are discrepancies in the definition of the Utstein patient subgroup by different international ambulance services, making comparison of survival rates difficult. In addition, different ambulance services follow different guidelines for when to start and/or stop resuscitation, which further complicates comparison of resuscitation outcomes data. It is also not possible to accurately know the extent to which some international organisations omit cases from their analyses of patient outcome data (eg. omitting cases with short, yet futile resuscitation attempts), as suggested by anecdotal evidence.

The Utstein patient subgroup definition used by AV no longer specifically selects patients where the arrest was due to a presumed cardiac cause. Instead, the AV Utstein patient group definition includes arrests due to any causes, as per the most recent recommendations for reporting of the Utstein comparator group (Perkins 2015). As evident in Table 6, 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.

Victorian OHCA patients experience a discharged alive rate for the Utstein patient subgroup (37%) which is comparable to a number of other ambulance services or other large collaborative studies/registries around the world. Some caveats should be noted, however, when comparing the Victorian Utstein group survival to other ambulance agencies, including markedly different service areas and population statistics.

Survival for metropolitan Melbourne was 39% in 2019-2020. 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 55%. This Utstein survival rate is similar to that of Seattle/King County (population 2.2 million). Given these survival statistics, Victoria is one of the safest places in the world to have a cardiac arrest.

Table 6: Published Victorian and international OHCA survival to hospital discharge data for the Utstein patient group.

Organisation	Time period	% survival
Ambulance Victoria - Metropolitan Melbourne - Inner Melbourne*	2019-2020	37% 39% 55%
Seattle & King County EMS 2019 Annual Report)^	2018	56%
London Ambulance Service Cardiac Arrest Annual Report 2018-2019^	2018-2019	37%
St John Western Australia Out-of-Hospital Cardiac Arrest Report 2019	2019	35%
Queensland Ambulance Service 2019 Annual Report	2019	35%
St John New Zealand (Out-of-Hospital Cardiac Arrest Registry Report 2018-2019)^^^	2018-2019	34%
CARES (Cardiac Arrest Registry to Enhance Survival) 2019 Annual Report^^	2019	33%
South Australian Ambulance Service Cardiac Arrest Registry Summary Report 2016-2017	2016-2017	33%
Out-of-Hospital Cardiac Arrest Register (OHCAR) Ireland Annual Report 2019^^	2019	28%
NSW Ambulance Cardiac Arrest Registry Report 2018 (NSW Health & NSW Ambulance, 2020)	2018	30%
EuReCa TWO (28 European country OHCA registries, Grasner 2020)	2017	28%
Pan Asian Resuscitation Outcomes Study, PAROS (7 Asian EMS services; Ong 2015)^	2009-2012	28%

*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.
^Only includes patients arresting due to a presumed cardiac cause.
^^ Excludes patients arresting due to a traumatic cause.
^^^Adult (≥15 years) survival to 30 days.

Yearly risk-adjusted odds of adult survival

The risk-adjusted odds of survival outcome provide a balanced method of measuring yearly trends in resuscitation performance and outcome. In the analyses presented in **Figures 27 and 28**, the odds of survival to hospital discharge for the adult EMS treated population is evaluated across years using a multivariate model adjusted for known predictors of survival. These predictors include: age, sex, public location, presenting in shockable rhythm^, bystander witnessed status and bystander CPR.

The 2004-2005 year is used as the reference category. **Table 7** outlines the start dates of a number of important AV programs and initiatives since the initiation of the VACAR, in 1999, up to the current fiscal year. Some of these initiatives are likely to have driven improvements in patient outcomes outlined in this report.

The analysis represented in **Figure 27** demonstrates strong growth in the survival to hospital discharge outcomes over recent years. In 2019-2020, the relative odds of survival to hospital discharge for adult EMS treated patients had increased over 2-fold compared to patient outcomes in 2004-2005 (adjusted odds ratio 2.1, 95% CI 1.6-2.7, p<0.001).

Similarly, over time there has been vast improvements in the odds of survival to hospital discharge for patients presenting in a shockable rhythm (see **Figure 28**). In 2019-2020, the relative odds of being discharged alive had increased almost 2.5-fold for adult EMS treated patients presenting in a shockable rhythm compared to patient outcomes in 2004-2005 (adjusted odds ratio 2.4, 95% CI 1.8-3.2, p<0.001).

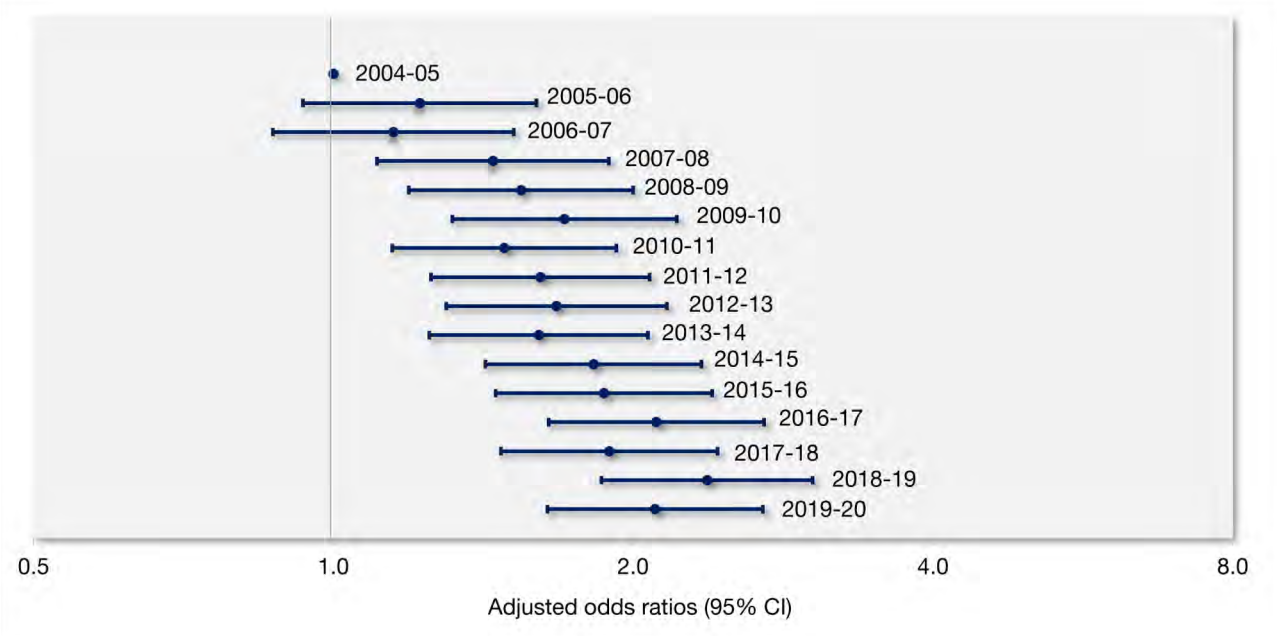


Figure 27: Risk-adjusted odds of adult survival to hospital discharge by year in the overall EMS treated population.

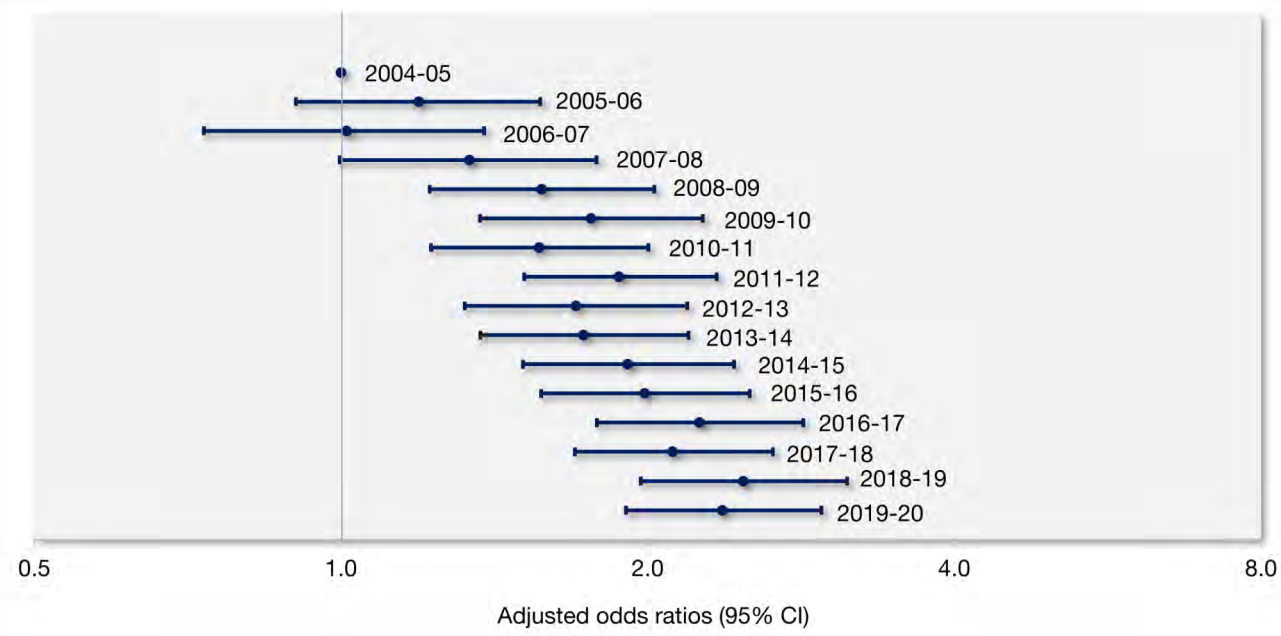


Figure 28: Risk-adjusted odds of survival to hospital discharge for adults presenting in a shockable rhythm by year in the overall EMS treated population. (For this analysis, only patients presenting in a shockable rhythm were included. As such, the "shockable rhythm" factor was removed from the regression model)

Impact of the COVID-19 pandemic on outcomes

Collateral damage to the Victorian OHCA system of care

Planning and preparation for disease outbreaks is critical to maintaining healthcare services during a pandemic. Analysis of health service data is essential to understand the impact of a pandemic on processes, patient care and outcomes. Findings can inform policies, procedures and clinical practice guidelines leading to pandemic preparedness. The COVID-19 pandemic has introduced unprecedented challenges and implications for healthcare services worldwide, including pre-hospital emergency medical services. This has been particularly pertinent for medical emergencies such as OHCA which requires a time-dependent emergency response.

For the pre-hospital response to OHCA, highly co-ordinated systems-of-care that optimise survival and functional outcomes are paramount. Such elements include time-dependent intervention strategies in the pre-hospital setting (e.g. early defibrillation) and use of appropriate diagnostic and treatment strategies at receiving hospitals. Any disruption to the system-of-care has the potential to influence patient outcomes.

The outcomes of out-of-hospital cardiac arrest (OHCA) during the COVID-19 pandemic period has predominantly been described by countries devastated by huge case numbers and overwhelmed healthcare services. However, for countries where infection and case-fatality rates have been low, imposed social restrictions and treatment precautions also influenced OHCA processes-of-care. The Centre for Research and Evaluation therefore investigated the impact of the COVID-19 pandemic period on the incidence, management, and outcomes of OHCA in Victoria (Ball et al, 2020).

We used data from VACAR to quantify the impact of the COVID-19 pandemic period (16th March 2020 [State of Emergency declared] to 12th May 2020 [Stage 3 restrictions lifted]) on OHCA incidence and outcomes.

During the pandemic period, 935 OHCA were attended by AV. For the same time in 2017, 2018 and 2019 (combined), 2,599 OHCA were attended. Of all attendances to cardiac arrest, 380 and 1,218 arrests received paramedic attempted resuscitation in the pandemic and comparator periods, respectively.

Key findings of this work were:

- Initiation of resuscitation by paramedics significantly decreased during the pandemic period (46.9% versus 40.6% versus, respectively; p=0.001). Therefore, more patients were declared deceased upon arrival of AV.

- For patients with attempted resuscitation:

- Arrests in public locations decreased in the pandemic period (10.0% versus 20.8% in the comparator period; p<0.001).
- Patients receiving an initial shock from public access defibrillation/community first responders decreased in the pandemic period (3.9% versus 6.9% in the comparator period; p=0.037).
- Moderate delays to key time-sensitive interventions were observed during the pandemic period (dispatch-to-scene, scene-to-patient, time-to-first defibrillation, time-to-first adrenaline).
- Median resuscitation duration by paramedics was significantly longer in the pandemic period for patients presenting in a shockable cardiac rhythm. (7.5 minutes longer than in the comparator period).
- Overall survival to hospital discharge decreased by 50% during the pandemic period (6.1% versus 11.7% during the comparator period; p=0.002). This persisted after adjusting for known confounders.
- Survival to hospital discharge for patients presenting in a shockable rhythm was also significantly reduced during the pandemic period (20.0% versus 36.7% in the comparator period; p=0.004).

Having an up to date registry has meant that the decline in survival could be rapidly identified and tactics to mitigate further decline investigated. Dr Jocasta Ball, Senior Research Fellow and Head of VACAR is currently looking at more recent cardiac arrest data to further explore factors impacting patient outcomes during COVID-19, which will result in additional recommendations.

Necessary social restrictions & the need for personal protective practices due to COVID-19 significantly impacted OHCA survival during 2020. Findings of this work will go towards informing future pandemic preparedness at Ambulance Victoria.


Victoria. The place to be (inside).
Social distancing saves lives.

Improving survival from out-of-hospital cardiac arrest

Ambulance Victoria is part of the Global Resuscitation Alliance (GRA) which is an international collaboration aiming to increase OHCA survival rates by at least 50%. The GRA promotes ten themes based on recent evidence and best practice in OHCA management that are designed to provide the framework for EMS systems to improve OHCA survival in their community (**Figure 29**).

In the last year, AV has been working to implement programs or improve upon existing programs in an effort to increase cardiac arrest survival rates in Victoria.

Ten Steps to Improve Cardiac Arrest Survival
1. Establish a cardiac arrest registry
2. Begin telephone-CPR with ongoing training and QI
3. Begin high-performance EMS CPR with ongoing training and QI
4. Begin rapid dispatch
5. Measure professional resuscitation using the defibrillator recording (and voice if possible)
6. Begin an AED program for first responders, including police officers, guards, and other security personnel
7. 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
8. Make CPR and AED training mandatory in schools and the community
9. Work toward accountability—submit annual reports to the community
10. Work toward a culture of excellence

Figure 29: Global Resuscitation Alliance – 10 Programs to Improve Cardiac Arrest Survival .

Programs 1 & 9: Establish a Cardiac Arrest Registry and submit Annual Reports to the community

Ambulance Victoria was the first Australian service to establish a statewide Cardiac Arrest Registry. VACAR is also the only registry in Australia and New Zealand which collects quality of life data on survivors. In addition, VACAR was the first cardiac arrest registry in Australia and New Zealand to produce an Annual report that is publicly available to the community. We will continue to expand VACAR data collection and reporting to actively evaluate new initiatives as they are implemented.

Programs 2 & 4: Telephone CPR and rapid dispatch with ongoing quality improvement

AV and the Emergency Services Telephone Authority (ESTA) have been working closely to improve systems of care to decrease call-taker time to recognition of OHCA and increase the incidence of bystander CPR and AED use at the scene. VACAR now collects extensive data from Triple Zero (000) calls of cardiac arrest events, including time of arrest recognition and time of telephone CPR instructions. Through the AIDE project (page 42), AV is also developing an artificial intelligence framework to assist call-takers in recognising the potential for the patient to be in cardiac arrest at the earliest point in the call.

Program 3: High-Performance CPR with ongoing training and quality improvement

AV paramedics commenced high-performance CPR (HP-CPR) training in late 2018 and it became standard practice service-wide on 11 February 2019. HP CPR reduces periods of hands-off-chest time during the resuscitation attempt and affords the patient a greater chance of achieving a return of spontaneous circulation (ROSC), surviving to hospital and surviving to hospital discharge with good neurological outcomes. Preliminary data suggests that implementing HP CPR has resulted in a 29% improvement in the odds of survival to hospital discharge during the first 12 months of the programme with further analyses to follow.

Program 5: Measure resuscitation efforts

Data from feedback pads used during the resuscitation, combined with call-taking and dispatch data, VACIS data and hospital data enables AV to accurately measure CPR performance during resuscitation efforts. These data are used to guide feedback and debriefing for responders with the aim to improve individual, team and organisation performance at management of OHCA. During 2020, VACAR staff worked on increasing and improving the data reported back to teams plus the time from resuscitation attempt to receiving feedback has been significantly reduced.

Program 6: AED programs for first responders

AV has a well-established AED program for first responders including Community Emergency Response Teams (CERTs), Ambulance Community Officers (ACOs) and Remote Area Nurses (RANs). AV also has a successful co-responder program with Fire Rescue Victoria (FRV) and the Country Fire Authority (CFA) through the Emergency Medical Response (EMR) program. FRV and participating CFA crews are co-dispatched to suspected cardiac arrests and commence life-saving CPR and rapid defibrillation prior to AV arrival. EMR crews then assist with continuing efforts at the resuscitation where required. The EMR program continues to expand to CFA stations and since it commenced in 2008, has now expanded to include over 30 volunteer and integrated CFA stations across Victoria with plans for further rollout over the next 12 months.

Program 7: Use technology to improve community response

AV have introduced the GoodSAM program to alert suitably qualified responders to cases of cardiac arrest and there are now numerous cases of off-duty paramedics providing early CPR and defibrillation with positive patient outcomes. The GoodSAM app connects people in cardiac arrest with nearby trained and trusted responders in the critical minutes between a Triple Zero (000) call and emergency services arriving. GoodSAM commenced at AV in January 2018, and was launched publicly in May 2018. The partnership with GoodSAM has also aided AV in maintaining a registry of publicly accessible AEDs that bystanders can be directed to when responding to an OHCA.

Long-term Outcomes

Discharge direction for all survivors

When considering all adult OHCA survivors, 85% were discharged home (including EMS witnessed events and excluding unknown discharge status; see **Figure 30**). Discharge home for adult survivors has remained consistent over the last decade. In 2019-2020, remaining adult survivors were discharged to rehabilitation (14%) 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, 86% were discharged home.

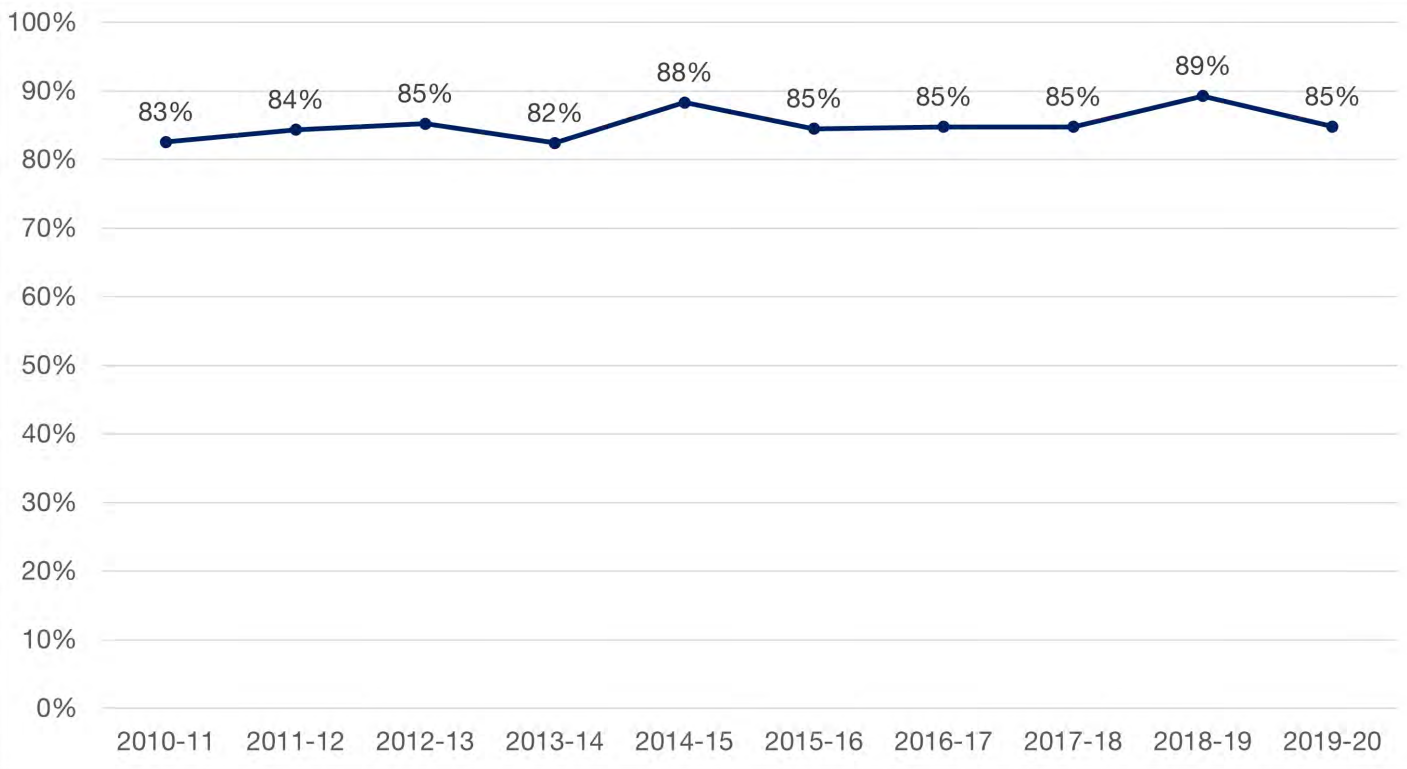


Figure 30: Proportion of adult discharged alive patients who are discharged to private residence (includes EMS witnessed events).

Assessing quality of life post arrest

Since January 2010, adult OHCA patients (aged ≥18 years) who were discharged alive have undergone health-related quality of life (HRQoL) interviews via telephone follow-up 12-months after their arrest. The Victorian Registry of Births, Deaths and Marriages is initially searched for death information. Patients identified as alive at 12-months are sent a letter indicating they will receive a telephone call regarding their health and requesting verification of current contact information. Patients are then contacted by a dedicated researcher experienced in undertaking these interviews. Where necessary, a proxy is interviewed in place of the patient (if appropriate for the tool being used). At least five attempts are made to contact patients at different time points, including after hours. Interviews are performed from a central location.

Interviews include the following measures:

The EuroQol 5 dimension (EQ-5D) questionnaire (Rabin 2001). The EQ-5D is validated to measure HRQoL. The tool assesses five domains: mobility, self-care, usual activities, pain/discomfort, anxiety/depression. EQ-5D health status can be converted to a single index score by weighting each of the dimensions against United Kingdom (UK) norms; scores range from -0.594 (worse than death) to 1 (full health) (Szende 2007).

Twelve-item short form (SF-12) health survey (Ware 1996). The SF-12 is a generic HRQoL instrument that measures physical and mental health status; only patients provide data. SF-12 scores consist of the Physical Health Component Summary (PCS) and Mental Health Component Summary (MCS). Standardised mean difference (SMD) was used to show the degree of deviation of a score from the population norm. SMD is calculated by subtracting the mean score of the corresponding Australian age and sex category from the OHCA respondent's score and dividing by the standard deviation of the appropriate age/sex category (McGough et al. 2009). The size of the SMD represents the magnitude of the difference between population groups, with values >0.8 considered large.

Glasgow Outcome Scale – Extended (GOS-E) (Wilson 1998). The GOS-E provides a global measure of function on an eight level scale from death (1) to upper good recovery (8). Scores ≥7 equate to good recovery.

Work related factors. Return to work is recorded, with additional questions regarding same employer and/or same role if the patient has returned to work.

Living status factors. Residential status of the patient at the time of interview is recorded. If the patient has returned home, they are asked about use of additional support services.

The VACAR is still one of only a few registries in the world that routinely collect health-related quality-of-life outcomes for cardiac arrest patients. VACAR contains one of the largest cohorts of OHCA quality-of-life outcomes.

Quality of life findings

Of 313 individuals who arrested between 1 July 2018 and 31 March 2019 and were discharged alive from hospital, 292 patients were alive 12-months post-arrest and were eligible for contact in 2019-2020. Interviews were conducted with 220 patients and 39 proxies (n=259), producing a response rate of 89%. There were 129 individuals who had worked prior to their arrest; 80% of individuals (103 of 129) returned to work after their arrest. Of those returning to work, 96% (99 of 103) 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); male gender (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) were positively associated with return to work.

SF-12 survey data for OHCA patients who arrested during 2018-2019 and were followed up 12 months later were expressed as SMD scores (outlined on page 53). The SMD (±95% CI) for the PCS crossed zero meaning that the physical health of the OHCA patients was not significantly different than Australian population norms (SMD PCS -0.033, 95% CI -0.201 to 0.136). The SMD (±95% CI) for the MCS also crossed zero meaning that the mental health of the OHCA patients was not significantly different than Australian population norms (SMD MCS 0.092, 95% CI –0.051 to 0.235) (see **Figure 31**). SF-12 data was available for n=193 patients.

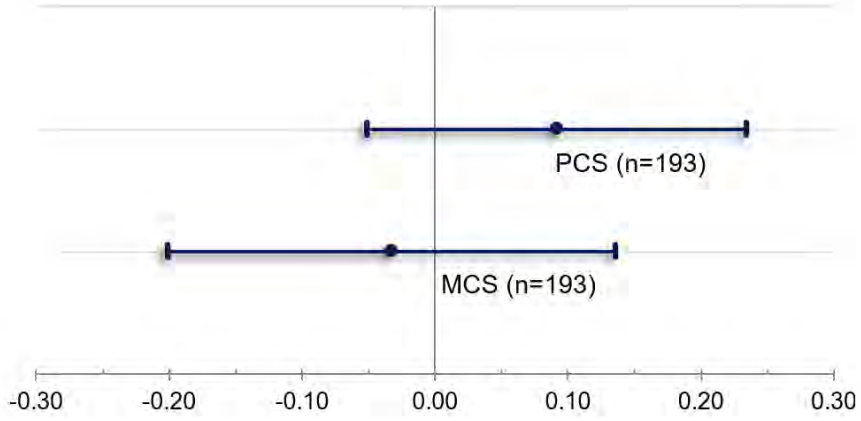


Figure 31: Standardised mean differences for SF-12 scores at 12 months post arrest for OHCA survivors versus the Australian population (patients who arrested between 2018-2019).

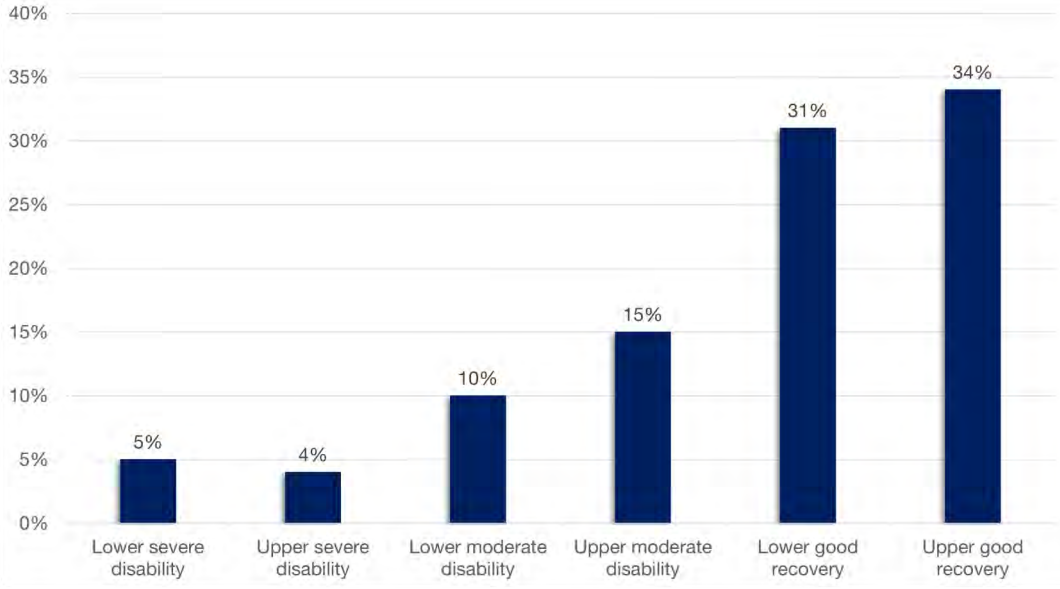


Figure 32: Disability or recovery status according to the GOS-E for OHCA survivors at 12 months post arrest (patients who arrested between 2018-2019).

The GOS-E measure indicated that 65% of survivors who arrested during 2018-2019 (156 of 239) were rated as having good functional recovery 12 months after their arrest (see **Figure 32**). An additional 26% reported recovery with only moderate disability.

Mean EQ-5D index score for responders followed up in 2019-2020 was 0.83 (95% CI 0.80 to 0.85); most (63%) had an EQ-5D index score ≥0.81, approaching full health level. These high EQ-5D index scores are similar to age-and sex-adjusted population norms (Smith 2015). EQ-5D index scores were available for 258 of 259 responders.

Together, the SF-12, GOS-E and EQ-5D results indicate good HRQoL for survivors of arrests during 2019-2020 who responded.

Temporal trends in quality of life

SF-12

Over the last decade, quality of life for Victorian OHCA patients has continued to improve. As demonstrated by patterns in the SF-12 PCS and MCS, mental health in OHCA patients has either been not significantly different or significantly better (in 2015, 2017 and 2018) than Australian population means. (**Figure 33**; 2009 used as the reference year). Only twice in the last 10 years has physical health been slightly worse than Australian population norms (in 2010-2011 and 2016-2017; **Figure 34**).

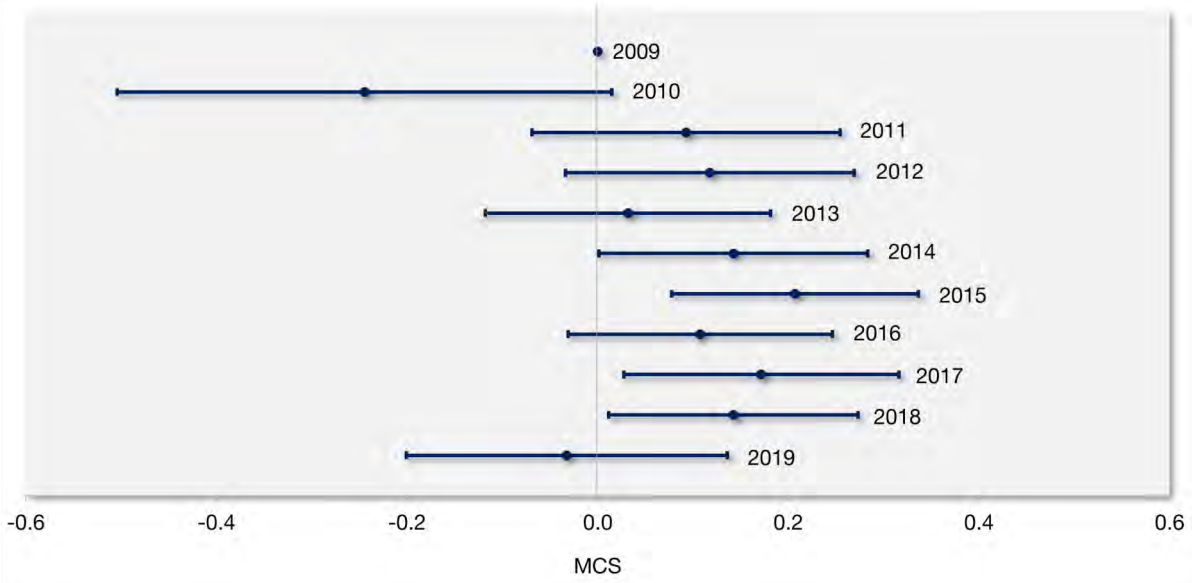


Figure 33: Standardised mean differences in SF-12 MCS (2010-2019)

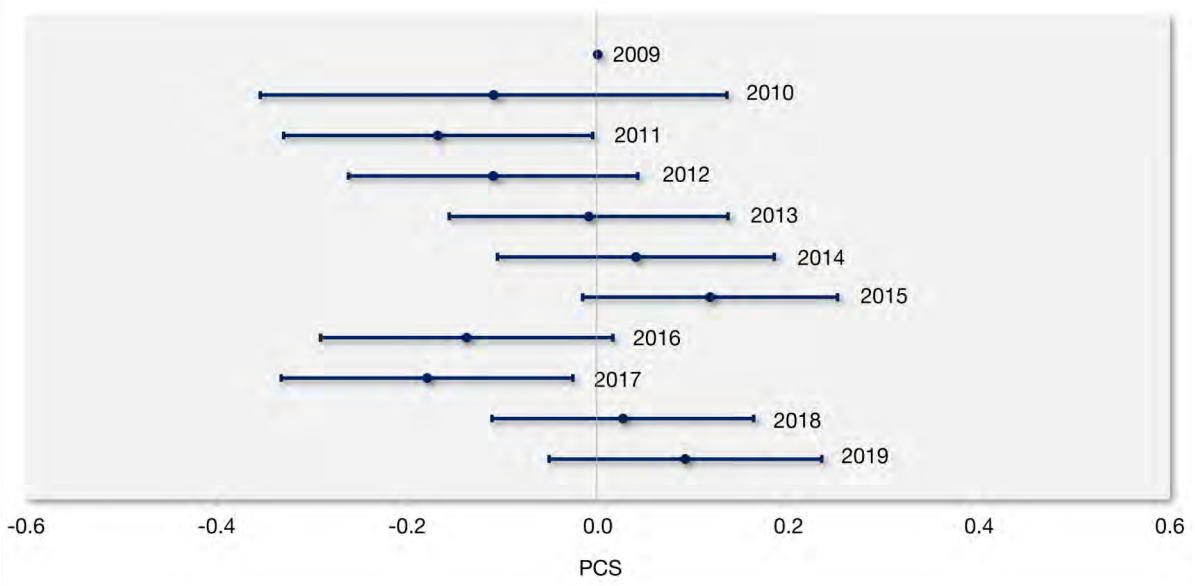


Figure 34: Standardised mean differences in SF-12 PCS (2010-2019)

GOSE-E

According to GOS-E scores recorded over the last decade, the majority of OHCA survivors have experienced good post-arrest recovery (indicated by a GOS-E score ≥7). After a decline in 2015 of survivors reporting good functional recovery, a steadily increase has been seen since 2016. In 2018-2019 and 2019-2020, the 65% of survivors have reported good functional recovery (Figure 35).

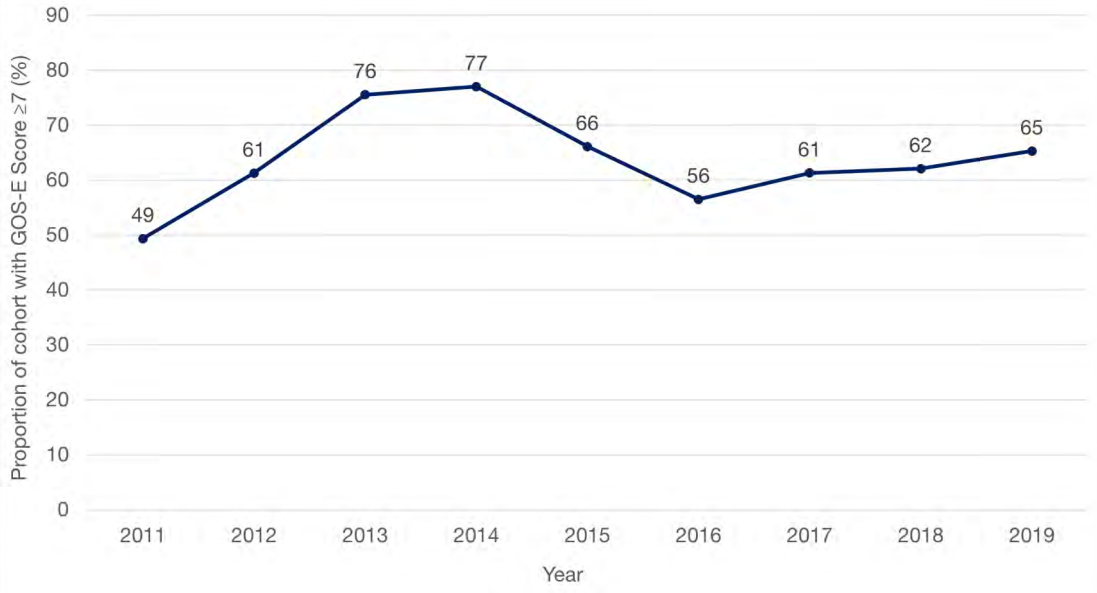


Figure 35: Proportion of survivors with a GOSE-E Score ≥7 (good recovery) over time

EQ-5D

Since 2010, OHCA survivors have consistently reported a high level of health as indicated by mean EQ-5D index scores of ≥0.81 which is approaching full health (Figure 36).

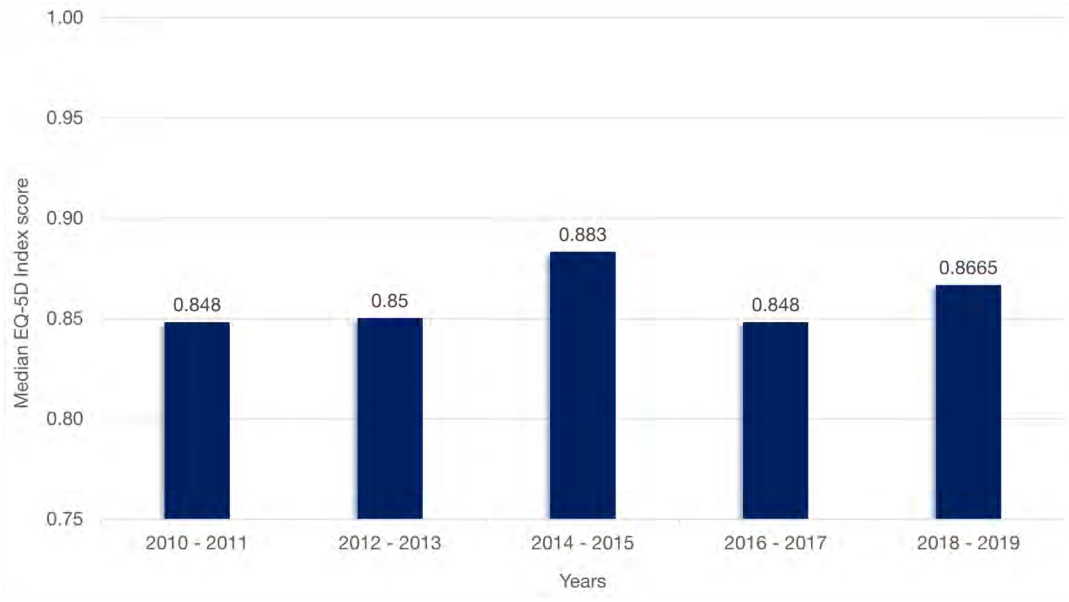


Figure 36: Median EQ-5D Index Score (2010-2019)


EMERGENCY AMBULANCE
PARAMEDIC

2019-2020 Research Highlights

'This year has seen the impact of the COVID-19 pandemic on cardiac arrest management and patient outcomes. We saw a significant impact on the elements of the Victorian OHCA system of care and have monitored arrest response, management and outcomes in real-time throughout 2020. In addition, we have continued our extensive research program including our ongoing investigation into the evolving epidemiology of OHCA.'

Professor Karen Smith, VACAR Principal Investigator and Chair.

The changing incidence of OHCA

The epidemiology of out-of-hospital cardiac arrest (OHCA) is changing rapidly. In this study, Alqahtani et al. used two decades of OHCA data from Victoria to examine changes in the incidence of presumed cardiac and non-cardiac OHCA. The authors found that OHCA of presumed cardiac aetiologies and initial shockable rhythms are declining rapidly over time, while the incidence of OHCA of non-cardiac aetiologies is increasing. Precipitating events with the largest increase over the last two decades included non-traumatic serious bleeding, respiratory, and neurological causes. The data indicates that by 2052, non-cardiac aetiologies will be the leading cause of OHCA in Victoria.

Alqahtani S, Nehme Z, Williams B, Bernard S and Smith K. Changes in the incidence of out-of-hospital cardiac arrest: Differences between cardiac and non-cardiac aetiologies. Resuscitation. 2020;155:125-133.

Factors associated with return to work

Given that survival rates from OHCA have increase over time, there is an increasing need to explore long-term functional outcomes of survivors such as return to work (RTW). Kearney et al. analysed baseline and 12-month follow-up data from VACAR for patients who arrested between 2010 and 2016. Detailed RTW interviews were conducted in a subset of survivors. Male gender, EMS witnessed arrests, discharge to home from hospital and favourable quality of life at 12 months were significantly associated with RTW. Of those who were further interviewed, 87% had RTW, 74% to flexible working hours or modified duties. The findings of this work highlight which patients are at risk of not RTW and who may benefit from target rehabilitation.

Kearney J, Dyson K, Andrew E, Bernard S, Smith K. Factors associated with return to work among survivors of out-of-hospital cardiac arrest. Resuscitation. 2020;146:203-212.

Impact of the COVID-19 pandemic on the OHCA system of care

During the first "wave" of COVID-19 in Victoria, Ball et al. sought to understand whether patterns in OHCA seen overseas in countries with high case numbers and overwhelmed healthcare systems were reflected in Victoria. Initiation of resuscitation by paramedics significantly decreased during the pandemic period (from 46.9% to 40.6%). Arrests occurring in public locations decreased by more than 50% in the pandemic period and initial shocks by PAD/first responders also decreased. Delays to key interventions increased resulting in a median 4-minute total delay during resuscitation efforts. The proportion of OHCA patients discharged alive decreased by almost 50% (from 11.7% to 6.1% as it did for patients presenting in VF/VT. Odds of survival to discharge reduced by 54% during the pandemic period (OR 0.46, 95% CI 0.25-0.86). Ball et al. concluded that COVID-19 initiated collateral damage to the Victorian OHCA system of care, resulting in delays to key time-sensitive interventions. However, this did not completely explain reductions in survival. Future research is planned to identify additional contributing factors.

Ball J, Nehme Z, Bernard S, Stub D, Stephenson M, Smith K. Collateral damage: Hidden impact of the COVID-19 pandemic on the out-of hospital cardiac arrest system-of-care. Resuscitation 2020;156:157-163.

Impact of medically-trained bystanders

There is growing interest in optimising the quality of cardiopulmonary resuscitation (CPR) provided by bystanders. In this study, Haskins and colleagues investigate the impact of bystander relation and medical training on survival from out-of-hospital cardiac arrest (OHCA). The study indicates that OHCA patients who received CPR from a medically-trained bystander (e.g. nurse, doctor or paramedic) had a 47% increased odds of survival to hospital discharge when compared to CPR provided by a layperson. The effect was even larger in initial shockable arrests, with medically-trained bystander CPR being associated with a 73% improvement in the odds of survival compared to layperson CPR. The study supports ongoing efforts to crowdsource a larger number of first responders with CPR or medical training to OHCA events.

Haskins B, Smith K, Cameron P, Bernard S, Nehme Z, Murphy-Smith J, Metcalf M, Moussa R, Harvey D, Turnbull L and Dyson K. The impact of bystander relation and medical training on out-of-hospital cardiac arrest outcomes. Resuscitation. 2020;150:72-79.

2019-2020 Peer-reviewed Publications*

2020

Alqahtani S, Nehme Z, Williams B, Bernard S and Smith K. Temporal trends in the incidence, characteristics and outcomes of hanging-related out-of-hospital cardiac arrest. Prehospital Emergency Care 2020;3:369-377.

Alqahtani S, Nehme Z, Williams B, Bernard S and Smith K. Changes in the incidence of out-of-hospital cardiac arrest: Differences between cardiac and non-cardiac aetiologies. Resuscitation 2020;155:125-133.

Alqudah Z, Nehme Z, Williams B, Oteir A, Bernard S and Smith K. Impact of temporal changes in the epidemiology and management of traumatic out-of-hospital cardiac arrest on survival outcomes. Resuscitation In Press 2020.

Alqudah Z, Nehme Z, Williams B, Oteir A, Bernard S, Smith K. Paediatric traumatic out-of-hospital cardiac arrest: A systematic review and meta-analysis. Resuscitation. 2020;149:52-73

Ball J, Nehme Z, Bernard S, Stub D, Stephenson M and Smith K. Collateral damage: hidden impact of the COVID-19 pandemic on the out-of-hospital cardiac arrest system-of-care. Resuscitation 2020;156:157-163.

Bloom J, Smith K and Stub D. ECMO CPR – Resisting the inevitable – Editorial. Emergency Medicine Australasia 2020;32:914-916.

Haskins B, Smith K, Cameron P, Bernard S, Nehme Z, Murphey-Smith J, Metcalf M, Moussa R, Douglas H, Turnbull L and Dyson K. The impact of bystander relation and medical training on out-of-hospital cardiac arrest outcomes. Resuscitation 2020;150:72-79.

Haskins B, Nehme Z, Cameron P, Bernard S, Parker-Stebbing L and Smith K. Coles and Woolworths have installed public access defibrillators in all their stores: It is time other Australian businesses followed their lead. Emergency Medicine Australasia 2020;32:166-8.

Hui-Chen H, Parsons S, The A, Sanders P, Neil C, Leong T, Koshy A, Vohra J, Kalman J, Smith K, O'Donnell D, Hare D, Farouque O, and Lim H. Characteristic Histopathological Findings and Cardiac Arrest Rhythm in Isolated Mitral Valve Prolapse and Sudden Cardiac Death. Journal of the American Heart Association. 2020; 9(7): e015587.

Kearney J, Dyson K, Andrew E, Bernard S and Smith K. Factors associated with return to work among survivors of out-of-hospital cardiac arrest. Resuscitation 2020;146:203-212.

Lim SL, Smith K, Dyson K, Pang Chan S, Earnest A, Nair R, Bernard S, Leong B, Arulanandam S, Ng Y Y and Ong M. Incidence and outcomes of out-of-hospital cardiac arrest in Singapore and Victoria: A collaborative study. Journal of the American Heart Association 2020;9:e015981.

Muller A, Dyson K, Bernard S and Smith K. Seasonal variation in out-of-hospital cardiac arrest in Victoria: Winter Peak. Prehospital Emergency Care 2020;24:769-777.

Nambiar D, Pearce J, Bray J, Stephenson M, Nehme Z, Masters S, Brink D, Smith K, Lowthian J, Arendts G, Fatovich D, Bernard S, Haskins B, Grantham H and Cameron P. Variations in the care of agitated patients in Australia and New Zealand ambulance services. Emergency Medicine Australasia 2020;32:438-445.

Paratz E, Costello B, Roswell L, Morgan N, Smith K, Thompson T, Semsarian C, Pflaumer A, James P, Stub D, La Gerche A, Zentner D and Parsons S. Can post-mortem coronary artery calcium scores aid diagnosis in young sudden death? Forensic Science, Medicine and Pathology 2020; ePub ahead of print.

Paratz E,, Rowsell L, Zentner D, Parsons S, Morgan N, Thompson T, James P, Pflaumer A, Semsarian C, Smith K, Stub D, La Gerche A for the Australian UCDP Registry. Cardiac arrest and sudden cardiac death registries: systematic review of global coverage. Open Heart 2020; 7:e001195. doi:10.1136/openhrt-2019-001195.

Paratz ED, Rowsell L, van Heusden A, Zentner D, Parsons S, Morgan N, Thompson T, James P, Pflaumer A, Semsarian C, Ingles J, Case R, Ball J, Smith K, Stub D, La Gerche A, for the Australian EndUCD Registry. The End Unexplained Cardiac Death (EndUCD) Registry for Young Australian Sudden Cardiac Arrest. Heart Lung Circ 2020: ePub ahead of print.

2019

Alqahtani S, Nehme Z, Williams B, Smith K. Emergency medical services and cardiac arrest from drug overdose: a protocol for a systematic review of incidence and survival outcomes. JBI Database System Rev Implement Rep. 2019;17(4):500-6.

Alqahtani S, Nehme Z, Williams B, Smith K. The incidence and outcomes of out-of-hospital cardiac arrest precipitated by drug overdose. A systematic review and meta-analysis. Resuscitation. 2019; 134: 10-18

Alqahtani S, Nehme Z, Williams B, Bernard S and Smith K. Long term trends in the epidemiology of out-of-hospital cardiac arrest precipitated by suspected drug overdose. Resuscitation 2019;144:17-24.

Alqudah Z, Nehme Z, Williams B, Oteir A, Bernard S, Smith K. A descriptive analysis of the epidemiology and management of paediatric traumatic out-of-hospital cardiac arrest. Resuscitation. 2019;140:127-34.

Andrew E, Nehme Z, Cameron P, Smith K. Drivers of increasing emergency ambulance demand. Prehosp Emerg Care. 2019.

Beck B, Smith K, Mercier E, Bernard S, Jones C, Meadley B, Clair TS, Jennings PA, Nehme Z, Burke M, Bassed R, Fitzgerald M, Judson R, Teague W, Mitra B, Mathew J, Buck A, Varma D, Gabbe B, Bray J, McLellan S, Ford J, Siedenburg J, Cameron P. Potentially preventable trauma deaths: A retrospective review. Injury. 2019;50(5):1009-16.

Beck B, Smith K, Mercier E, Gabbe B, Bassed R, Mitra B, Teague W, Siedenburg J, McLellan S, Cameron P. Differences in the epidemiology of out-of-hospital and in-hospital trauma deaths. PLoS ONE. 2019;14(6):e0217158.

Bray JE, Smith K, Hein C, Finn J, Stephenson M, Cameron P, Stub D, Perkins GD, Grantham H, Bailey P, Brink D, Dodge N, Bernard S. The EXACT protocol: A multi-centre, single-blind, randomised, parallel-group, controlled trial to determine whether early oxygen titration improves survival to hospital discharge in adult OHCA patients. Resuscitation. 2019;139:208-13.

Colbeck M, Swain A, Gibson J, Parker L, Bailey P, Burke P, Caffey M, Kinnear F. Australasian paramedic clinical practice guidelines for managing cardiac arrest: an appraisal. 2019. 2019;16.

Dolerenzo A, Nehme Z, Yates J, Bernard S, Smith K. Double sequential external defibrillation for refractory ventricular fibrillation out-of-hospital cardiac arrest: A systematic review and meta-analysis. Resuscitation. 2019; 135: 124-129

Dyson K, Brown SP, May S, Smith K, Koster RW, Beesems SG, Kuisma M, Salo A, Finn J, Sterz F, Nürnberger A, Morrison LJ, Olasveengen TM, Callaway CW, Shin SD, Gräsner J-T, Daya M, Ma MH-M, Herlitz J, Strömsöe A, Aufderheide TP, Masterson S, Wang H, Christenson J, Stiell I, Vilke GM, Idris A, Nishiyama C, Iwami T, Nichol G. International variation in survival after out-of-hospital cardiac arrest: A validation study of the Utstein template. Resuscitation. 2019;138:168-81.

Eastwood D, Andrew E, Smith K, Nair R, Nehme Z, Bernard S, Dyson K. Exercise-related out-of-hospital cardiac arrest in Victoria, Australia. Resuscitation. 2019;139:57-64.

Epinephrine in Out-of-Hospital Cardiac Arrest. N Engl J Med. 2019;380(4):394-8.

Nehme Z, Andrew E, Bernard S, Smith K. Reply to: Poor prognosis of female out-of-hospital cardiac arrest survivors: A risk assessment. Resuscitation. 2019.

Nehme Z, Andrew E, Bernard S, Smith K. Sex differences in the quality-of-life and functional outcome of cardiac arrest survivors. Resuscitation. 2019;137:21-8.

Nehme Z, Delorenzo A, Yates J, Bernard S, Smith K. 'Reply to:' Importance of the distinction between recurrent and shock-resistant ventricular fibrillation: Call for a uniform definition of refractory VF. Resuscitation. 2019;138:306-7.

Nehme Z, Smith K. More evidence that out-of-hospital cardiac arrest is preventable. Resuscitation. 2019.

Nehme Z, Andrew E, Bernard S, Haskin B, Smith K. Trends in survival from out-of-hospital cardiac arrests defibrillated by paramedics, first responders and bystanders. Resuscitation 2019;143:85-91.

Higher Degree by Research students using VACAR data

VACAR fosters a significant body of work produced by Higher Degree by Research students from a number of different Universities both nationally and internationally. Two examples of current PhD students utilising VACAR data are below:

Zainab M Alqudah

Trends in the epidemiology and outcomes of traumatic out-of-hospital cardiac arrest in Victoria, Australia

The mortality rate from cardiac arrest associated with trauma is exceptionally high, with the majority of deaths occurring in the prehospital setting. Although there are tremendous efforts to reduce the mortality rate, achieving return of spontaneous circulation in the field remains difficult for reasons not well understood. Therefore, more detailed information relating to the changes in the epidemiology, prehospital management, and outcomes of traumatic out-of-hospital cardiac arrest (OHCA) are needed to identify opportunities to improve the system response for this population. In this project, we are performing several observational studies to investigate the impact of temporal changes in the epidemiology and prehospital management of traumatic OHCA on survival outcomes in Victoria, Australia, using data from the Victorian Ambulance Cardiac Arrest Registry. The findings of this project will inform the future direction of prehospital management for traumatic OHCA patients.

Brian Haskins

Optimisation of first responders for out-of-hospital cardiac arrest in a Victorian setting

In Australia, there are over 25,000 out-of-hospital cardiac arrests (OHCA) annually with a survival rate of just 9-12%. International studies have shown that a substantial positive impact can be made on survival rates, by providing the initial links in the ‘Chain of Survival’ before the arrival of ambulance paramedics. These links are, calling 000, providing bystander CPR and early defibrillation using Public Access Defibrillators (PAD). Using data from the Victorian Ambulance Cardiac Arrest Registry, we are conducting a number of retrospective observational studies to examine the effect of bystander CPR and defibrillation on survival outcomes for OHCA in Victoria. We are also conducting an online survey of GoodSAM First Responders in Victoria and New Zealand, to investigate the functionality of the GoodSAM app and the incidence of long-term Post Traumatic Stress Disorder experienced by GoodSAM first responders. This project will help inform the ongoing development of Heart Safe Communities and first responder programs in Victoria.

List of Abbreviations

ABS	Australian Bureau of Statistics
ACO	Ambulance Community Officer
ALS	Advanced Life Support
AED	Automated external defibrillator
AV	Ambulance Victoria
CCF	Chest Compression Fraction
CERT	Community Emergency Response Team
CFA	Country Fire Authority
CI	Confidence Interval
CPR	Cardiopulmonary Resuscitation
CSO	Clinical support officer
DHHS	Department of Health and Human Services
ECC	External Chest Compressions
ECG	Electrocardiogram
EMS	Emergency Medical Services
EQ-5D	EuroQoL 5 Dimension questionnaire
FRV	Fire Rescue Victoria
GOS-E	Extended Glasgow Outcome Scale
HP CPR	High-performance CPR
HRQoL	Health-related quality of life
LGA	Local Government Area
MCS	Mental Component Summary of the SF-12 survey
MICA	Mobile Intensive Care Ambulance
OHCA	Out-of-Hospital Cardiac Arrest
OR	Odds Ratio
PCR	Patient Care Record
PCS	Physical Component Summary of the SF-12
PEA	Pulseless Electrical Activity
ROSC	Return of Spontaneous Circulation
VACAR	Victorian Ambulance Cardiac Arrest Registry
SF-12	Twelve-item Short Form health survey
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia

Ambulance Victoria key initiatives over time

Table 7 outlines the start dates of a number of important AV programs and initiatives since the initiation of the VACAR, in 1999, up to the current fiscal year. Some of these initiatives are likely to have driven improvements in patient outcomes in this report.

Table 7: Key Ambulance Victoria and other national/international initiatives impacting cardiac arrest outcomes in Victoria, since the establishment of the VACAR.

Year	AV and other national/international cardiac arrest initiatives
1999 - 00	▶ Victorian Ambulance Cardiac Arrest Registry (VACAR) established ▶ Pilot of firefighters as first responders in central Melbourne
2000 - 01	▶ Metropolitan Ambulance Service and Rural Ambulance Victoria start training paramedics in Advanced Life Support (ALS)
2001 - 02	▶ Roll out of firefighters as first responders across metropolitan Melbourne ▶ Victorian State Government announces funding for a Public Access Defibrillation (PAD) program
2003 - 04	▶ CPR awareness program launched in Victoria by Metropolitan and Rural Ambulance Services
2004 - 05	▶ Commencement of VACIS in-field electronic data capture system and linked clinical database in Metropolitan Ambulance Service
2005 - 06	▶ Completion of VACIS roll-out in ambulances servicing metropolitan regions of Victoria ▶ Australian Resuscitation Council (ARC) Guidelines update 2006
2006 - 07	▶ Simplification of telephone-assisted CPR instructions to 400 compressions before mouth-to-mouth
2007 - 08	▶ Pilot of volunteer firefighters as first responders in peripheral Melbourne ▶ Pre-hospital therapeutic hypothermia for selected patients
2008 - 09	▶ AV Dispatch Grid review/monitoring to increase accuracy of event prioritisation and Medical Priority Dispatch System coding, as well as increase appropriateness of dispatched care ▶ Completion of VACIS roll-out in ambulances servicing rural regions of Victoria ▶ Metropolitan Ambulance Service, Rural Ambulance Victoria and Alexandra District Ambulance Service merge to form Ambulance Victoria (AV) ▶ AV commences AED Registry which records the locations of AEDs across Victoria

Year	AV and other national/international cardiac arrest initiatives
2010 - 11	► 2011 ARC Guidelines update ► AV CPR awareness programs hits milestone of 800,000 people trained since 2004
2011 - 12	► Pilot of firefighter first responders in peripheral Melbourne and one rural location ► Expansion of operating area for MICA Single Responder Units in metropolitan areas ► Victorian State Government announces funding for mobile intensive care (MICA) single responder units (SRUs) in rural areas
2013 - 14	► Electronic call-taking algorithm implemented in rural areas
2014 - 15	► Update and simplification of the Utstein template for uniform collection and reporting of OHCA data ► AV Dispatch Grid review and implementation of revised grid ► Victorian Government commits to expanding firefighter first responder program to all integrated (staffed by both fulltime and volunteer firefighters) fire stations
2015 - 16	► 2016 ARC Guidelines update ► AV OHCA Guidelines updated ► Commenced rollout of firefighter first responders at all integrated fire stations across Victoria
2017 - 18	► More than 95,000 OHCA cases entered into VACAR ► AV CPR awareness programs train more than 1 million people since 2004 ► Upgrade of the AV AED Registry and publicity campaign encouraging AED owners to register their devices ► Pilot of real-time and post-event feedback on CPR quality for paramedics ► Roll out of the GoodSAM first responder app to paramedics and members of partner organisations
2018 - 19	► VACAR contains 20 years of Victorian OHCA data ► The 100,000th OHCA case entered into VACAR ► Roll out of High-Performance CPR for EMS management of OHCA ► Expansion of the GoodSAM first responder app to appropriately first-aid trained members of the public ► Establishment of Sudden Cardiac Arrest Australia (SCAA) support group for cardiac arrest survivors
2019 - 20	► More than 110,000 cases entered into VACAR ► Introduction of the Team Performance Report for cardiac arrest debrief ► Impact of COVID-19 on OHCA outcomes monitored in real-time; findings used to reinforce maintaining the links in the Chain of Survival where possible and to educate the public on CPR/AED use

Definitions used in this Report

Adults	Patients aged greater than 15 years of age, or where the age is missing/unknown.
Dead on arrival	Cases for which paramedics determine a patient to be deceased on arrival.
Died at scene	Patients who receive an EMS attempted resuscitation but do not survive to transport.
Emergency Medical Services (EMS)	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 emergency call 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)	Return of spontaneous circulation (i.e. 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 automated external defibrillator.
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.

The VACAR Group

VACAR Chief Investigators

Prof Karen Smith (Chair)
Director, Centre for Research & Evaluation
Ambulance Victoria

Prof Stephen Bernard
Medical Director
Ambulance Victoria

VACAR Staff

Dr Jocasta Ball
Senior Research Fellow, Centre for Research & Evaluation
Ambulance Victoria

Dr Resmi Nair
Performance Analyst, Centre for Research & Evaluation
Ambulance Victoria

Ms Kimberley Magain
Data Processor, Centre for Research & Evaluation
Ambulance Victoria

Ms Davina Vaughan
Data Processor, Centre for Research & Evaluation
Ambulance Victoria

Mr Dale Oldis
Data Processor, Centre for Research & Evaluation
Ambulance Victoria

Mrs Vanessa Blake
Research Officer, Centre for Research & Evaluation
Ambulance Victoria

VACAR Steering Committee

Prof Karen Smith (Chair)
Director, Centre for Research & Evaluation
Ambulance Victoria

Prof Stephen Bernard
Medical Director
Ambulance Victoria

Prof Peter Cameron
Pre-hospital, Emergency and Trauma Unit
Monash University

Prof John McNeil
Head School of Public Health and Preventative Medicine
Monash University

A/Prof Mick Stephenson
Executive Director, Emergency Operations
Ambulance Victoria

Mr Ross Salathiel
Clinical Manager
Ambulance Victoria

Dr Chris James
Paediatric Intensive Care Consultant
Royal Children's Hospital

Dr Jocasta Ball
Senior Research Fellow
Ambulance Victoria

References

- Andrew E, Nehme Z, Bernard S, Abramson M, Newbigin E, Piper B, Dunlop J et al. Stormy weather: a retrospective analysis of demand for emergency medical services during epidemic thunderstorm asthma. BMJ. 2017:j5636.
- Australian Commission on Safety and Quality in Health Care. Economic evaluation of clinical quality registries: Final report. Sydney: ACSQHC; 2016.
- Ball J, Nehme Z, Bernard S, Stub D, Stephenson M and Smith K. Collateral damage: hidden impact of the COVID-19 pandemic on the out-of-hospital cardiac arrest system-of-care. Resuscitation 2020;156:157-163.
- Beck B, Bray J, Smith K, Walker T, Grantham H, Hein C, Thorrowgood M et al. Establishing the Aus-ROC Australian and New Zealand out-of-hospital cardiac arrest Epistry. BMJ Open. 2016; 6(4):e011027.
- Berdowski J, Berg R, Tijssen J and Koster R. Global incidence of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation. 2010; 81(11)1479-87.
- Blewer AL, Fu Wah Ho A, Shahidah N, White AE, Pek PP, Ng YY et al. Impact of bystander-focused public health interventions of cardiopulmonary resuscitation and survival: a cohort study. Lancet Public Health. 2020; 5:e428-436.
- Bobrow BJ, Vadeboncoeur TF, Stolz U, Silver AE, Tobin JM, Crawford SA et al. The influence of scenario-based training and real-time audiovisual feedback on out-of-hospital cardiopulmonary resuscitation quality and survival from out-of-hospital cardiac arrest. Ann Emerg Med. 2013; 62:47-56 e1.
- Bray J, Deasy C, Walsh J, Bacon A, Currell A and Smith K. Changing EMS dispatcher CPR instructions to 400 compressions before mouth-to-mouth improved bystander CPR rates. Resuscitation. 2011; 82:1393-8.
- CARES (Cardiac Arrest Registry to Enhance Survival) 2019 Annual Report, https://mycares.net/).
- Chatalas H, editor. 2019. Division of Emergency Medical Services 2019 Annual Report to the King County Council. Seattle, WA.
- Deasy C, Bray J, Smith K, Hall D, Morrison C, Bernard S and Cameron P. Paediatric traumatic out-of-hospital cardiac arrests in Melbourne, Australia. Resuscitation. 2012; 83(4):471-5.
- Dicker B, Oliver V and Tunnage B. 2020. Out-of-Hospital Cardiac Arrest Registry Annual Report 2018/19.
- Dyson S. NSW Ambulance Cardiac Arrest Registry, 2018 Report. Rozelle [NSW]: NSW Ambulance; 2020.
- Eisenberg M, Lippert FK, Castren M, Moore F, Ong M, Rea T et al. Improving Survival from Out-of-Hospital Cardiac Arrest: Acting on the Call. 2018.
- Fridman M, Barnes V, Whyman A, Currell A, Bernard S, Walker T and Smith K. A model of survival following pre-hospital cardiac arrest based on the Victorian Ambulance Cardiac Arrest Register. Resuscitation 2007; 75(2): 311-22.
- Gräsner J, Wnent J, Herlitz J, Perkins GD, Lefering R, Tjelmeland I et al. Survival after out-of-hospital cardiac arrest in Europe—Results of the EuReCa TWO study. Resuscitation 2020;148:218-26.
- Duckett S, Jorm C and Danks L. 2017. Strengthening Safety Statistics: how to make hospital safety data more useful. Grattan Institute.
- Hopkins CL, Burk C, Moser S, Meersman J, Baldwin C and Youngquist ST. Implementation of pit crew approach and cardiopulmonary resuscitation metrics for out-of-hospital cardiac arrest improves patient survival and neurological outcome. J Am Heart Assoc. 2016;5.
- Kearney J, Dyson K, Andrew E, Bernard S and Smith K. Factors associated with return to work among survivors of out-of-hospital cardiac arrest. Resuscitation 2020; 146:203-12.
- Lijovic M, Bernard S, Nehme Z, Walker T and Smith K; Victorian Ambulance Cardiac Arrest Registry Steering Committee. Public access defibrillation—results from the Victorian Ambulance Cardiac Arrest Registry. Resuscitation. 2014; 85(12):1739-44.
- London Ambulance Service Cardiac Arrest Annual Report: 2018/19.
- McGough J and Faraone S. Estimating the size of treatment effects: Moving beyond P values. Psychiatry. 2009; 6(10):21-9.
- Muller A, Dyson K, Bernard S and Smith K. Seasonal variation in out-of-hospital cardiac arrest in Victoria: Winter Peak. Prehospital Emergency Care 2020;24:769-777
- Nehme Z, Andrew E, Cameron P, Bray J, Meredith I, Bernard S and Smith K. Direction of first bystander call for help is associated with outcome from out-of-hospital cardiac arrest. Resuscitation. 2014; 85(1):42-8.
- Nehme Z, Namachivayam S, Forrest A, Butt W, Bernard S and Smith K. Trends in the incidence and outcome of paediatric out-of-hospital cardiac arrest: A 17-year observational study. Resuscitation. 2018; 128 (1):43-50.
- Nichol G, Rumsfeld J, Eigel B, Abella B, Labarthe D, Hong Y et al. Essential features of designating out-of-hospital cardiac arrest as a reportable event: a scientific statement from the American Heart Association Emergency Cardiovascular Care Committee; Council on Cardiopulmonary, Perioperative, and Critical Care; Council on Cardiovascular Nursing; Council on Clinical Cardiology; and Quality of Care and Outcomes Research Interdisciplinary Working Group. Circulation. 2008; 117(17):2299-308.
- OHCAR (Out-of-Hospital Cardiac Arrest Register) Ireland Annual Report 2019.
- Ong M, Shin S, De Souza N, Tanaka H, Nishiuchi T, Song K et al. Outcomes for out-of-hospital cardiac arrests across 7 countries in Asia: The Pan Asian Resuscitation Outcomes Study (PAROS). Resuscitation 96 (2015) 100–110.
- Pearson DA, Darrell Nelson R, Monk L, Tyson C, Jollis JG, Granger CB et al. Comparison of team-focused CPR vs standard CPR in resuscitation from out-of-hospital cardiac arrest: Results from a statewide quality improvement initiative. Resuscitation. 2016; 105:165-172.

- Perkins G, Jacobs I, Nadkarni V, Berg RA, Bhanji F, Biarent D et al. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: A Statement for Healthcare Professionals From a Task Force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Resuscitation. 2015; 96:328-40.
- Rabin R and de Charro F. EQ-5D: a measure of health status from the EuroQol Group. Annals of Medicine. 2001; 33(5):337-43.
- Rumsfeld JS, Brooks SC, Aufderheide TP, Leary M, Bradley SM, Nkonde-Price C et al. Use of mobile devices, social media, and crowdsourcing as digital strategies to improve emergency cardiovascular care. Circulation. 2016; 134:e87-108.
- Semeraro F, Zace D, Bigham BL, Scapigliati A, Ristagno G, Bhanji F et al. First responder engaged by technology. Consensus on Science with Treatment Recommendations [Internet]. Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) EIT Task Force, 2019 January 5. Available from http://ilcor.org.
- Smith K, Andrew E, Lijovic M, Nehme Z and Bernard S. Quality of life and functional outcomes 12-months after out-of-hospital cardiac arrest. Circulation. 2015 13;131(2):174-81.
- Soreide E, Morrison L, Hillman K, Monsieurs K, Sunde K, Zideman D et al. The formula for survival in resuscitation. Resuscitation. 2013; 84:1487-1493.
- St John Ambulance WA, Out-of-Hospital Cardiac Arrest Report 2019.
- Stub D, Nehme Z, Bernard S, Lijovic M, Kaye D and Smith K. Exploring which patients without return of spontaneous circulation following ventricular fibrillation out-of-hospital cardiac arrest should be transported to hospital? Resuscitation. 2014; 5(3):326-33.
- Stub D, Smith K, Bray, J, Bernard S, Duffy SJ and Kaye D. Hospital characteristics are associated with patient outcomes following out-of-hospital cardiac arrest. Heart. 2011; 97(18):1489-94.
- Szende A and Williams A, editors. Measuring Self-Reported Population Health: An International Perspective based on EQ-5D. Rotterdam (The Netherlands): SpringMed Publishing; 2004.
- The Resuscitation Academy. 10 Steps for Improving Survival from Sudden Cardiac Arrest. https://resuscitationacademy.org.
- Valeriano A, Van Heer S, de Champlain F, Brooks SC. Crowdsourcing to save lives: a scoping review of bystander alter technologies for out-of-hospital cardiac arrest. Resuscitation. 2021; 158:94-121.
- Vellano K, Crouch A, Rajdev M and McNally B. CARES Report on the Public Health Burden of Out-of-Hospital Cardiac Arrest, Institute of Medicine (June 2015).
- Ware J Jr, Kosinski M and Keller S. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. Medical Care. 1996; 34(3):220-33.
- Wilson J, Pettigrew L and Teasdale G. Structured interviews for the Glasgow Outcome Scale and the extended Glasgow Outcome Scale: guidelines for their use. Journal of Neurotrauma. 1998; 15 (8): 573-85.

In an emergency call Triple Zero (000)

Ambulance Membership 1800 64 84 84

Ambulance Victoria
PO Box 2000
Doncaster VIC 3108

T 03 9840 3500

ambulance.vic.gov.au