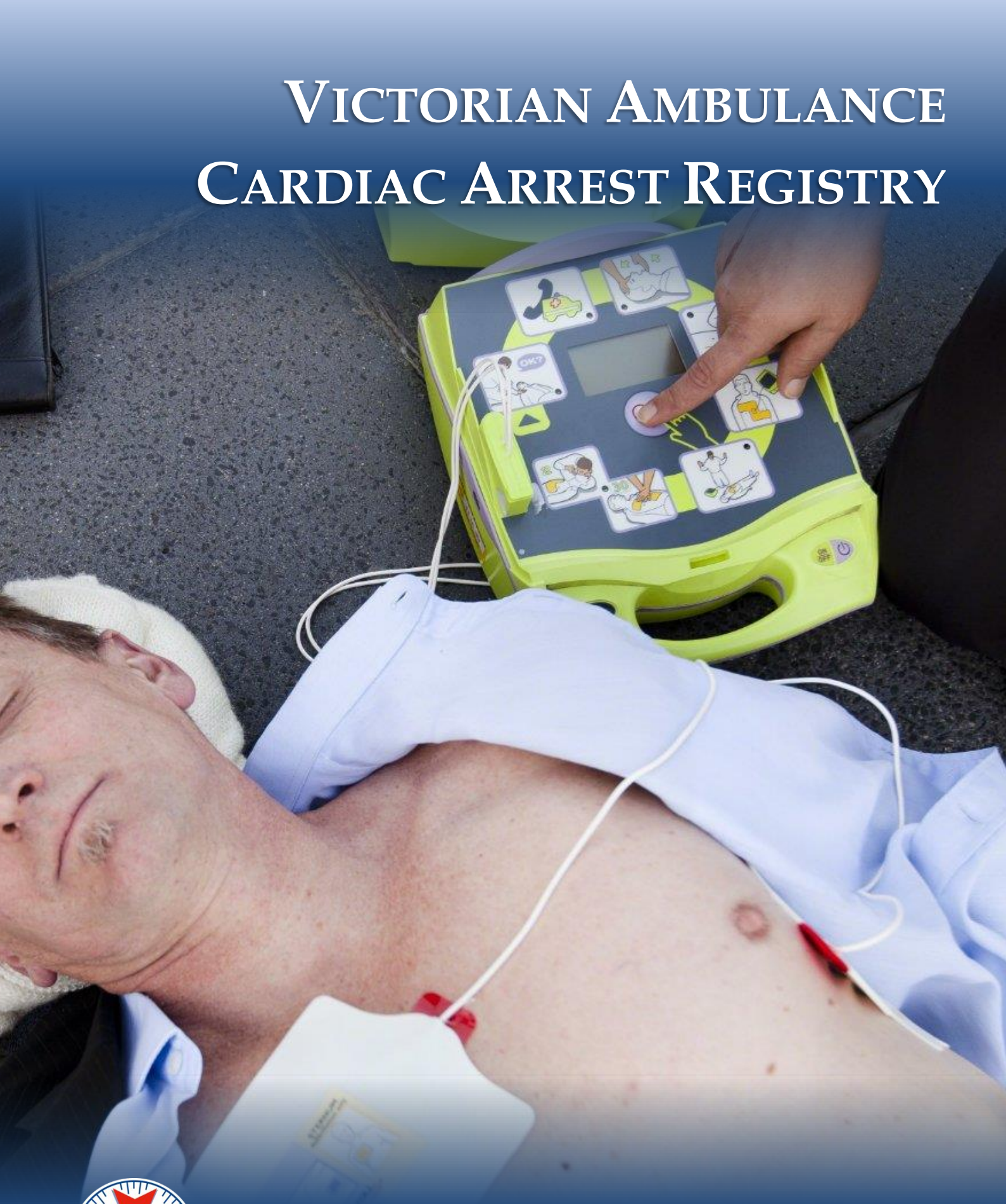
Victorian Ambulance Cardiac Arrest Registry



Annual Report 2014-2015

Victorian Ambulance Cardiac Arrest Registry
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Introduction

Out-of-hospital cardiac arrest (OHCA) is a significant public health issue. In Australia, as many as 30,000 OHCAs occur every year – with less than 10% surviving. However, when cardiopulmonary resuscitation (CPR) and defibrillation are provided quickly and there is an effective system of care, the chance of successfully resuscitating a cardiac arrest patient with good neurological recovery is possible.

In order to improve systems of care and patient outcomes, it is essential to monitor performance, identify problems and successes and track progress. This can be achieved through a registry where consecutive patients are enrolled to create complete patient populations. A registry can drive a quality agenda and fosters a performance culture. Ambulance paramedics and first responders such as fire fighters, often with bystanders, comprise the front line in resuscitation from OHCA. As such, measuring the response, treatment and outcomes of OHCA patients is an essential component of an ambulance quality of care agenda.

The Victorian Ambulance Cardiac Arrest Registry (VACAR) has been collecting data on cardiac arrest patients attended by ambulance in Victoria since 1999 and is one of the most comprehensive OHCA registries in the world. On behalf of Ambulance Victoria, we are very pleased to present the 2014-2015 VACAR Annual Report.

Associate Professor Karen Smith
Manager Research and Evaluation
Ambulance Victoria

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Senior Medical Advisor
Ambulance Victoria

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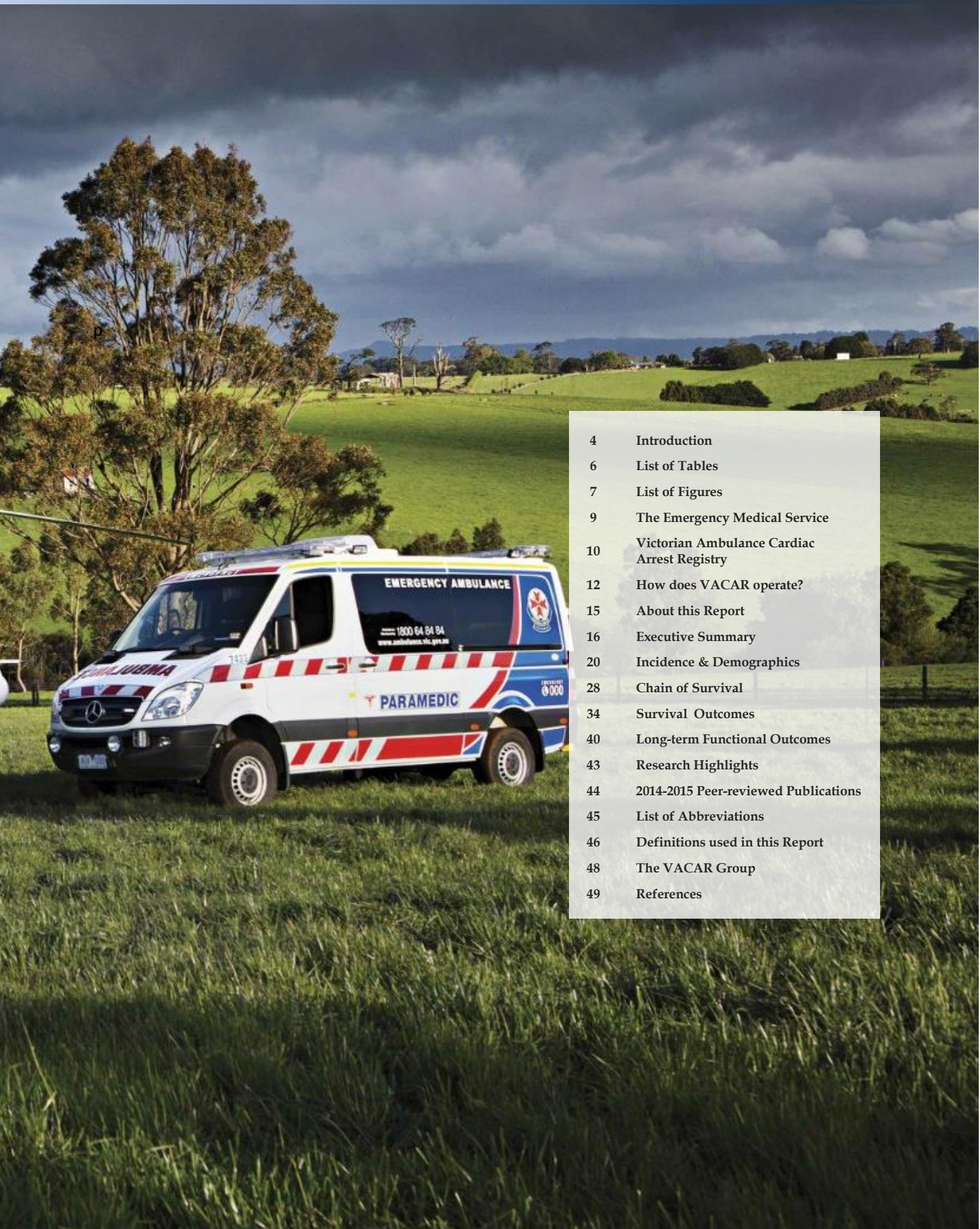

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EMERGENCY AMBULANCE

The Emergency Medical Service

The state of Victoria, Australia has an estimated population of 5.8 million, with 76% living in the state's capital city of Melbourne. Thirteen per cent of the population are aged over 65 years. The emergency medical service (EMS) comprises ambulance paramedics who have some 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.

Australia operates a single national telephone number for community access to emergency services (i.e. "000"). Telephone triage of emergency calls is performed using the Medical Priority Dispatch System. Unless circumstances suggest ventilations first (e.g. drowning), suspected cardiac arrest events identified in-call receive further call-taker instruction recommending 600 chest compressions until 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 the inner and some peripheral areas of Melbourne. In addition, AV co-responds with 29 volunteer community teams in smaller, predominately rural communities across the state.

The AV cardiac arrest protocols follow the recommendations of the Australian Resuscitation Council. AV paramedics are not obliged to commence resuscitation when the clinical presentation is inconsistent with life. Paramedics may discontinue resuscitation if advanced life support has been performed for 30 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.

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 Associate Professor Karen Smith (Manager Research & Evaluation, Ambulance Victoria).

The VACAR is a clinical quality assurance initiative, 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 78,000 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, the rate of successful defibrillation, event survival and survival to hospital discharge.

The VACAR is also used to measure the impact of ambulance programs such as the Firefighter Emergency Medical Response Program, Four Steps to Life Plus CPR training and Public Access Defibrillation (for more information, see www.ambulance.vic.gov.au). In addition, VACAR has successfully established an internationally recognised research program, with the publication of scientific literature in key medical journals (see 2014-2015 Peer-reviewed Publications, page 44).

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 VACAR provides a robust framework for the measurement of immediate, early and long term quality clinical outcomes following OHCA in Victoria.


AMBULANCE
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 opposite (see Tables 2 & 3).

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

1. Metropolitan Fire Brigade
2. Country Fire Authority (Limited pilot)
3. Community Emergency Response Teams

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 givers.
2. Brief episodes of pulselessness which do not receive cardiopulmonary resuscitation or defibrillation by EMS.
3. Bystander suspected a cardiac arrest, where the patient is not in cardiac arrest on arrival of EMS, or no defibrillation attempt prior to arrival, or no other evidence verifying a cardiac arrest state is present.

Data capture

The registry is based on the internationally recognised Utstein template and definitions (*Perkins et al. 2015*). Ambulance Victoria's in-field recording of patient data is performed electronically using VACIS©, an electronic data capture system. All electronic patient care records (PCR) are synchronised daily with organisational databases, providing an effective medium of clinical and administrative data capture. To ensure the capture of all OHCA cases 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 may be 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 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. ethics approved participation) 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) questionnaires.

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 research 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 AV's clinical support officers (CSOs). All cases where a patient requires defibrillation or where a death occurs in AV care undergo audit by a CSO.

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 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 almost 100 ethics approvals from Victorian hospitals for the access of 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 Ambulance Victoria, 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, 2014-2015 (n=5,657).

Patient age	94 (1.7%)
Patient sex	17 (0.3%)
Arrest location	Nil
Witnessed status	51 (0.9%)
Bystander CPR	140 (2.5%)
Rhythm on arrival	10 (0.2%)
EMS response time	4 (0.1%)
Defibrillation time	23 (0.4%)
Outcome at scene	Nil
Event survival	12 (0.2%)
Hospital discharge status	18 (0.3%)
Hospital discharge direction	3 (0.1%)


Mark Event
26 Jul 2012 11:05
A
B
SpO2 Interference
02:14
Adult Non-Paced
HR
bpm
100
150
30
Pulse bpm
-?-
II
I, II...
SpO2 %
-?-
100
90
1207261103168a7b
26-Jul-2012 11:04:58
67 years MALE
HR 101
PR 149
QRSD 132
QT 360
QTc 477
--Axis--
P 82
QRS 65
T 44
Sinus tachycardia
Right bundle branch block
ST elevation, consider inferior injury
- ABNORMAL ECG -
Unconfirmed diagnosis
Start NBP
Exit 12-Lead
New 12-Lead
Print
MENU

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.

While cardiovascular mortality has declined over the last three decades, the case-fatality rate of sudden cardiac arrest has not declined *(Nichol et al. 2008)*. OHCA is a significant cause of disability and death in Australia, with a reported incidence of 113 events per 100,000 peoples *(Berdowski et al. 2010)*. Much of the burden associated to 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 the treatment of OHCA by EMS agencies should be the sentinel measure of the quality of EMS care in our communities *(Nichol et al. 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 2014 to 30 June 2015. Data for this report was extracted on 7 September 2015, 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 46.

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 (http://health.vic.gov.au/maps/mapflash/vicpage.htm). The Melbourne metropolitan region is comprised of three geographical regions: North and West, Eastern and Southern Regions. Rural regions comprises five geographical regions: Barwon South Western, Grampians, Loddon Mallee, Hume and Gippsland Regions. 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 cases in New South Wales and South Australia which occur close to the Victorian border; these cases are attributed to the nearest Victorian Department of Health and Human Services region. Any cases which occur off the coastline of Victoria are attributed to the nearest Victorian Department of Health and Human Services region.

Population figures used in this report are defined by the Regional Population Growth reports published 18 August 2015 by the Australian Bureau of Statistics. The Victorian population estimate up to the end of June 2015 (excluding unincorporated areas) was 5,840,910 persons.

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 (e.g. time to defibrillation, presenting rhythm etc.) and may therefore skew the analyses presented in this report. Data relating to paramedic or EMS witnessed OHCA have therefore been analysed and depicted separately to those which are unwitnessed by paramedics. Unless specifically stated, all analyses should be assumed to exclude EMS witnessed events.

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 5,657 OHCA events in the period between July 2014 and June 2015, with almost 99% involving adults. The proportion of all adult patients receiving emergency treatment by EMS was 48%, or 44% of adult EMS attended arrests. The crude incidence of OHCA was higher in the rural region than in the metropolitan region: 123.8 versus 87.8 events per 100,000 population. The Gippsland region recorded the highest crude incidence rates of OHCA. However, state-wide incidence, adjusted for sex and gender, decreased over the last decade (95.3 events per 100,000 population in 2014-2015 versus 97.0 events per 100,000 population in 2005-2006). (see Incidence & Demographics, pages 21-23).
2. The demographic profile of events in 2014-2015 was similar to those observed over the last decade. OHCA precipitated by a presumed cardiac aetiology accounted for 73% of adult EMS attended events. Aside from presumed cardiac causes, sudden infant death syndrome (SIDS) was one of the leading causes of OHCA in paediatrics. Patients who arrested in a public location had significantly better survival outcomes than those who arrested in the home (see Incidence & Demographics, pages 24-27).
3. Most bystander calls for help following OHCA were appropriately directed to ambulance (95%). Emergency call-takers were effective at identifying cardiac arrest events during the emergency call; 85% of all arrests and 89% of arrests due to cardiac aetiology were correctly identified (see Chain of Survival, page 29).
4. The median state-wide response time to EMS treated events in 2014-2015 was 8.0 minutes (90^{th} percentile time, 16.4 minutes), significantly lower than observed in the previous year. The median EMS response time to EMS treated events in the metropolitan region (median 7.5 minutes, 90^{th} percentile 12.9 minutes) was similar to observations from the previous year, whilst the median EMS response time to EMS treated events in the rural regions (median 10.2 minutes; 90^{th} percentile time 24.5 minutes) was significantly lower than in the previous year (see Chain of Survival, page 29).
5. The rate of bystander CPR increased to 64% for bystander witnessed OHCA events, compared to 35% in 2005-2006). This was the highest rate of bystander CPR for the last decade. The use of automated external defibrillators by members of the public increased six-fold over the last decade for patients presenting in a shockable rhythm (see Chain of Survival, pages 30-31).
6. 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 (41% vs 30%, respectively). Similarly, when an arrest was witnessed by a bystander, the proportion of patients who were discharged alive from hospital was higher than for all OHCA events combined (16% vs 10%, respectively) (see Chain of Survival, page 32).
7. The state-wide rate of ROSC in adult EMS treated events was 40% in 2014-2015. Survival for all-cause OHCA in the EMS treated population was 10% in 2014-2015 and remains within recent observations (see Survival Outcomes, pages 35-36).
8. The rate of event survival for adult EMS treated patients presenting in a shockable rhythm was 52%, with 29% surviving to hospital discharge. For adult EMS treated patients presenting in a shockable rhythm and witnessed to arrest by EMS, event survival and survival to hospital discharge were 75% and 71%, respectively. Adults presenting in asystole or pulseless electrical activity experienced the poorest survival outcomes, with 0.5% and 8% surviving to hospital discharge, respectively (see Survival Outcomes, pages 36-37).
9. 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 2014-2015 was more than two times higher than for OHCA patients in 2002-2003 (adjusted odds ratio 2.4, 95% CI 1.8-3.1, $p<0.001$). This significant improvement was also observed for patients who presented in a shockable rhythm over the same period (adjusted odds ratio 2.9, 95% CI 2.1-4.1, $p<0.001$) (see Survival Outcomes, page 39).
10. The majority of OHCA patients with known survival to hospital discharge continued to be discharged home (86% in 2014-2015). 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, 77% had returned to work 12 months after their arrest (see Long-term Functional Outcomes, pages 40-41).

The following two pages provide an illustrated overview of 2014-2015 data, for all patients (Figure 1) and for patients presenting in a shockable rhythm (Figure 2). The notation * indicates that the data excluded EMS witnessed arrests.

Figure 1. All cardiac arrest patients, 2014-2015.

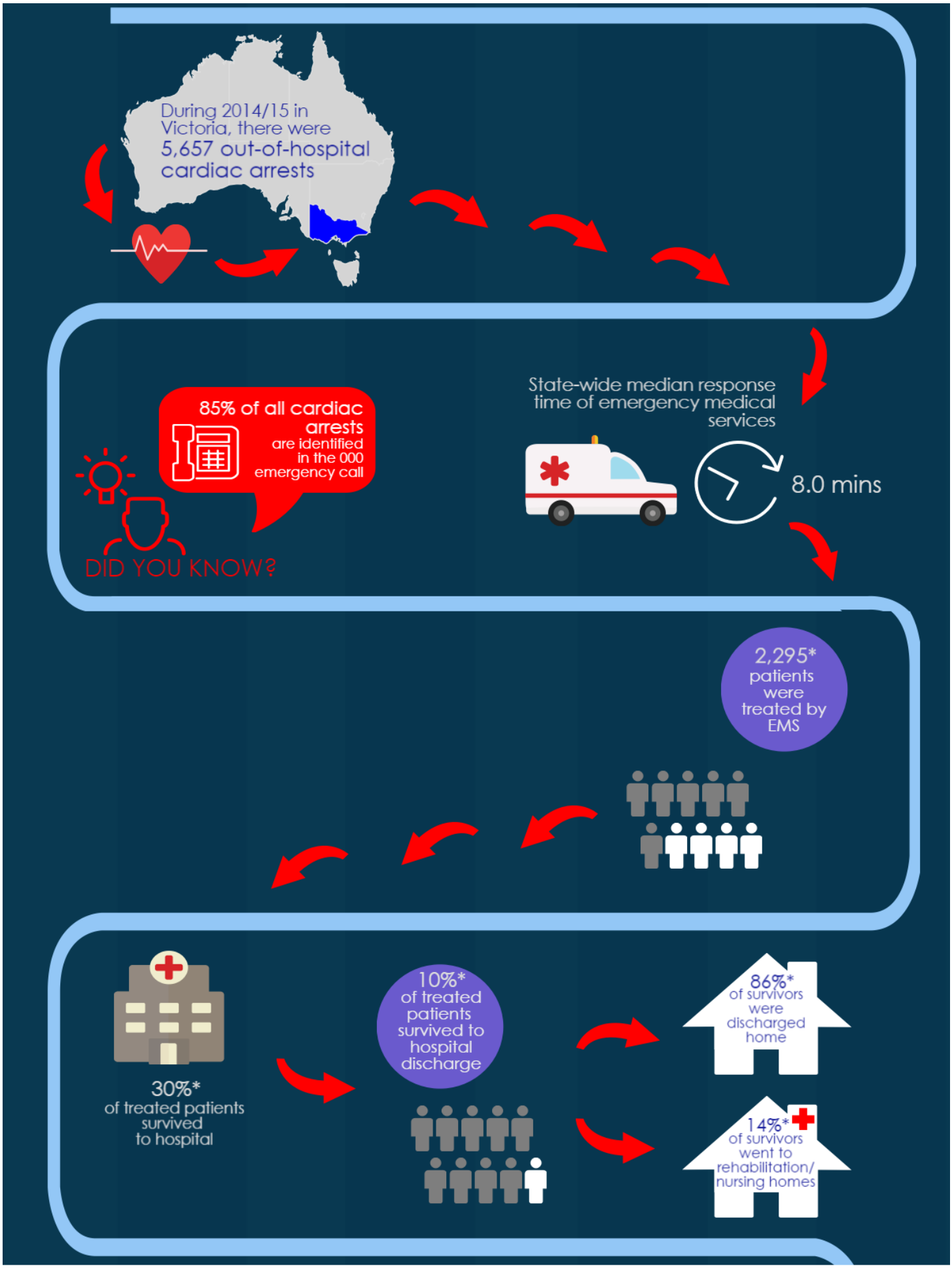
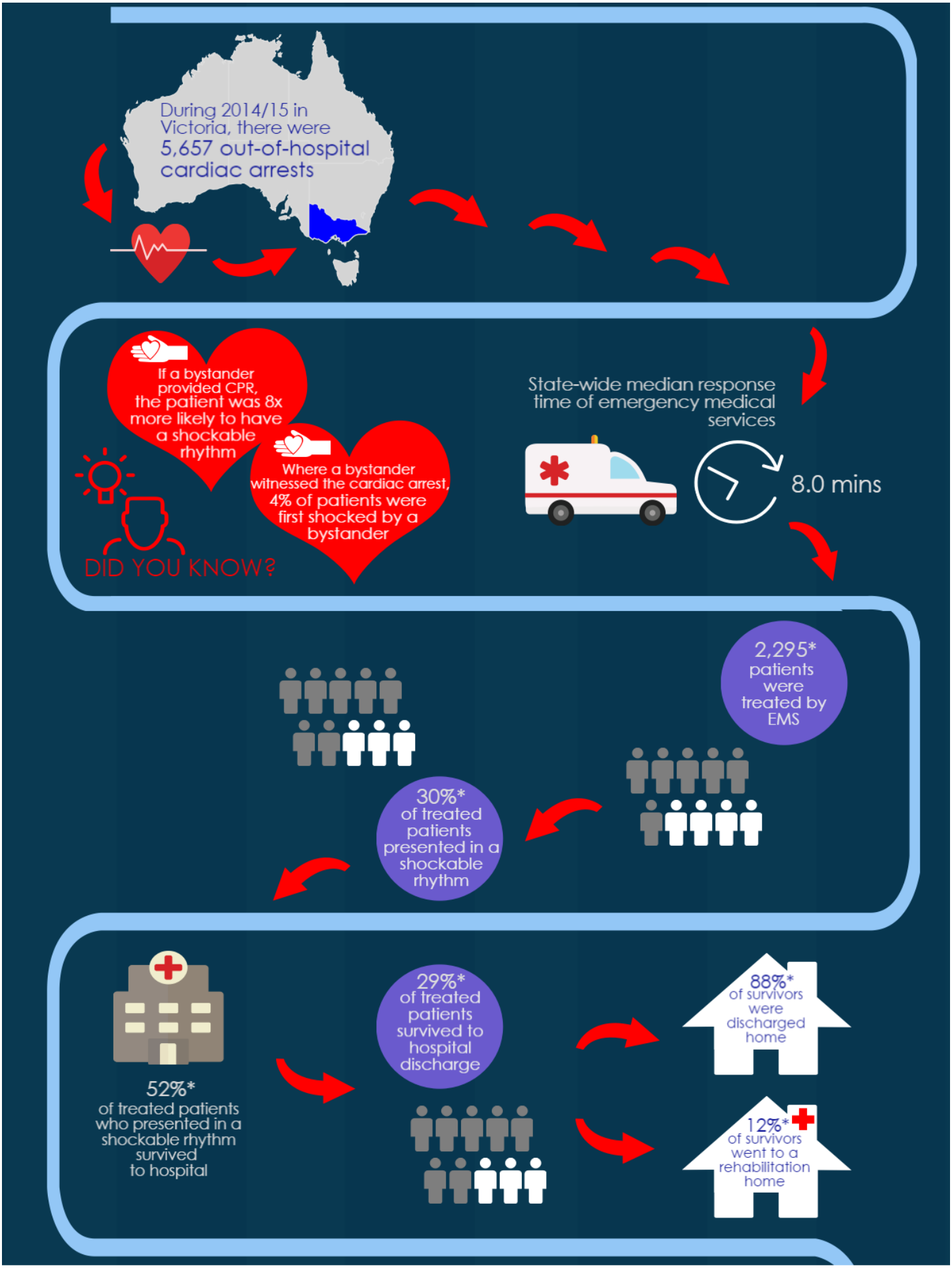


Figure 2. Cardiac arrest patients presenting in a shockable rhythm, 2014-2015.

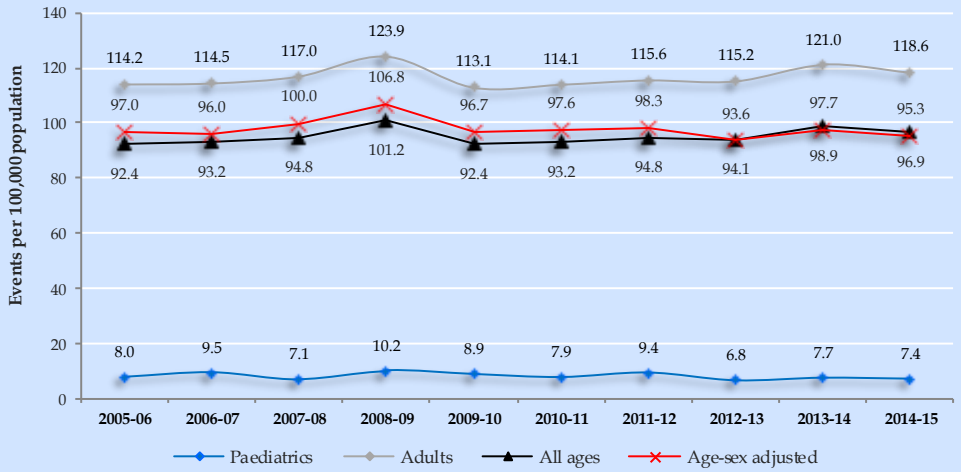



Police
VH-PVG
ulance

Incidence & Demographics

Incidence & Demographics

Figure 3: Crude incidence of all ages, adult and paediatric EMS attended OHCA in Victoria and age-sex adjusted incidence rate of EMS attended events (includes EMS witnessed events).



Incidence of all adult & paediatric events †

In 2014-2015, Ambulance Victoria attended 5,657 OHCA events, of which 5,573 (98.5%) were defined as adults aged greater than 15 years or patients with unknown age. The number of adult cases represents the highest number of events in a 10 year period. The number of paediatric events attended by paramedics remains low (84 cases in 2014-2015), though this number is within normal yearly fluctuations.

The crude incidence of OHCA has remained relatively consistent over the last decade. In 2014-2015, the unadjusted incidence of all OHCA in Victoria was 96.9 events per 100,000 population, compared with 92.4 event per 100,000 population in 2005-2006 (see Figure 3). However, when the incidence rate is adjusted for sex and gender, we note there has been a decrease in incidence over the last ten year period (95.3 events per 100,000 population in 2014-2015 versus 97.0 events per 100,000 population in 2005-2006).

The incidence of adult and paediatric events also remained within recent observations; 118.6 and 7.4 events per 100,000 population, respectively. While variation in OHCA incidence across continents and regions are well established, these figures are within previously reported incidence rates.

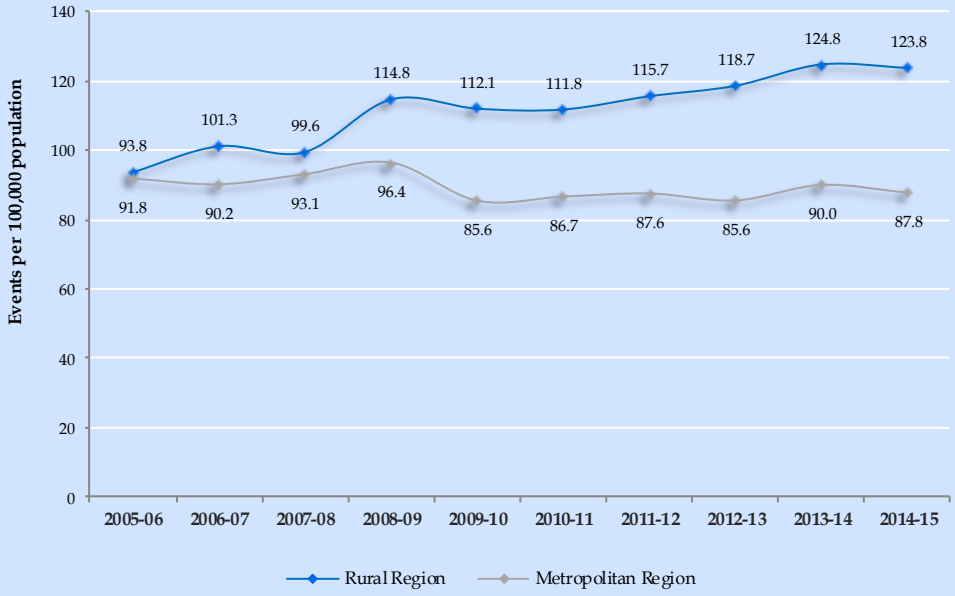
Of all adult OHCA events attended, 48% received an emergency resuscitation attempt by paramedics and/or first-responders (includes EMS witnessed events). This figure remains under 50%, as also noted in the previous fiscal year, but is significantly higher than the lowest 10 year finding in 2005-2006 (48% vs. 41%, $p<0.001$).

Lack of bystander witnesses and prolonged downtime are a major reason for EMS withholding resuscitation efforts in adult patients. The crude incidence of adult EMS treated events was 56.7 events per 100,000 population.

In paediatric events, the proportion of EMS treated events is higher than in adults, with the majority receiving an attempted resuscitation by EMS (83% in 2014-2015, includes EMS witnessed events). The trend in the rate of attempted resuscitation for paediatric events has increased over the last 10 years; this rate was 66% in 2005-2006. The crude incidence of paediatric EMS treated events was 6.2 events per 100,000 population.

† All results in this section include EMS witnessed events.

Figure 4: Yearly crude incidence of EMS attended events across metropolitan and rural regions of Victoria (includes EMS witnessed events).



In 2014-2015, Ambulance Victoria attended 5,573 adult OHCA events, one of the highest number of events in adults in recent years. The rate of attempted resuscitation by EMS remains just under 50%.

Incidence across regions of Victoria†

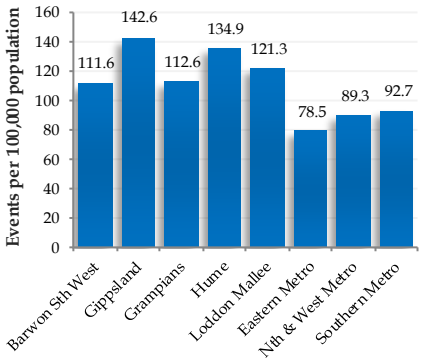


Figure 5: Crude incidence of EMS attended events across Department of Health and Human Services regions, 2014-2015.

A significantly higher number of OHCA events were observed in the metropolitan region representing 3,841 cases (68% of the total number of events attended in 2014-2015). The number of events attended in rural Victoria yielded its highest 10 year figure with 1,816 events, a 44% increase since 2005-2006.

Despite the increased proportion of events occurring in the metropolitan region, the crude incidence of OHCA was significantly higher in the rural region (123.8 vs. 87.8 events per 100,000 population, p<0.001) (see Figure 4).

† All results in this section include EMS witnessed events.

The crude incidence of OHCA has observed a steady increase over the last 10 years in rural Victoria, rising from 93.8 events in 2005-2006 to 123.8 events per 100,000 population in 2014-2015 (p<0.001). However, this observation may reflect better case capture, especially after the 2008-2009 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. Figure 3 showed that the state-wide adjusted incidence of OHCA has decreased over the last ten years.

Regional variability in OHCA incidence was observed across Department of Health and Human Services regions in 2014-2015 (see Figure 5). The lowest crude incidence was observed in the Eastern Metropolitan Region (78.5 events per 100,000 population) and the highest incidence in the Gippsland region (142.6 events per 100,000 population). The North and West Metropolitan region, which includes the Melbourne Business District, had a total of 1,698 OHCA cases. This was the highest frequency of events in the North and West Metropolitan region in the last 10 year period. Within the rural region, the Barwon South Western and Hume regions recorded their highest frequency of OHCA events over the last 10 years.

The proportion of events receiving an attempted resuscitation varies considerably across regions. The highest EMS treated proportion was found in the North and West Metropolitan region (54%) and the lowest in the Grampians region (41%).

Demographics of adults

The demographic profile of adult OHCA events (excluding EMS witnessed arrests) has been consistent over the last decade. In 2014-2015, EMS attended adult events were predominately male patients (67%). The median age of OHCA patients was 68.0 years. The age distribution varied significantly across the sexes (see Figure 6), with females having a higher median age of arrest (74.0 vs. 66.0 years, p<0.001). The proportion of cases witnessed to arrest by a bystander (32%) and occurring in a public location (14%) were similar to the previous year. Notably in 2014-2015, the proportion of adult patients receiving bystander CPR (42%) was the highest for the last decade, more than double the rate in 2005-2006 (17.0%) (p<0.001). In 2014-2015, 14% of adult OHCA patients presented in a shockable rhythm (VF or VT); defibrillation by EMS or a bystander with automated external defibrillator can restore a normal cardiac rhythm.

Paramedics attempted resuscitation in 44% 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 (70%), a lower median age (67.0 years), more events occurring in a public location (19%), more events witnessed by a bystander (55%) and an increased rate of bystander CPR (74%).

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 (76 in 2014-2015). The median age of arrest was 18 months and is driven predominantly by cardiac aetiology in this population (see Figure 9, page 25). The vast majority of paediatric OHCA occur in paediatrics aged less than three years; 55% of all arrests in this population.

The demographic profile of paediatric OHCA varies significantly across reporting years and is impacted by smaller samples sizes. In 2014-2015, EMS attended paediatric events were predominantly young males (69%). Within the paediatric OHCA population, 21% of events occurred in a public location. Significantly more paediatric patients received bystander CPR than adult patients (66% vs. 42%, p<0.001). The vast majority of paediatric patients present to EMS in an asystolic rhythm (74%). In 2014-2015, one paediatric case was defibrillated prior to the arrival of EMS by a bystander with a public automated external defibrillator. The proportion of paediatric cases receiving an attempted resuscitation by paramedics was significantly higher than for adults (82% vs 44% in 2014-2015, p<0.001).

Figure 6: Age distribution of EMS attended OHCA events, 2014-2015.

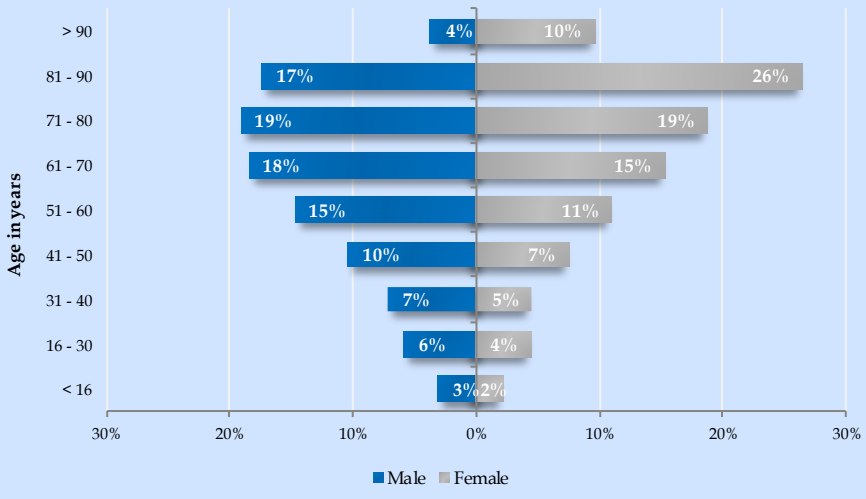
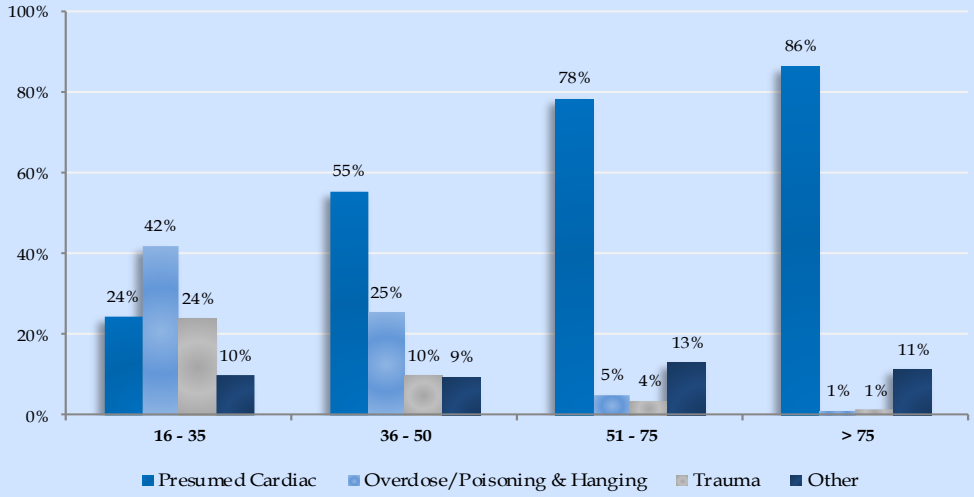


Figure 7: Adult precipitating events across age groups for EMS attended events, 2014-2015.



Precipitating events for adults

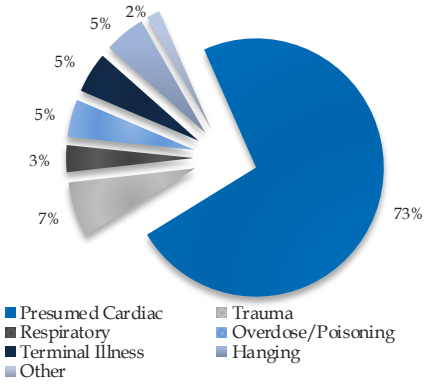


Figure 8: Adult precipitating events for EMS attended events, 2014-2015.

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 et al. 2015*). In total, VACAR records 13 precipitating events for adults, of which six are the predominant causes of arrest.

In 2014-2015, 73% of EMS attended adult OHCA were presumed to be of a cardiac cause. Arrests precipitated by trauma (7%), respiratory (3%), overdose/poisoning (5%), terminal illness (5%) and hanging (5%) were also frequent causes of OHCA (see Figure 8).

In patients receiving an attempted resuscitation by EMS, most cases were of presumed cardiac origin (79%).

The rate of EMS attempted resuscitation differed amongst patients according to the precipitating cause of the event. Compared to presumed cardiac cases, the rate of EMS attempted resuscitation is lower for arrests precipitated by trauma, overdose/poisoning, terminal illness and hangings. In 2014-2015, less than half of OHCA cases due to a presumed cardiac cause received an attempt at resuscitation by EMS (45%). Meanwhile, the majority of OHCA cases due to a respiratory cause received EMS attempted resuscitation (65%).

The precipitating event for arrests across age groups in the EMS attended population is depicted in Figure 7. This graph highlights the important relationship between arrest aetiology and patient age group. While arrests from a presumed cardiac cause dominated overall proportions, arrests secondary to overdose/poisoning, hanging and trauma accounted for the majority of arrests in the 16-35 year age group. In fact, arrests secondary to overdose/poisoning and hanging are a leading cause of arrest in patients aged 16-50 years.

Presumed cardiac causes remain the most common precipitating event for both adult and paediatric OHCA events. For adults, this accounts for the majority of cases. Meanwhile, in paediatric cases, sudden infant death syndrome, trauma and respiratory events remain common causes.

Precipitating events for paediatrics

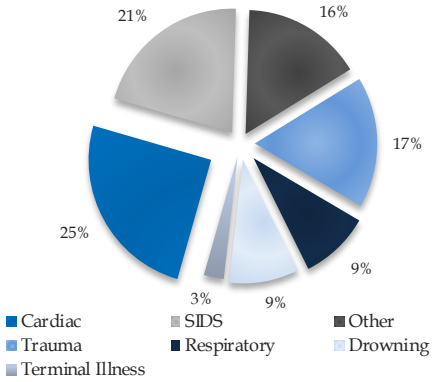


Figure 9: Paediatric precipitating events for EMS attended events, 2014-2015.

Precipitating events for paediatrics who suffer OHCA vary considerably in comparison to adults, with only 25% of EMS attended paediatric events being of a presumed cardiac cause (see Figure 9). Another overwhelming cause of OHCA in paediatrics is presumed to be secondary to SIDS (21% of events). Trauma also played a significant role in the aetiology of arrest in paediatrics and contributes strong prognostic information in this population (*Deasy et al. 2012*). The distribution of precipitating events in the EMS treated paediatric population mirrors that of the overall paediatric population.

Mechanism of arrest in the traumatic sub-group

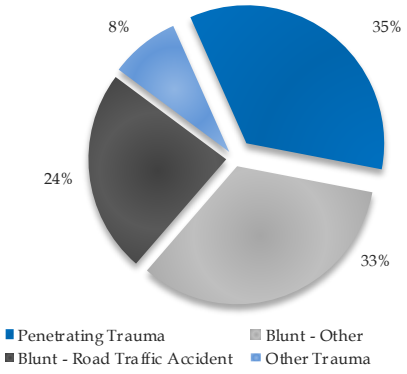


Figure 10: Sources of trauma in EMS attended traumatic OHCA sub-group, 2014-2015.

Cardiac arrests secondary to major trauma represent an important surveillance group in Victoria. In this population, arrests secondary to road trauma were responsible for 24% of traumatic OHCA in 2014-2015. Blunt trauma involving falls, crush injuries, or other blunt forces, were responsible for 33% of events, while arrests following ballistic trauma and stabbings accounted for 35% (see Figure 10).

The leading mechanism precipitating cardiac arrests associated with road trauma incidents were: a car or light vehicle (57%), train (17%) or motorcycle (14%). Of these, the majority of OHCA events involved the driver (54%). Pedestrians (26%) and vehicle passengers (14%) were less frequently the OHCA patient.


AED
AUTOMATED EXTERNAL
DEFIBRILLATOR
HEARTSTART
FR2

Bystander action in public places, including bystander cardiopulmonary resuscitation, is a key factor influencing overall survival following OHCA.

Arrest location for adults and paediatrics

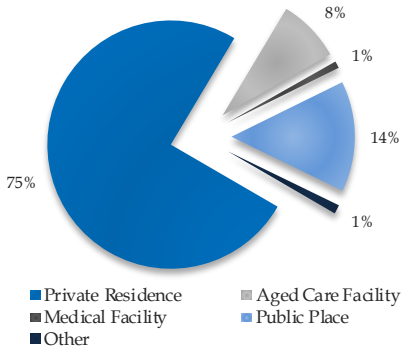


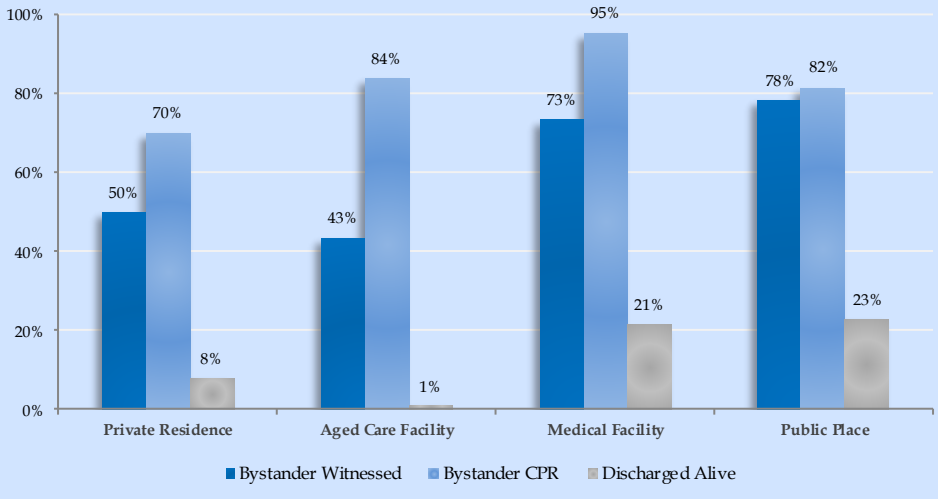
Figure 11: Location of arrest for EMS attended adult events, 2014-2015.

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 depicted in Figure 12. Public places include places of work, streets or roads, shops, vehicles and sporting/recreational facilities. In 2014-2015, 75% of EMS attended adult OHCA events occurred within a private residence, while 14% occurred in a public place (see Figure 11). Of the patients receiving an attempted resuscitation, 68% were in a private residence and 19% in a public place. 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 12).

The presence of bystanders, witnessing the arrest and/or providing CPR, in public places has an important contribution on survival for adult events occurring in these locations. Unadjusted survival to hospital discharge varied significantly between a private residence and public place (8% vs. 23%, $p<0.001$).

The locations of arrest for paediatric events were similar to those in adults. In 2014-2015, 21% of EMS attended paediatric events occurred in a public place.

Figure 12: Proportion of EMS treated adult events that are bystander witnessed, receive bystander CPR and are discharged alive across arrest locations, 2014-2015.



Chain of Survival

EARLY
ACCESS

EARLY
CPR

EARLY
DEFIBRILLATION

EARLY
ADVANCED
CARE

Chain of Survival

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

Bystander call for help

The direction of a bystander's first phone call can have a significant impact on the effective and timely delivery of CPR and defibrillation. Previous work by VACAR demonstrated that emergency call delays as a result of bystanders inappropriately directing their first call for help to neighbours, relatives or local doctor were associated with significantly poorer outcomes following OHCA (*Nehme et al. 2014*).

In 2014-2015, the first bystander call for help was correctly directed to ambulance in the majority of cases (95%). However, emergency call delays continue to exist for a small portion of cases attended, where the first call for help is instead directed to a relative/friend (2%), neighbour (1%), police (1%) or other person (1%).

Accurate identification of cardiac arrest during the emergency call is also an important factor influencing the receipt of early dispatcher-assisted CPR instructions and the timely response of emergency medical teams. In 2014-2015, 85% of EMS attended arrests were correctly identified during the emergency call. For EMS attended arrests due to presumed cardiac aetiology, 89% were correctly identified during the emergency call. For this subgroup due to presumed cardiac causes, this figure was effectively the same in the metropolitan and rural regions (89% and 90%, respectively).

Emergency response to the incident

EMS response time, or the time from the emergency call to arrival of EMS on scene, is an important measure of time to definitive resuscitation treatment by EMS. Some OHCA events may occur after the "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. The distribution of response times for the EMS treated population across regions in 2014-2015 is depicted in Figure 13.

State-wide, median response time to EMS treated events was 8.0 minutes (90th percentile time, 16.4 minutes). This was significantly lower than response times noted in the previous year (median time 8.3 minutes; 90th percentile time 17.1 minutes; p=0.004). In 2014-2015, median response times to EMS treated events in metropolitan regions was 7.5 minutes (90th percentile time 12.9 minutes) compared to 7.6 minutes (90th percentile time 13.1 minutes) in the previous year (p=0.206). Median response time in rural areas in 2014-2015 was 10.2 minutes (90th percentile time 24.5 minutes), significantly lower than in the previous year (median time 11.5 minutes; 90th percentile time 23.8 minutes; p=0.003).

Figure 13: Distribution of time from call to arrival of EMS on scene in the EMS treated population, 2014-2015.

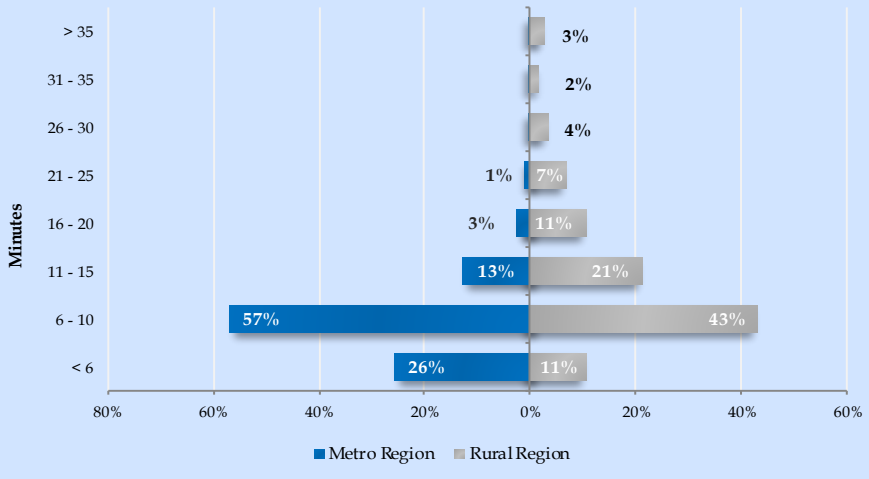
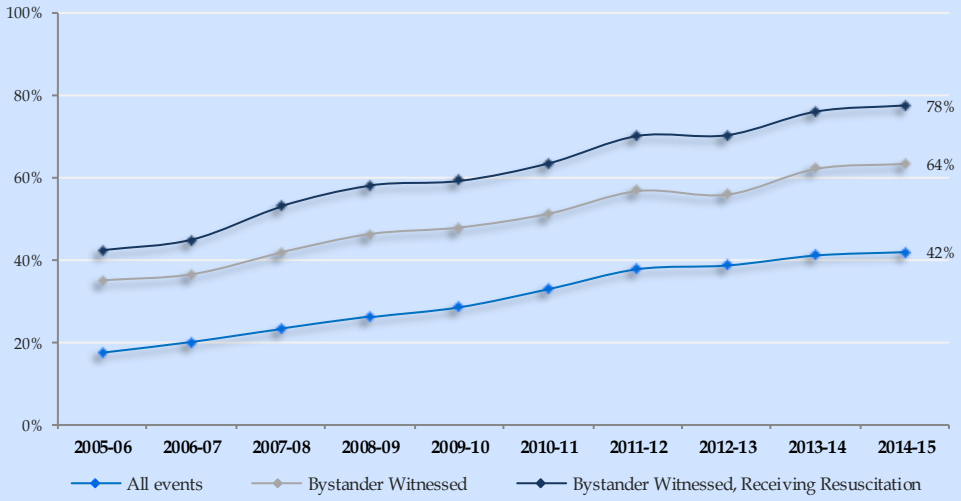


Figure 14: Bystander CPR rates.

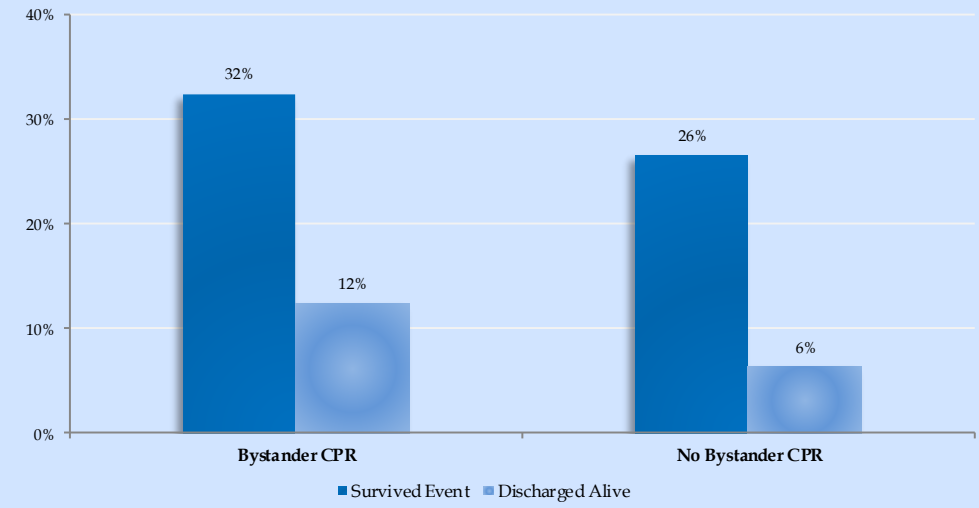


Bystander cardiopulmonary resuscitation

Previous research by VACAR has shown that early effective bystander CPR increases the likelihood of an initial shockable rhythm and greatly improves the chance of survival following OHCA (*Fridman et al. 2007*). Over the last decade in Victoria, there have been significant increases in bystanders CPR rates, which can be partly attributed to accurate identification of OHCA during the emergency call and delivery of dispatcher-assisted telephone instructions for CPR (*Bray et al. 2011*). In 2014-2015, bystanders performed CPR for 42% of all OHCA events compared to 17% in 2005-06 ($p<0.001$). Patients witnessed to collapse by bystanders had a 64% chance of receiving bystander CPR, in comparison to 35% in 2005-2006 ($p<0.001$). Of the bystander witnessed events receiving an attempted resuscitation by EMS, 78% received CPR by a bystander in 2014-2015 (see Figure 14), compared to 42% in 2005-06 ($p<0.001$). This is the highest rate of bystander CPR for the last decade.

Unadjusted likelihood of survival was strongly associated with the presence of bystander CPR (see Figure 15). In 2014-2015, for the EMS treated population, both event survival (32% vs. 26%, $p=0.016$) and survival to hospital discharge (12% vs.6%, $p<0.001$) were significantly higher in patients receiving bystander CPR compared to those with no bystander intervention.

Figure 15: Unadjusted survival outcomes after bystander CPR in the EMS treated population, 2014-2015.



Time to first defibrillation

The time from emergency call to first defibrillation for patients presenting in a shockable rhythm is a key performance indicator 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 et al. 2014*). In fact, the proportion of cases where Ambulance Victoria performed the first defibrillation has reduced significantly since 2005-2006, from 92% to 82% in 2014-2015 ($p<0.001$). This decline has been driven by a six-fold increase in the use of public automated external defibrillators (AED) by bystanders over the same period (from 1.7% to 10.3%, excluding EMS witnessed events). First defibrillation by EMS first responders has been relatively stable over this period (8% of events in 2014-2015).

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 16). While fluctuations in survival proportions are commonly observed in this analysis (small samples sizes), 2014-2015 demonstrated particularly rewarding outcomes for patients receiving first defibrillation by bystanders. The proportion of patients surviving the event when first defibrillated with a public AED was 69%, compared with 48% when shocked by paramedics and 72% by first responders.

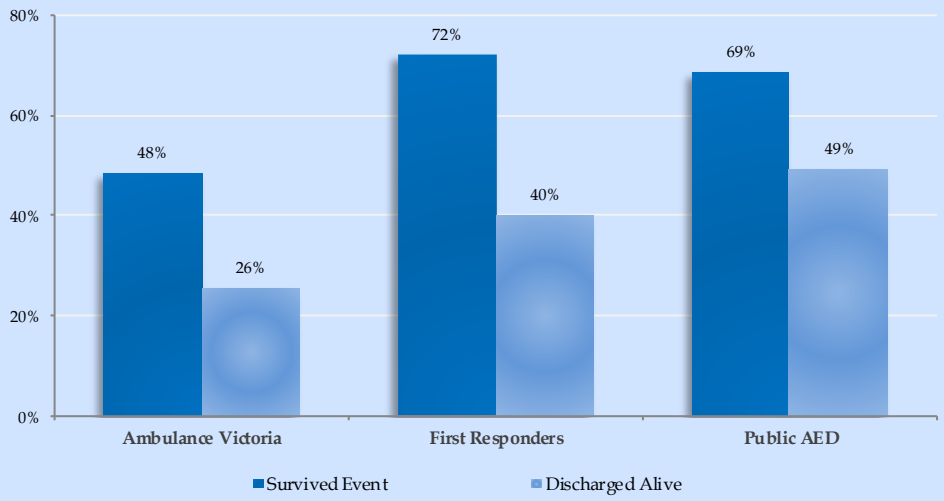
Survival to hospital discharge was significantly different according to who provided the first defibrillation. The proportion of patients surviving to hospital discharge when first defibrillated by public AED was 49%, compared with 26% when shocked by paramedics or 40% by first responders ($p<0.001$).

The time to first defibrillation by EMS is recorded for EMS treated patients whose rhythm is shockable on EMS arrival. In 2014-2015, the median time to defibrillation in the metropolitan region was 10.2 minutes (90th percentile time 14.6 minutes), similar to the previous year (median time 10.3 minutes; 90th percentile time 15.2 minutes; $p=0.373$). In the rural region, median time to defibrillation was 12.3 minutes (90th percentile time 22.8 minutes), similar to the previous year (median time 12.8 minutes; 90th percentile time 24.5 minutes; $p=0.089$).

In 2014-2015, the state-wide time to defibrillation of 10.8 minutes (90th percentile time 17.4 minutes) was similar to the previous year (median time 11.0 minutes; 90th percentile time 17.4 minutes; $p=0.199$).

Time to defibrillation for patients in a shockable rhythm correlates closely with EMS response time. (see Emergency response to the incident, page 29).

Figure 16: Unadjusted survival outcome according to who shocked first in the EMS treated population with a shockable rhythm on or before EMS arrival, 2014-2015.



A discharged alive rate of 49% in 2014-2015 for patients defibrillated with a public AED represents the most rewarding outcome for patients in a shockable rhythm and encourages improvements in outcomes for OHCA patients.

Impact of bystanders on OHCA

Bystanders can play an important role in improving OHCA survival. Three of the four steps of the chain of survival for OHCA 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 possibly having had prior CPR training, bystanders can start CPR prior to the arrival of EMS. If an AED happens to be located near the location of the arrest, bystanders have the opportunity to provide vital defibrillation prior to the arrival of EMS. The effect of an OHCA event being witnessed to occur by a bystander tends to have a positive impact on the survival of the patient.

Table 5 provides an overview of the impact of bystanders on OHCA outcomes in 2014-2015. Bystander CPR rates were higher in the patient subgroup who were witnessed to arrest by a bystander (64% vs 42%). In addition, the unadjusted likelihood of an OHCA patient presenting in a shockable rhythm was eight times higher for patients who received bystander CPR compared to those who did not receive bystander CPR.

Table 5: Number and proportion of patients who received bystander CPR or bystander defibrillation and unadjusted survival outcomes for EMS treated events, for all OHCA events and bystander witnessed events, 2014-2015.

	All OHCA	Bystander witnessed
Total events	5,657^	1,644
- Bystander CPR	2149 (42%)	1044 (64%)
- Bystander AED use	70 (1.2%)	63 (3.8%)
- Shockable rhythm	829 (15%)	541 (33%)
EMS treated events	2,295	1,248
- Survived event	678 (30%)	505 (41%)
- Discharged alive	238 (10%)	199 (16%)

^ *Total OHCA events include EMS witnessed events; all other data in the table exclude 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 (33% vs 15%). When an arrest was witnessed by a bystander, the proportion of patients who survived the event was higher than for all OHCA patients combined (41% vs 30%, 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).

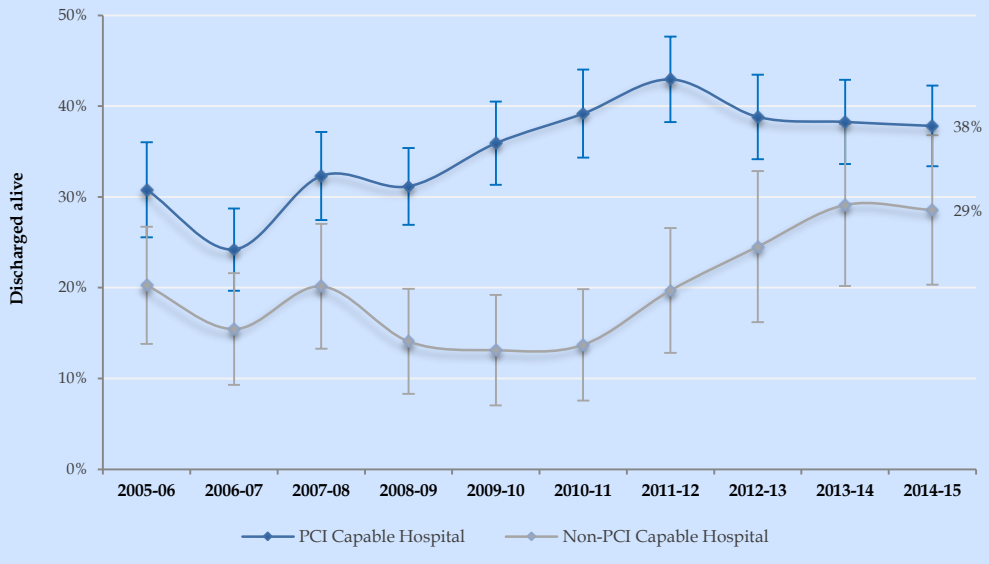
Transport to a cardiac centre

Previous research by VACAR has demonstrated that transport to a percutaneous coronary intervention (PCI)-capable hospital is associated with improved survival to hospital discharge following OHCA *(Stub et al. 2011)*.

Of EMS treated arrests due to presumed cardiac cause and transported to hospital in 2014-2015, 38% of rural and 93% of metropolitan cases were transported to a PCI-capable hospital (80% state-wide). While this rate has remained relatively unchanged in metropolitan regions, rural trends experience yearly fluctuations and are predominantly associated with location of arrest and transport to two PCI-capable hospitals (University Hospital Geelong and Ballarat Hospital).

In 2014-2015, 38% of patients transported to PCI-capable hospitals survived to hospital discharge, whilst 29% of patients transported to hospitals without PCI capability were discharged alive (unadjusted survival, see Figure 17). It is also plausible that other hospital-based factors are contributing to the variation in outcomes observed across hospitals, which may include the uptake of optimal post-arrest treatment strategies.

Figure 17: Unadjusted survival to hospital discharge for adult presumed cardiac EMS treated events according to transport to a PCI-capable hospital‡. Error bars show the 95% confidence interval around the proportion.

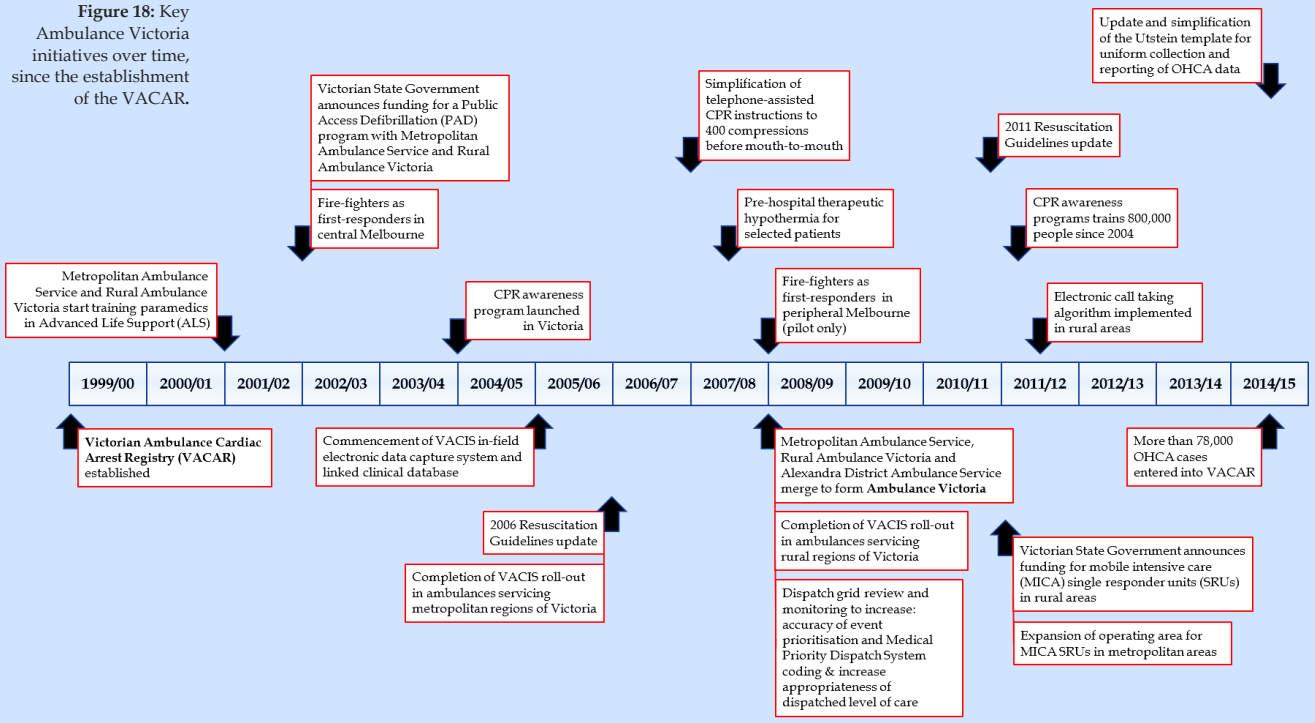


‡ *Data in this graph refers to Victorian hospitals which have a current process in place to receive AV emergency patients via a pre-notification system, have full-time PCI-interventional capabilities and was the first hospital that the OHCA patient was transported to.*

Ambulance Victoria key initiatives over time

Figure 18 is a diagrammatic representation of 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.

Figure 18: Key Ambulance Victoria initiatives over time, since the establishment of the VACAR.



Ambulance Victoria has invested significantly in improving the system response to out-of-hospital cardiac arrest patients.

Survival Outcomes

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. In 2014-2015, ROSC was achieved in 40% of adult EMS treated events state-wide. For metropolitan events, significantly better ROSC outcomes were observed when compared to rural events (43% vs. 34%, $p<0.001$). A reduction in the proportion of ongoing resuscitation efforts during transport was reflected by an increase in those whose resuscitation efforts were ceased at scene (see Figure 19). The proportion of adult EMS treated events which were transported from the scene with ROSC was 29% in 2014-2015.

In fact, VACAR data has shown that the majority of OHCA patients with OHCA and an initial shockable rhythm who do not achieve sustained ROSC in the field are declared deceased rather than transported to hospital (*Stub et al. 2014*). Over the ten year study period 2003 to 2012, it was noted that fewer patients were being transported with ongoing CPR. 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.

Figure 19: Scene outcomes for adult EMS treated events

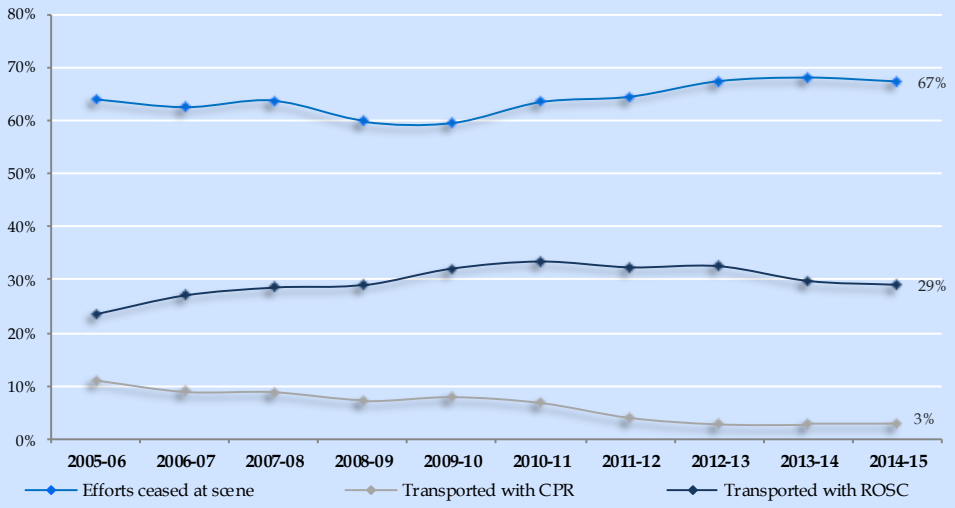
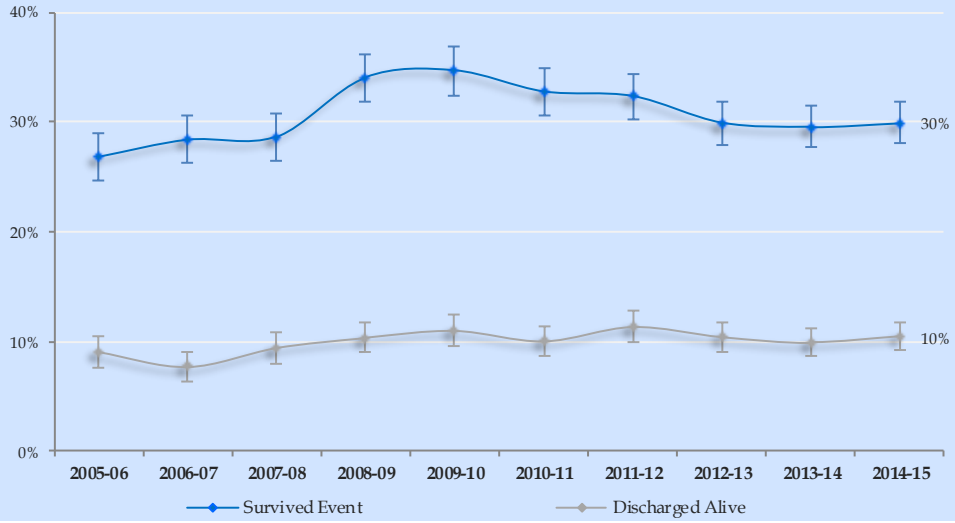


Figure 20: Unadjusted survival outcomes for all-cause adult EMS treated events.



Adult survival from all-cause cardiac arrest

Unadjusted adult survival from all-cause OHCA has increased modestly over the past 10 years. In 2014-2015, the rates of event survival and survival to hospital discharge for adult EMS treated events were 30% and 10%, respectively. These rates of survival are consistent with recent observations (see Figure 20).

Adult and all-ages survival from shockable rhythms

The presence of a shockable rhythm on arrival of EMS or bystanders is a strong predictor of survival from OHCA (*Fridman et al. 2007*). Survival proportions for patients who presented to EMS or bystanders in a shockable rhythm are consistently better than those who presented in pulseless electrical activity (PEA) or asystole (see Figure 21).

In fact, 29% of patients found in a shockable rhythm survived to hospital discharge compared with 8% of patients in PEA. Five patients (0.5%) who presented in asystole survived to hospital discharge in 2014-2015.

In 2014-2015, the proportion of adult EMS treated patients that presented to EMS or bystanders in a shockable rhythm was 30% of the overall population. Outcomes for patients with shockable rhythms have shown improvement over time (see Figure 22). In 2014-2015, adult event survival for patients presenting in a shockable rhythm was 52%, compared with 54% in the previous year. The rate of adult survival to hospital discharge was 29%, equivalent to the previous year.

When considering patients of all ages presenting in a shockable rhythm, the rate of event survival in 2014-2015 was 52% and the rate of survival to hospital discharge was 29%.

Figure 21: Unadjusted survival outcomes for adult EMS treated events according to presenting rhythm on arrival, 2014-2015.

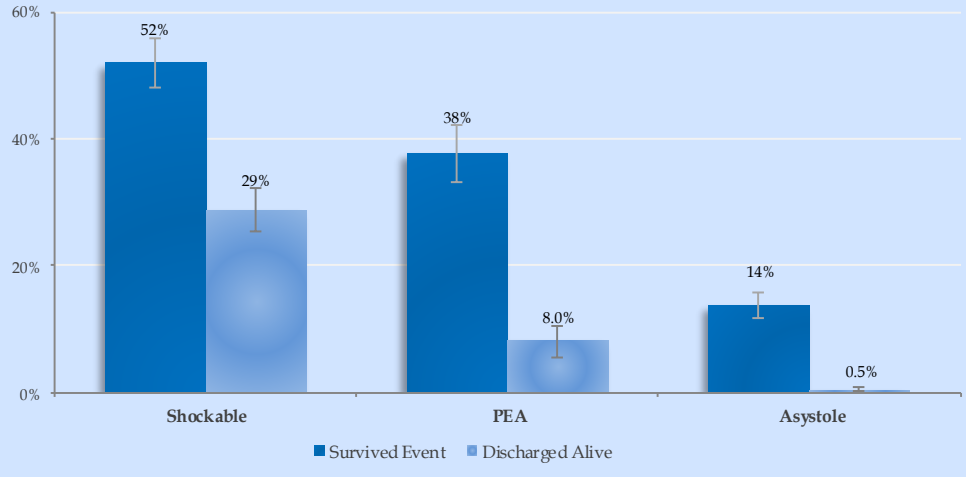
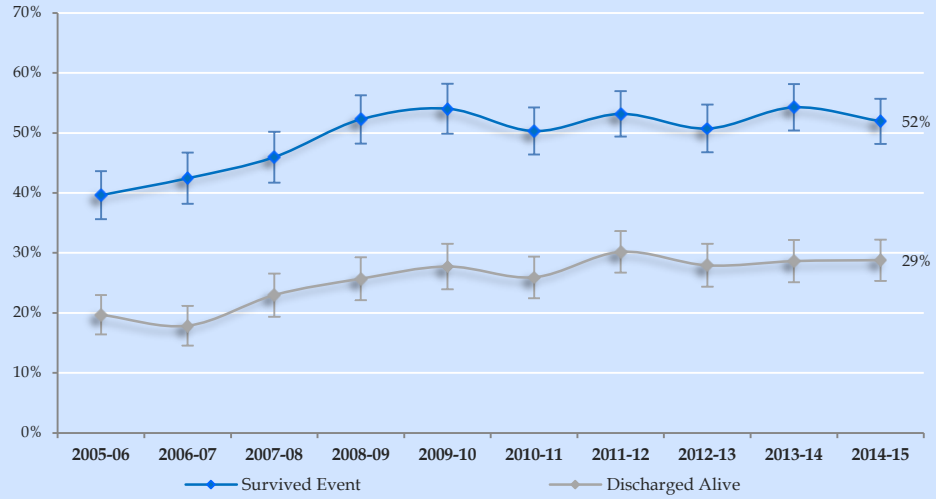


Figure 22: Unadjusted survival outcomes for adult EMS treated events with a shockable rhythm on arrival.



Adult survival from EMS witnessed arrests

The greatest survival benefit for patients found in a shockable rhythm is observed when immediate intervention is administered by paramedics. In 2014-2015, for adult EMS witnessed events presenting in a shockable rhythm, event survival and survival to hospital discharge were 75% and 71%, respectively (see Figure 23). These findings are consistent with those observed over recent years. When considering all adult EMS witnessed events, event survival and survival to hospital discharge were 46% and 28%, respectively.

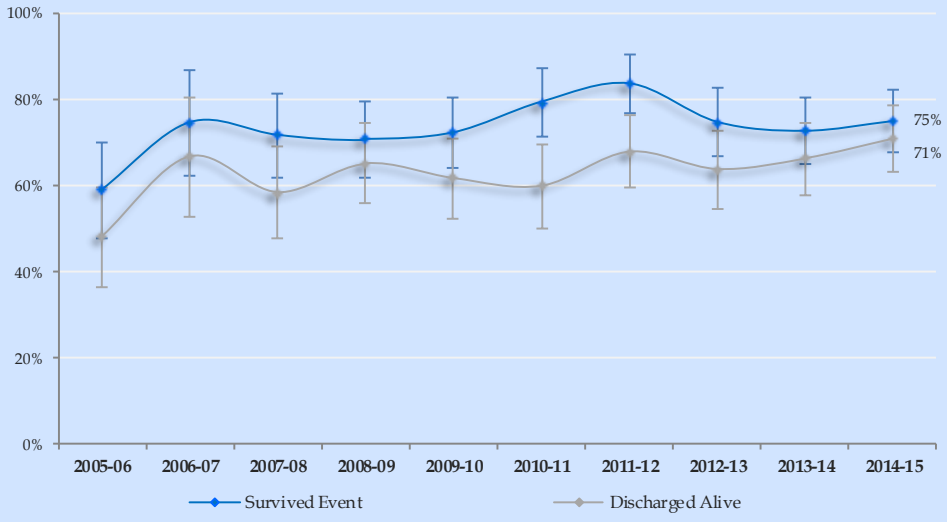
Paediatric survival from all-cause cardiac arrest

The annual incidence of paediatric OHCA is low and survival factors vary significantly from those observed in adults. In particular, presenting cardiac rhythms in children are rarely shockable. In 2014-2015, only two paediatric cases treated by EMS presented in a shockable rhythm (2%). Asystole is the most common finding in paediatric OHCA, with 76% of the EMS treated population being found in this rhythm.

In 2014-2015, 20% (n=12) of paediatric EMS treated patients survived the event, with 11% (n=7) of cases being discharged alive. These findings are consistent with the observed trends over the last decade.

A total of eight EMS witnessed paediatric events were identified in 2014-2015, of which two survived the event (25%) and both patients survived to hospital discharge (25%).

Figure 23: Unadjusted survival outcomes for EMS witnessed, adult EMS treated events with a shockable arrest rhythm.



Utstein patient group survival

The Utstein template is part of a set of guidelines which was developed to promote uniform presentation of OHCA survival data across different regions of the world (*Perkins et al. 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 where emergency medical services commenced resuscitation within the following patient subgroup: patients who arrested due to presumed cardiac aetiology, were witnessed to arrest by a bystander and the presenting cardiac rhythm is VF or VT.

Figure 24 shows the total number of OHCA events in 2014-2015 and progressively shows the breakdown of events according to EMS attempted resuscitation, precipitating event, witnessed status and presenting rhythm.

In 2014-2015, survival to hospital discharge for the Utstein patient subgroup presenting in VF/VT was 32%. Within the metropolitan and rural regions, the rate of survival to hospital discharge within this patient subgroup was 35% and 24%, respectively.

Figure 24: Survival outcomes for the Utstein patient group, 2014-2015 (comparing shockable rhythm (VF/VT) on arrival of EMS/bystanders to non-shockable (non-VF/VT) rhythm on arrival).

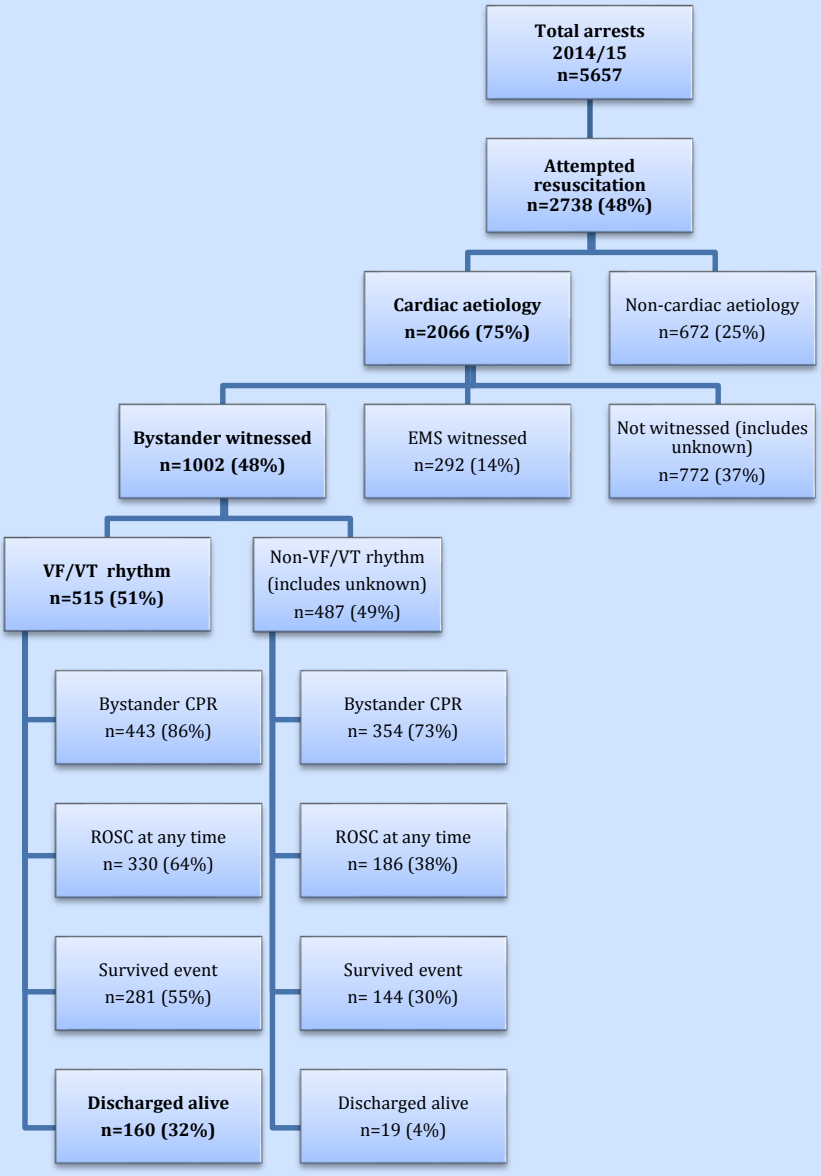
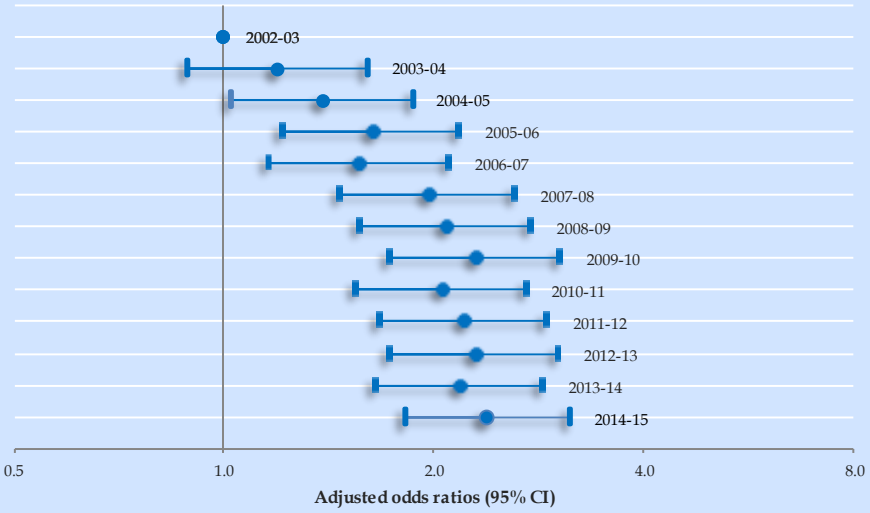


Figure 25: Risk-adjusted odds of adult survival to hospital discharge by year in the overall EMS treated population.



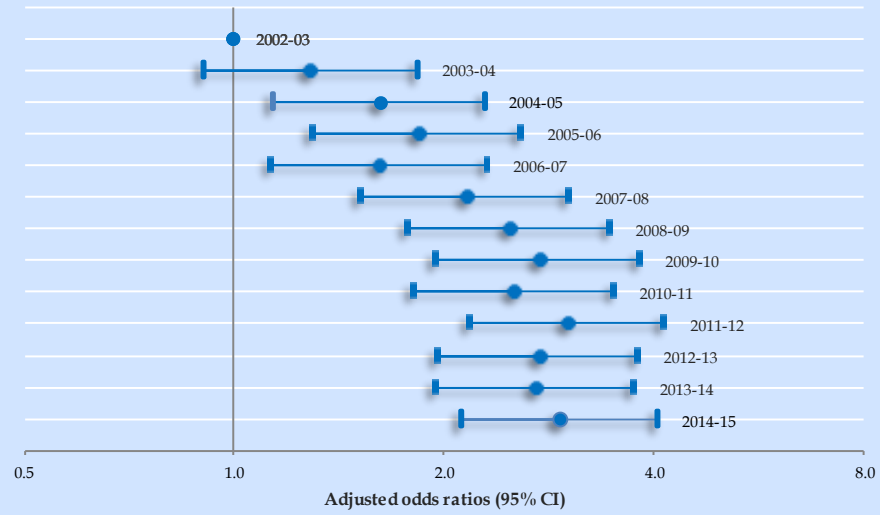
Yearly risk-adjusted odds of adult survival

The risk-adjusted odds of survival outcome provide a balanced method of measuring yearly trends in resuscitation performance and outcome. In the analysis presented in Figure 25, 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, shockable rhythm on arrival, bystander witnessed status and bystander CPR. The 2002-2003 year is used as the reference category; this is the first year that data capture within the VACAR can be considered complete and reliable.

The analysis demonstrates strong growth in the survival to hospital discharge outcomes over recent years. In 2014-2015, the relative odds of survival to hospital discharge had increased two-fold when compared to outcomes observed in 2002-2003 (adjusted odds ratio 2.4, 95% CI 1.8-3.1, p<0.001). The odds of survival to hospital discharge for adult OHCA patients in 2014-2015 are consistent with recent observations.

Similarly, there have been significant improvements in the risk-adjusted odds of survival to hospital discharge for adult patients presenting in a shockable rhythm over time. In 2014-2015, the risk-adjusted odds of survival to hospital discharge for a patient presenting in VF/VT was 2.9 (95% CI 2.1-4.1, p<0.001) when compared with 2002-2003 (see Figure 26).

Figure 26: Risk-adjusted odds of survival to hospital discharge for adults presenting in a shockable rhythm by year in the overall EMS treated population.



Long-term Functional Outcomes

Discharge direction for all survivors

In 2014-2015, 86% of all OHCA survivors were discharged home (excluding EMS witnessed events and unknown discharge status). For survivors who had presented in a shockable rhythm, 88% were discharged home (excluding EMS witnessed events and unknown discharge status). Discharge direction trends in adult survivors have improved modestly over the last decade (see Figure 27). In 2014-2015, 89% of all adult OHCA survivors were discharged home (excludes unknown discharge status). This proportion equates to 86% for non-EMS witnessed adult events and 95% in adult events witnessed by EMS. Remaining adult survivors were discharged to rehabilitation (10%) and nursing homes (1%).

Assessment of quality of life post arrest

Since January 2010, adult OHCA patients (aged ≥18 years) who survived to hospital discharge 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 the administration of the study instruments. Where necessary and applicable, a proxy is interviewed in place of the patient. 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 et al. 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 et al. 2007*).

Twelve-item short form (SF-12) health survey (*Ware et al. 1996*). The SF-12 is a generic HRQoL instrument that measures physical and mental health status. SF-12 scores consist of the Physical Component Summary (PCS) and Mental Component Summary (MCS). Standardised mean difference (SMD) can be used to show the degree of deviation of a score from the population norm. SMD was 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 SF-12 SMD represents the magnitude of the difference between population groups, with values greater than 0.8 are considered large.

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

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.

Figure 27: Proportion of adult discharged alive patients who are discharged to private residence (includes EMS witnessed events).

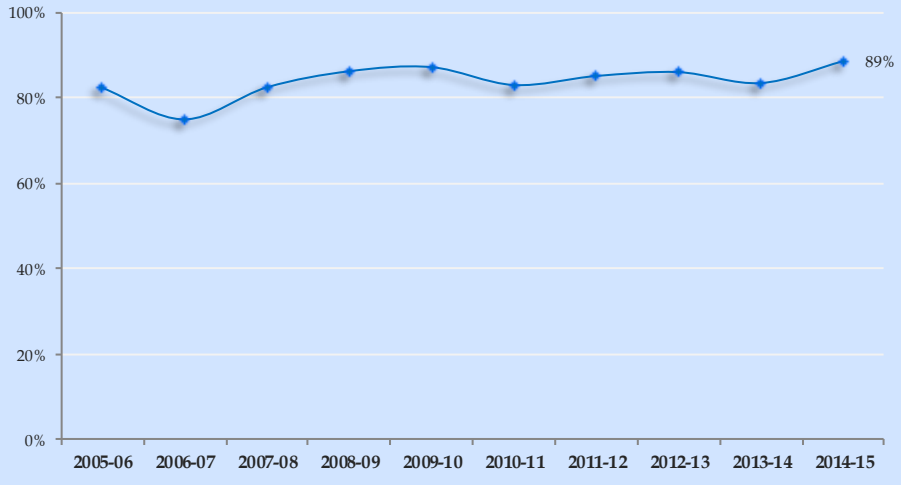
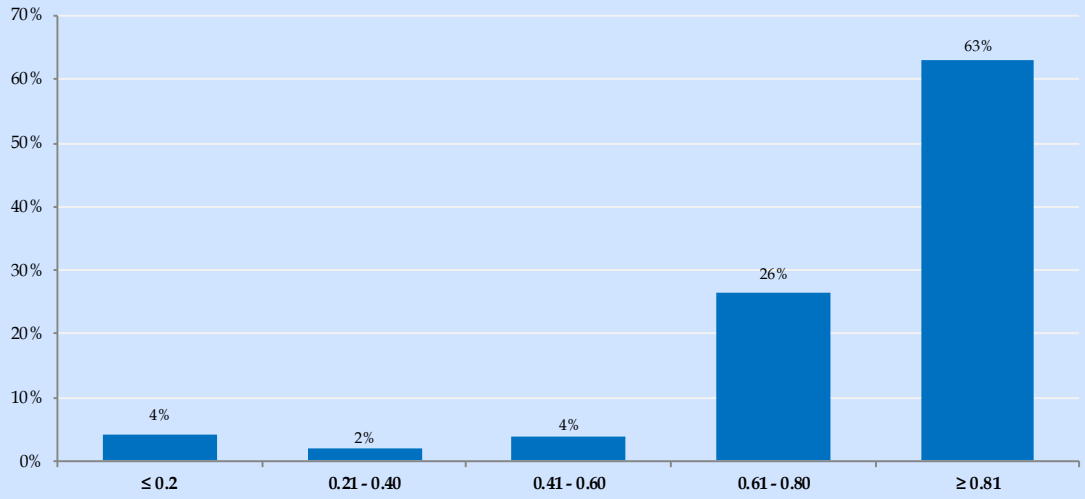


Figure 28: Distribution of EQ-5D Index scores for OHCA survivors at 12 months post arrest (patients who arrested between 2013-2014).



The VACAR is one of the few out-of-hospital cardiac arrest registries in the world to routinely collect health-related quality of life outcomes. The registry has constructed one of the largest cohorts of quality of life outcomes for cardiac arrest patients.

Quality of life findings

Of 345 individuals who arrested between 1 July 2013 and 30 June 2014 and were discharged alive from hospital, 292 patients were alive 12-months post-arrest and were eligible for contact in 2014-2015. Interviews were conducted with 196 patients and 40 proxies (n=236), producing a response rate of 81%. There were 135 individuals who had worked prior to their arrest; work status after the arrest was available for 124 individuals. We note 77% of individuals (96 of 124) returned to work after their arrest. More specifically, 75% (93 of 124) returned to work in the same role.

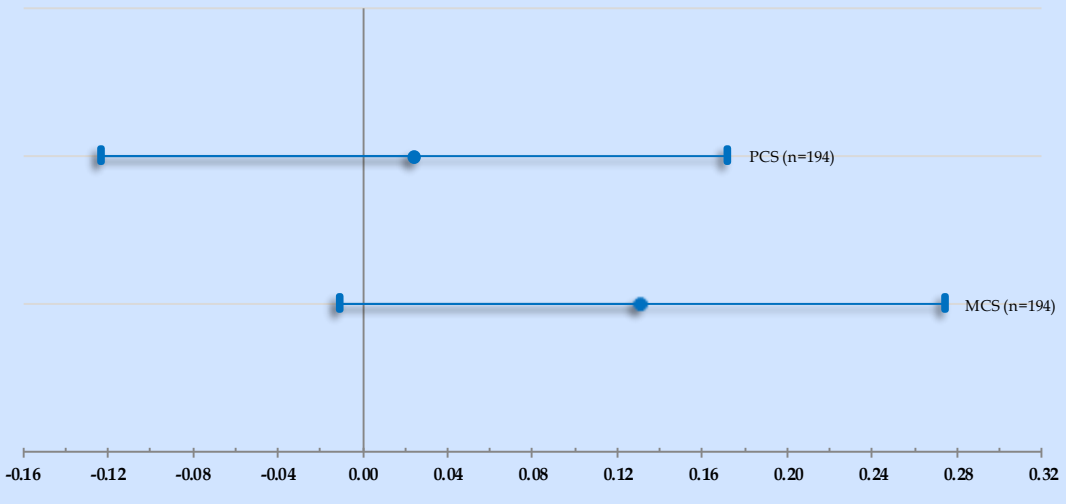
The mean EQ-5D index score for responders was 0.82 (95% CI 0.79 to 0.85). Most (63%) respondents have an EQ-5D index score ≥0.81 (see Figure 28). This corresponds with EQ-5D index scores seen in age-and sex-adjusted population norms (*Smith et al. 2015*). EQ-5D index scores were available for 231 of 236 responders.

The results of the SF-12 survey show that, overall, OHCA patients reported physical health (PCS) scores similar the Australian population (SMD 0.024, 95% CI -0.124 to 0.172). OHCA patients also reported similar mental health (MCS) scores as the Australian population (SMD 0.131, 95% CI -0.011 to 0.274) (see Figure 29).

The standardised mean differences for both the PCS and MCS scores for the patients followed up from 2013-2014 crossed zero, meaning there was no significant difference from Australian population norms.

The HRQoL summary scores obtained via the EQ-5D and the SF-12 both support good quality of life in survivors who responded.

Figure 29: Standardised mean differences for SF-12 scores at 12 months post arrest for OHCA survivors versus the Australian population (patients who arrested between 2013-2014).

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Research Highlights

"Our research agenda focuses on every aspect of the chain of survival, from the early actions of bystanders and EMS following patient collapse to outcome at hospital discharge. We continue to strive towards addressing the important and unanswered questions relating to cardiac arrest."

A/Prof Karen Smith, VACAR Principal Investigator and Chair

Paramedic exposure to out-of-hospital cardiac arrest

The quality of resuscitation care by paramedics may be a contributing factor to the observed low survival of OHCA patients. Paramedic exposure to OHCA may be an important factor in skill maintenance and quality of care. In this study published in *Resuscitation*, Dyson et al. assessed paramedic exposure to OHCA events (specifically referring to attendance at cases where EMS attempted resuscitation) over a 10 year period in Victoria. On average, paramedics were exposed to an OHCA every 163 days (1.4 per year (IQR = 0.0–3.0). Mean annual OHCA exposure declined from 2.8 in 2003 to 2.1 in 2012 (p=0.007). The observed low exposure to OHCA highlights the potential risk to resuscitation competency and skills maintenance by paramedics. As such, paramedics may benefit from additional training or simulation to supplement their low exposure, especially for rare case types.

Dyson K, Bray J, Smith K, Bernard S, Straney L and Finn J.Paramedic exposure to out-of-hospital cardiac arrest is rare and declining in Victoria, Australia. Resuscitation. 2015;89:93-8.

Cardiac registry to measure quality of EMS care

Survival from OHCA is closely related to EMS performance. As such, surveillance of OHCA treatment by EMS using registry-quality data is a key measure of clinical care. In this study published in *Resuscitation*, Nehme et al. report on the methodology and surveillance outcomes of OHCA patients over a 10 year period using data from the state-wide OHCA registry in Victoria (VACAR). The adjusted odds of receiving bystander CPR (OR 2.96, 95% CI, 2.62–3.33), event survival (OR, 1.55; 95% confidence interval, 1.30–1.85) and survival to hospital discharge (OR, 2.81; 95% CI, 2.07–3.82) significantly improved between 2002/03 and 2011/12. Regional and inter-hospital variability in survival outcomes were observed, which poses significant challenges for future improvements in care.

Nehme Z, Bernard S, Cameron P, Bray JE, Meredith IT, Lijovic M and Smith K. Using a cardiac arrest registry to measure the quality of emergency medical service care: decade of findings from the Victorian Ambulance Cardiac Arrest Registry. Circ Cardiovasc Qual Outcomes. 2015;8(1):56-66.

Out-of-hospital cardiac arrest before and after EMS arrival

For patients who arrest prior to EMS arrival, reduced EMS response time and time to defibrillation may improve survival rates. However, some reports show lower survival for events witnessed by EMS compared to bystander witnessed events. In this study published in *Resuscitation*, Nehme et al. compared witness status on survival and 12-month functional recovery of OHCA patients in Victoria. When compared to bystander witnessed cases receiving bystander CPR, EMS witnessed cases are associated with a significant improvement in the adjusted odds of survival to hospital (OR 2.02, 95% CI: 1.75–2.35), survival to hospital discharge (OR 6.16, 95% CI: 5.04–7.52) and survival to 12 months with good functional recovery (OR 5.56, 95% CI: 4.18–7.40). Further community education to access EMS prior to OHCA onset could improve survival and neurological outcome.

Nehme Z, Andrew E, Bernard S and Smith K. Comparison of out-of-hospital cardiac arrest occurring before and after paramedic arrival: Epidemiology, survival to hospital discharge and 12-month functional recovery. Resuscitation. 2015;89:50-7.

Treating OHCA patients not responding to standard CPR

OHCA patients who do not respond to paramedic resuscitation are not routinely transported to hospital. The use of veno-arterial extracorporeal membrane oxygenation (ECMO) assisted CPR (E-CPR) is proposed for refractory cardiac arrest, both in and out of hospital. The CHEER trial (mechanical CPR, Hypothermia, ECMO and Early Reperfusion) is a single centre, prospective, observational study conducted at The Alfred Hospital, with AV. Survival to hospital discharge with full neurological recovery occurred in 14/26 (54%) in-hospital and out-of-hospital cardiac arrest patients, much higher than rates in other reports. Establishing an E-CPR program appears feasible in a large city with a dedicated ECMO centre.

Stub D, Bernard S, Pellegrino V, Smith K, Walker T, Sheldrake J, Hockings L, Shaw J, Duffy SJ, Burrell A, Cameron P, Smit de V and Kaye DM. Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial). Resuscitation. 2015;86:88-94.

2014-2015 Peer-reviewed Publications

1. Dennekamp M, Straney LD, Erbas B, Abramson MJ, Keywood M, Smith K, Sim MR, Glass DC, Del Monaco A, Haikerwal A and Tonkin AM. Forest Fire Smoke Exposures and Out-of-Hospital Cardiac Arrests in Melbourne, Australia: A Case-Crossover Study. Environ Health Perspect. 2015 Oct;123(10):959-64.
2. Haikerwal A, Akram M, Del Monaco A, Smith K, Sim M, Meyer M, Tonkin A, Abramson M and Dennekamp M. The impact of fine particulate matter (PM2.5) exposure during wildfires on cardiovascular health outcomes. Journal of the American Heart Association. 2015 Jul 15;4(7). pii: e001653.
3. Dyson K, Bray J, Smith K, Bernard S, Straney L and Finn J. Paramedic exposure to out-of-hospital cardiac arrest is rare and declining in Victoria, Australia. Resuscitation. 2015 Apr;89:93-8.
4. Nehme Z, Andrew E, Bray J, Cameron P, Bernard S, Meredith I and Smith K. The significance of pre-arrest factors in out-of-hospital cardiac arrests witnessed by emergency medical services: a report from the Victorian Ambulance Cardiac Arrest Registry. Resuscitation. 2015 Mar;88:35-42.
5. Nehme Z, Andrew E, Bernard S and Smith K. Comparison of out-of-hospital cardiac arrest occurring before and after paramedic arrival: epidemiology, survival to hospital discharge and 12-month functional recovery. Resuscitation. 2015 Jan 22;89:50-7.
6. Smith K, Andrew E, Lijovic M, Nehme Z and Bernard SA. Quality of life and functional outcomes 12-months after out-of-hospital cardiac arrest. Circulation. 2015 Jan 13;131(2):174-81.
7. Nehme Z, Bernard S, Cameron P, Bray J, Meredith I, Lijovic M and Smith K. Using a Cardiac Arrest Registry to Measure the Quality of Emergency Medical Service Care. Decade of Findings From the Victorian Ambulance Cardiac Arrest Registry. Circ Cardiovasc Qual Outcomes. 2015 Jan;8(1):56-66.
8. Stub D, Bernard S, Pellegrino V, Smith K, Walker T, Sheldrake J, Hockings L, Shaw J, Duffy SJ, Burrell A, Cameron P, Smit DV and Kaye DM. Refractory Cardiac Arrest Treated with Mechanical CPR, Hypothermia, ECMO and Early Reperfusion (the CHEER Trial). Resuscitation. 2015 Jan;86:88-94.
9. Lijovic M, Bernard S, Nehme Z, T Walker and Smith K. Public access defibrillation- results from the Victorian Ambulance Cardiac Arrest Registry. Resuscitation Dec. 2014;85(12):1739-44.
10. Smith K and Lijovic M. Increasing bystander participation in resuscitation. Resuscitation. 2014 2014 Nov;85(11):1640-1.
11. Andrew E, Nehme Z, Lijovic M, Bernard S and Smith K. Outcomes following out-of-hospital cardiac arrest with an initial cardiac rhythm of asystole or pulseless electrical activity in Victoria, Australia. Resuscitation. 2014 Nov;85(11):1633-9.
12. Nishiyama C, Brown SP, May SJ, Iwami T, Koster RW, Beesems SG, Kuisma M, Salo A, Jacobs I, Finn J, Sterz F, Nürnberger A, Smith K, Morrison L, Olasveengen TM, Callaway CW, Shin SD, Gräsner JT, Daya M, Ma MH, Herlitz J, Strömsöe A, Aufderheide TP, Masterson S, Wang H, Christenson J, Stiell I, Davis D, Huszti E and Nichol G. Apples to apples or apples to oranges? International variation in reporting of process and outcome of care for out-of-hospital cardiac arrest. Resuscitation. 2014 Nov;85(11):1599-609.
13. Smith K and Bernard S. Quality of life after cardiac arrest: How and when to assess outcomes after hospital discharge? Resuscitation. 2014 Sep;85(9):1127-8.
14. Nehme Z, Andrew E, Bernard S and Smith K. The impact of partial resuscitation attempts on the reported outcomes of out-of-hospital cardiac arrest in Victoria, Australia: Implications for Utstein-style outcome reports. Resuscitation. 2014 Sep;85(9):1185-91.
15. Dyson K, Bray J, Smith K, Bernard S and Finn J. A systematic review of the effect of emergency medical service practitioners' experience and exposure to out-of-hospital cardiac arrest on patient survival and procedural performance. Resuscitation. 2014 Sep;85(9):1134-41.

List of Abbreviations

ACO	Ambulance Community Officers
ALS	Advanced Life Support
AED	Automated external defibrillator
AV	Ambulance Victoria
CERT	Community Emergency Response Teams
CFA	Country Fire Authority
CPR	Cardiopulmonary Resuscitation
CSO	Clinical support officer
DHHS	Department of Health and Human Services
ECG	Electrocardiogram
EMS	Emergency Medical Services
EQ-5D	EuroQoL 5 Dimension questionnaire
GOS-E	Extended Glasgow Outcome Scale
HRQoL	Health-related quality of life
LGA	Local Government Areas
MCS	Mental Component Summary of the SF-12 survey
MFB	Metropolitan Fire Brigade
MICA	Mobile Intensive Care Ambulance
OHCA	Out-of-Hospital Cardiac Arrest
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	Pulseless Ventricular Tachycardia

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)	Cases in which the resuscitation attempt results in a return of spontaneous circulation (i.e. detectable pulse) at any time.
Survival to discharge	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 arrest due to a presumed cardiac cause, are witnessed to arrest by a bystander, present in a shockable rhythm and an attempt at resuscitation was made by EMS.


AED
AUTOMATED EXTERNAL DEFIBRILLATOR
SAFE FOR PUBLIC USE
IN THE EVENT OF NO SIGNS OF LIFE
• CALL 000 [triple zero] and ask for ambulance
• Remove AED
• Push the ON button
• Follow INSTRUCTIONS
000 EMERGENCY
Victoria
Register your AED with Ambulance Victoria at www.registermyaed.com.au
HEARTSTART FR2
Laerdal
RAPP BAGS FOR REPAIR

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