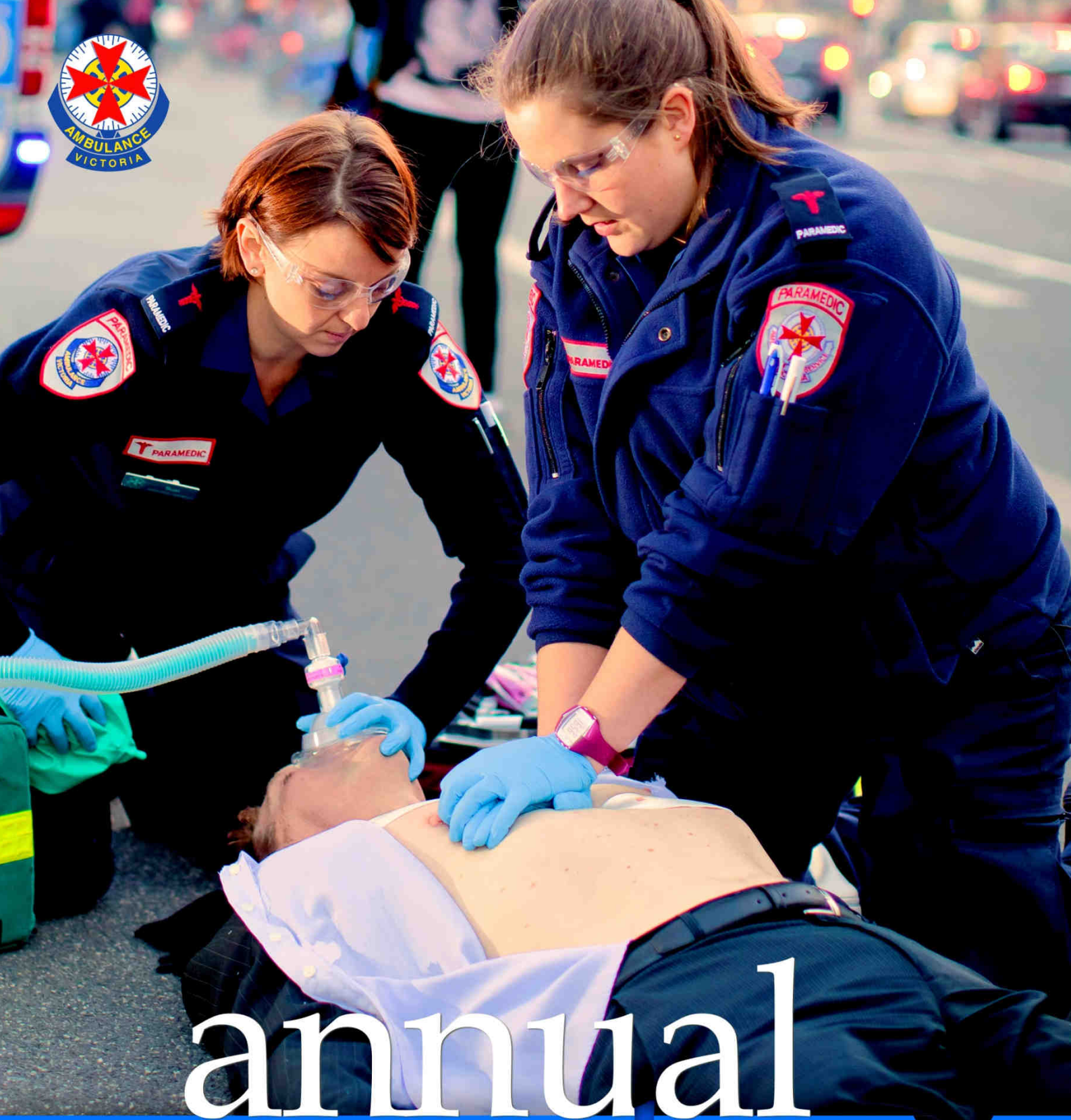

annual report

victorian ambulance **cardiac arrest** registry annual report 2012-13

Victorian Ambulance Cardiac Arrest Registry
Annual Report 2012-13

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Greg Sassella
Chief Executive Officer

From the CEO

> "Given the sparsely populated nature of many of our regional areas, the task of improving outcomes from cardiac arrest requires both a timely response by our paramedics, and a willingness by the community to participate in life-sustaining resuscitation efforts."
>
> *Greg Sassella, Chief Executive Officer*

Ambulance Victoria (AV) is one of the largest emergency medical services in the world. Our emergency call centres receive over 800,000 calls every year with requests for emergency and unscheduled medical care across both metropolitan and rural areas of Victoria. Our highly trained paramedics are some of the best in world, providing cutting-edge pre-hospital interventions to the critically ill and injured.

In 2012/13, we continue our focus on out-of-hospital cardiac arrest (OHCA) performance. Given the sparsely populated nature of many of our regional areas, the task of improving outcomes from cardiac arrest requires both a timely response by our paramedics, and a willingness by the community to participate in life-sustaining resuscitation efforts. Despite an enormous growth in ambulance demand over the last decade, we are continually improving our survival outcomes following cardiac arrest.

In 2000, we partnered with the Metropolitan Fire Brigade to establish an Australian-first early responder program that saw professionally-trained fire-fighters provide basic life support interventions to cardiac arrest victims in our community. Today, this initiative consistently achieves quicker times to cardiopulmonary resuscitation and defibrillation in over a quarter of cardiac arrest cases treated by AV. With the support of our partners we are extending these initiatives into regional areas, allowing both community emergency response team volunteers and the Country Fire Authority to provide critically needed basic life support care to victims of cardiac arrest.

The outcomes of these partnerships are some of the most rewarding we've ever seen. In 2012/13, early defibrillation by first responders doubled over the ten year period from 2003/04. A result that is magnified by enormous growth in community-initiated cardiopulmonary resuscitation and early defibrillation using a public automated external defibrillator. In fact, the proportion of cases receiving a defibrillation prior to arrival of emergency crews has increased ten-fold over the last decade. It's no surprise that survival following early defibrillation by first responders and bystanders is continuing to produce the best results for cardiac arrest patients in Victoria.

As an organisation, we are continually determined to deliver better outcomes for our critically ill patients. Our investments to this cause have included an expanding workforce particularly in regional areas, greater access to Mobile Intensive Care Ambulances (MICA), improved communication and call-centre capabilities, new community education initiatives, and a world-leading research agenda. Our widely successful '4 Steps for Life Plus' initiative has an expanded focus, providing both cardiopulmonary resuscitation and early defibrillation awareness to thousands of Victorians every year.

Most importantly, we have an unmatched capacity for measuring the quality of care provided to victims of cardiac arrest through the Victorian Ambulance Cardiac Arrest Registry. In fact, we remain the only state in Australia that routinely monitors and reports its survival outcomes from OHCA. Our commitment to this cause ensures that all Victorians receive the world's very best pre-hospital care when it really matters.

Greg Sassella
Chief Executive Officer
AMBULANCE VICTORIA


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The Emergency Medical Service

The state of Victoria, Australia has a population of 5.6 million with approximately 4 million residing in metropolitan Melbourne. The emergency medical service (EMS) comprises ambulance paramedics who have some advanced life support skills (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.

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. Suspected cardiac arrest events identified in-call receive further call-taker instruction recommending 400 chest compressions before mouth-to-mouth resuscitation.

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. A pilot fire-fighter first responder program involving the Country Fire Authority (CFA) commenced in 2008, and operates at a number of sites in outer metropolitan Melbourne and at Shepparton.

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.

The 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), and 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 supported by funding from the Victorian Government Department of Health.

The VACAR is a quality control 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 survivors 12 months post cardiac arrest (commenced January 2010, excludes children). Hospital outcome data is supplemented by death records from the Victorian Registry of Births Deaths and Marriages.

Pre-hospital data for all cardiac arrest patients attended by AV since October 1999 has been successfully captured for over 66,000 patients. The data is collated in the registry using 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 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 medical journals (see Peer-reviewed publications, page 38).

The VACAR is overseen by a Steering Committee and chaired by Associate Professor Karen Smith (Manager Research & Evaluation, Ambulance Victoria). The registry maintains ethical review as a quality assurance initiative from the Department of Health Human Research Ethics Committee and 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 follow-up data from all OHCA transported to a hospital in the state of Victoria.

In 2010, VACAR expanded its methodology to become one of few registries globally that consistently captures the quality of life of adult survivors of OHCA. A structured telephone interview at 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.


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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 into 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 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

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 supplement potentially eligible cases.

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 patients identified as having survived to discharge. The interview questionnaires used include: the Extended Glasgow Outcome Scale (GOS-E), SF-12® Health Survey and 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. Comparisons of these results are made with national and international data. 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. All cases where a patient requires defibrillation or where a death occurs in the care of AV undergo audit by a clinical support officer.

Ethical review

As a quality assurance initiative, ethical approval from the Department of Health Human Research Ethics Committee is supported by almost 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 Ambulance Victoria, with strict access to authorised VACAR staff.

Missing data

The value of VACAR is partly due to its 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, 2012/13 (n=5,302).

Patient age	102 (1.9%)
Patient gender	14 (0.3%)
Arrest location	Nil
Witnessed status	58 (1.1%)
Bystander CPR	380 (7.2%)
Rhythm on arrival	11 (0.2%)
EMS Response time	9 (0.2%)
Outcome at scene	1 (<0.1%)
Event survival	9 (0.9%)
Hospital discharge status	25 (0.5%)

About this report

> The American Heart Association states that monitoring the treatment of out-of-hospital cardiac arrest by EMS agencies could 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 the hospital, and 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 could 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, July 2012 to June 2013. Data for this report was extracted on 13 August 2013, with pending hospital follow-up remaining in a small proportion of events.

The registry is based on the internationally recognised Utstein template and definitions *(Jacobs et al. 2004)*. The data in the registry is subject to ongoing quality control, most of which has been incorporated back into the registry at the time of this report. Quality assurance measures are conducted routinely, leading to improvements in the integrity of the data with time. Data on survival to hospital discharge is also being continually updated and hence should be treated and interpreted with caution.

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 40.

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 and population regions of Victoria. These models were adjusted for known predictors of survival and are described in more detail in the report. Unless otherwise stated, all other statistical comparisons were unadjusted.

Analyses in this report contain Metropolitan and Rural comparisons. Geospatial mapping has been used to define regional boundaries according to the Victorian Government Department of Health regions (www.health.vic.gov.au/regions). The Melbourne metropolitan region is comprised of three geographical boundaries including the North and West, Eastern and Southern Regions. Rural boundaries comprise the Barwon South Western, Grampians, Loddon Mallee, Hume, and Gippsland regions. Population figures used in this report are defined by the Regional Population Growth reports published 30 August 2013 by the Australian Bureau of Statistics. The population figures are provided for the end of June 2012, with a Victorian population estimate of 5,629,122.

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. response time, 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

Survival outcomes are supported by a decade of growth in community-initiated cardiopulmonary resuscitation and a ten-fold increase in the use of automated external defibrillators by members of the public.

1. Ambulance Victoria attended 5,302 OHCA events in the period between July 2012 and June 2013, with almost 99% involving adults. The proportion of patients receiving emergency treatment by EMS was 49% overall, or 44% in the non-EMS witnessed population. The crude incidence of OHCA was higher in the rural region than in the metropolitan region: 118.8 versus 85.7 events per 100,000 population. The Gippsland and Hume regions recorded the highest crude incidence rates of OHCA (see Incidence & demographics, page 18).

2. The demographic profile of events in 2012/13 was similar to those observed over the last decade. Despite a high proportion of bystander CPR participation in patients undergoing an attempted resuscitation, we observed the lowest rate of shockable rhythms in ten years (28%). OHCA precipitated by a presumed cardiac aetiology accounted for 69% of adult EMS attended events. Sudden infant death syndrome (SIDS) remains the leading cause of OHCA in paediatrics. Arrests in public locations produce significantly better survival outcomes than arrest in the home (see Incidence & demographics, page 18).

3. Almost one in 10 bystander calls for help following OHCA are inappropriately directed to a relative, friend or neighbour. Emergency call-takers are effective at identifying cardiac arrest events during the emergency call, with 91% being correctly identified in the metropolitan region. Median EMS response times to EMS treated events in the metropolitan region observed a modest improvement in 2012/13 when compared to the previous year, reducing from 8.1 to 7.8 minutes. EMS response times in rural areas remained unchanged (see Chain of survival, page 26).

4. Bystander CPR increased to 70% for bystander witnessed events undergoing an attempted resuscitation by EMS (46% in 2003/04). The use of automated external defibrillators (AED) by members of the public increased 10-fold over the last decade for patients presenting in shockable rhythms. The growth in the use of AEDs is coupled with a doubling in the rate of first responder defibrillations over the last decade (see Chain of survival, page 26).

5. The rate of ROSC in EMS witnessed events increased to 60% in 2012/13. Scene outcomes for unwitnessed and bystander witnessed events experienced non-significant declines compared to previous years. Survival for all-cause OHCA in the EMS treated population was 10% in 2012/13 and remains within recent year's figures. Patients presenting in asystole and pulseless electrical activity experienced the poorest survival outcomes, with 0.7% and 8% surviving to discharge respectively (see Survival outcomes, page 31).

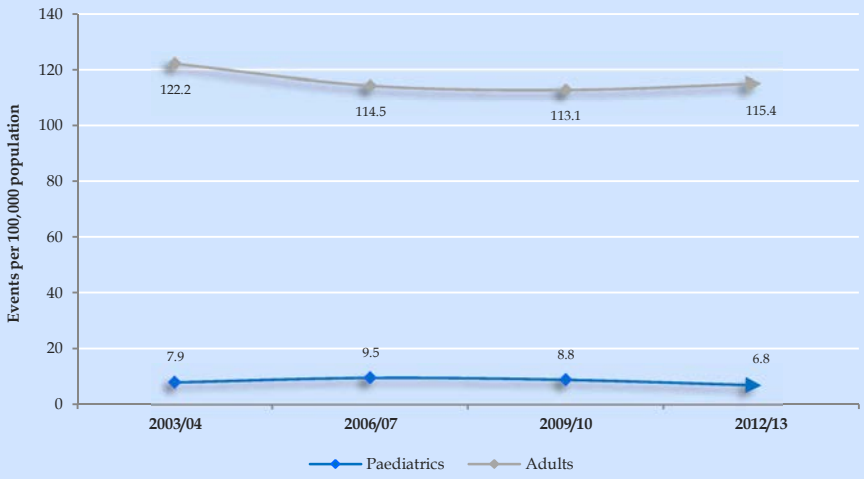
6. Survival outcomes for EMS treated patients presenting in shockable rhythms was 50% and 26% for event survival and survival to discharge respectively. For patients presenting in shockable rhythms and witnessed to arrest by EMS, event survival was 74% and 62% were discharged alive. The majority of cases with known survival to discharge continue to be discharged home, 86% in 2012/13 (see Survival outcomes, page 31).

7. The risk-adjusted odds of survival to discharge have improved significantly over the last 10 years. The odds of survival to discharge are two times higher in 2012/13 than cases in 2003/04. This improvement is also observed for cases presenting in shockable rhythms. Regional variation in the risk-adjusted odds of adult survival to discharge was observed across regions of Victoria, although no statistically significant findings were demonstrated (see Survival outcomes, page 31).

Incidence & Demographics

Incidence & demographics

Figure 1: Crude incidence of adult and paediatric EMS attended OHCA in Victoria (includes EMS witnessed events).



Incidence of all adult & paediatric events †

In 2012/13, Ambulance Victoria attended 5,302 OHCA events, of which 5,227 (98.6%) 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 or 75 cases in 2012/13. This number is within normal yearly fluctuations, although is lower than the 102 cases observed in 2011/12.

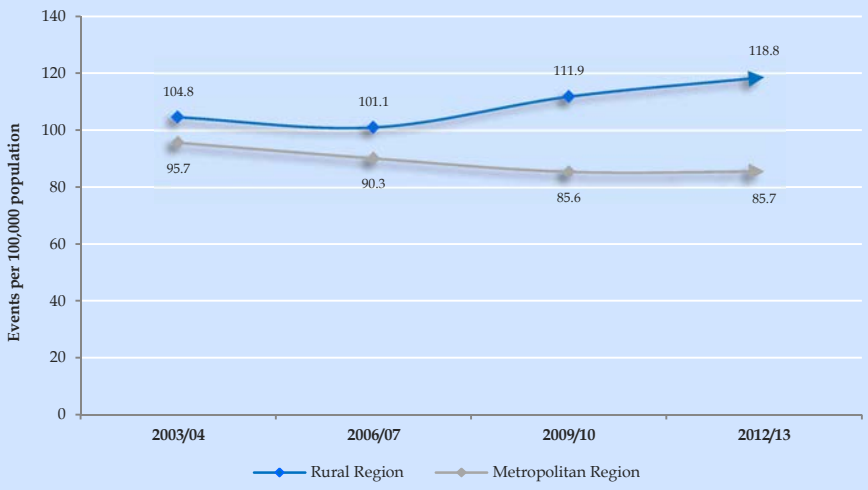
The crude incidence of OHCA has remained consistent over the last decade. In 2012/13, the incidence of all OHCA in Victoria was 94.2 events per 100,000 population. The incidence of adult and paediatric events also remained within recent observations, and was 115.4 and 6.8 events per 100,000 population 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, 49% received an emergency resuscitation attempt by paramedics and/or first-responders (includes EMS witnessed events). This finding represents the largest proportion of attempted resuscitations in a 10 year period, and is significantly higher than the previous fiscal year (49% vs. 46%, p=0.03) and the lowest 10 year finding in 2005/06 (49% vs. 41%, p<0.001). The crude incidence of adult EMS treated events was 56.0 events per 100,000 population. Evidence of prolonged downtime and futility were major reasons for withholding resuscitation efforts in adult patients.

In paediatric events, the proportion of EMS treated events is higher, with the majority receiving an attempted resuscitation by paramedics (79% in 2012/13, includes EMS witnessed events). This figure represents an increase over 10 year trends, and compares with 67% observed in 2003/04. The crude incidence of paediatric EMS treated events was 5.4 events per 100,000 population.

† All results in this section include EMS witnessed events

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



In 2012/13, Ambulance Victoria attended 5,227 adult OHCA events, representing the highest number of events in a 10 year period. The rate of attempted resuscitations has also increased to a 10 year high of 49%.

Incidence across regions of Victoria †

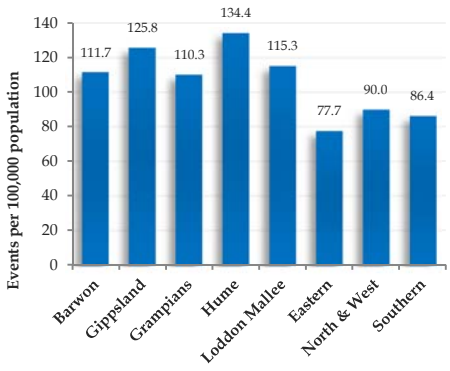


Figure 3: Crude incidence of EMS attended events across Department of Health regions, 2012/13.

A significantly higher number of OHCA events were observed in the metropolitan region representing 3,589 cases or 68% of the total number of events attended in 2012/13. The number of events attended in rural Victoria yielded its highest 10 year result with 1,713 events, a 23% increase since 2003/04.

Despite the increased proportion of events occurring in the metropolitan region, the crude incidence of OHCA was significantly higher in the rural region: 118.8 vs. 85.7 events per 100,000 population, $p<0.001$. In fact, the crude incidence of OHCA has observed a steady 10 year growth in rural Victoria increasing from 104.8 events in 2003/04 to 118.8 events per 100,000 population in 2012/13 ($p<0.001$). The increase is mirrored by a gradual decline in incidence in the metropolitan region across the same period (see Figure 2).

Regional variability in OHCA incidence was observed across Department of Health regions in Victoria (see Figure 3). The lowest crude incidence was observed in the Eastern Metropolitan Region (77.7 events per 100,000 population) and the highest incidence observed in the Hume region (134.4 events per 100,000 population). The North and West Metropolitan region, which includes the Melbourne Business District, recorded the highest frequency of events in a 10 year period, totalling 1,610 cases. Increases were also observed in the Barwon South Western and Hume regions. In fact, the proportion of cases occurring in the Hume region increased from 5.8% in 2011/12 to 6.8% in 2012/13 ($p=0.03$).

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 (53%) and the lowest in the Loddon Mallee region (42%).

† All results in this section include EMS witnessed events

Demographics of adults

The demographic profile of adult events has remained consistent over the last decade. In 2012/13, EMS attended adult events consisted of predominately males (66%) with a median age of 68.0 years. The age distribution varied significantly across genders (see Figure 4), 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 bystander (33%), occurring in a public location (16%), and receiving bystander CPR (38%) was not significantly different to those observed in the previous year.

Paramedics attempted resuscitation in approximately 44% of all EMS attended adult OHCA events. The demographic profile of patients receiving an attempted resuscitation varies significantly from the overall population, with a lower median age (67.0 years), more events occurring in a public place (21%), more events witnessed by a bystander (54%), and an increased rate of bystander CPR (67%). In 2012/13, the proportion of patients presenting in a shockable rhythm was at a 10 year low, and significantly lower than the previous year (28% vs. 34%, $p<0.001$).

Demographics of paediatrics

The frequency of EMS attended paediatric events has remained relatively low over the last decade with fewer than 100 events per year (70 in 2012/13). The median age of arrest remains at 12 months, and is driven predominantly by aetiology in this population (see Figure 7, page 23). The vast majority of paediatric OHCA occur in paediatrics aged two years or less, accounting for over half of all arrests in this population.

The demographic profile of paediatric OHCA varies significantly across reporting years, and is impacted by smaller samples sizes. The proportion of cases involving males was 59%, with 17% occurring in a public location. While approximately the same proportions of cases are witnessed by a bystander when compared to adults (33%), significantly more receive bystander CPR (38% vs. 73%). The vast majority of paediatric events present in an asystolic rhythm (75%), with only 1% presenting to EMS in a shockable rhythm. The proportion of cases receiving an attempted resuscitation by paramedics is significantly higher than adults (77% in 2012/13).

Figure 4: Age distribution of EMS attended OHCA events, 2012/13.

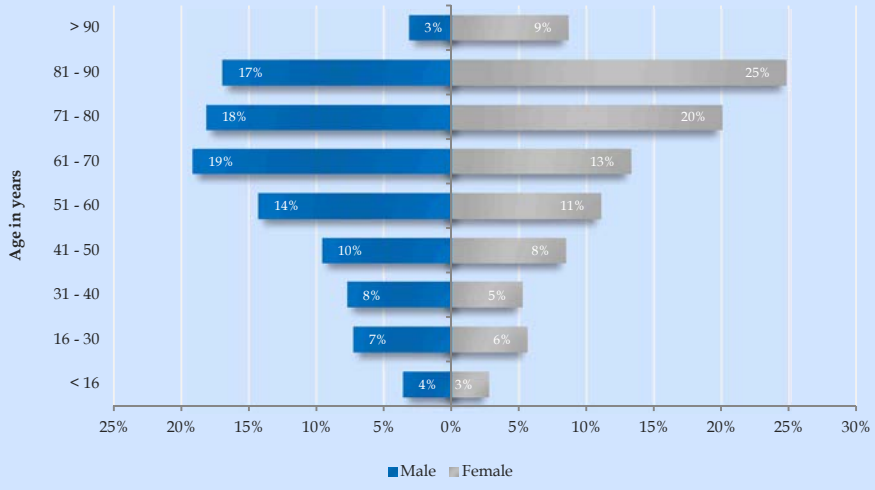
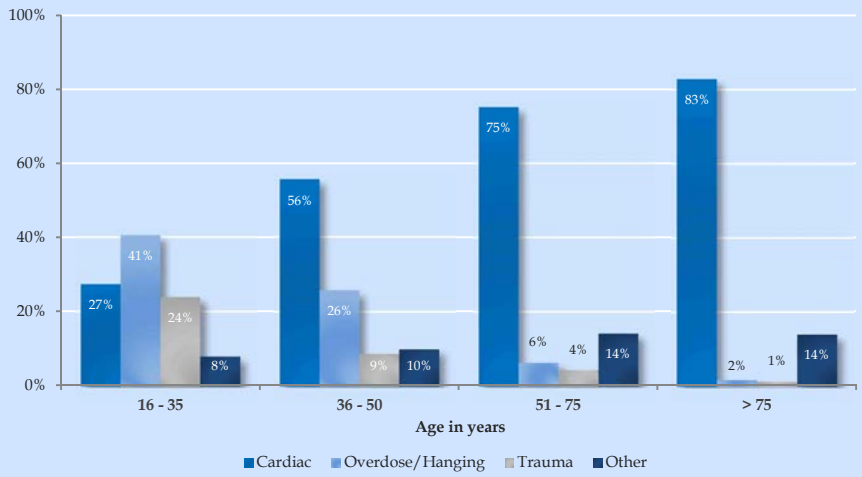


Figure 5: Adult precipitating events across age groups for EMS attended events, 2012/13.



Precipitating events for adults

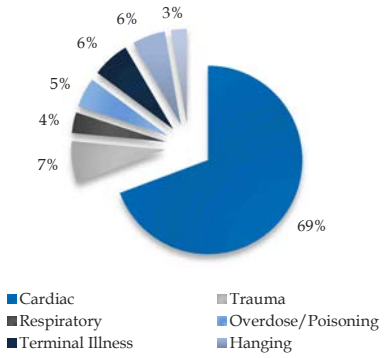


Figure 6: Adult precipitating events for EMS attended events, 2012/13.

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. In total, VACAR records 13 precipitating events for adults, of which six remain the predominant causes of arrest.

In 2012/13, 69% of EMS attended adult OHCA were presumed to be of a cardiac cause. Arrests precipitated by trauma (7%), respiratory (4%), overdose/poisoning (5%), terminal illness (6%) and hanging (6%) were also frequent causes of OHCA (see Figure 6).

In patients receiving an attempted resuscitation by EMS, significantly more cases were of cardiac origin (76%). Arrests precipitated by trauma, overdose/poisoning, terminal illness and hangings less frequently received an EMS attempted resuscitation when compared events precipitated by a presumed cardiac aetiology. In fact, respiratory causes were most commonly associated with an attempted resuscitation by paramedics (70%), with the lowest being hangings and trauma (both 24%).

The precipitating cause of arrest across age groups in the EMS attended population is depicted in Figure 5. 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 hangings are a leading cause of arrest in patients aged 16-50 years.

Road traffic accidents remain a significant cause of death and disability in Australia, with 63% of all OHCA from a traumatic cause being attributed to road trauma.

Precipitating events for paediatrics

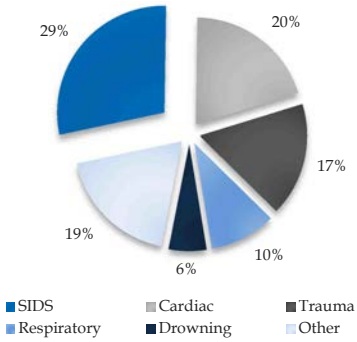


Figure 7: Paediatric precipitating events for EMS attended events, 2012/13.

Precipitating events for paediatrics who suffer OHCA vary considerably in comparison to adults, with only 20% of EMS attended paediatric events being of a presumed cardiac cause (see Figure 7). Trauma, respiratory and terminal illnesses play a greater role in the aetiology of arrest in paediatrics, and contributes strong prognostic information in this population. In fact, the overwhelming cause of OHCA in paediatrics is presumed to be secondary to SIDS, where there are no survivors. The distribution of precipitating events in the EMS treated population is similar to the overall population.

Mechanism of arrest in the traumatic sub-group

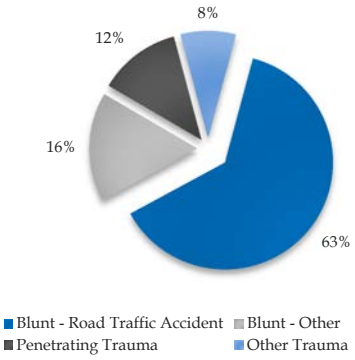


Figure 8: Sources of trauma in EMS attended traumatic OHCA sub-group, 2012/13.

Cardiac arrests secondary to major trauma represent an important surveillance group in Victoria. In this population, arrests secondary to road trauma were responsible for 63% of traumatic OHCA in 2012/13. Blunt trauma involving falls, crush injuries, or other blunt forces, were responsible for 16% of events, while arrests following ballistic trauma and stabbings accounted for 12% (see Figure 8).

The leading mechanism precipitating cardiac arrests associated with road trauma incidents were: a car or light vehicle (58%), train (17%) or motorcycle (14%). Of these, the majority of events implicated the driver (57%), with the remaining involving pedestrians (30%) or passengers (11%).

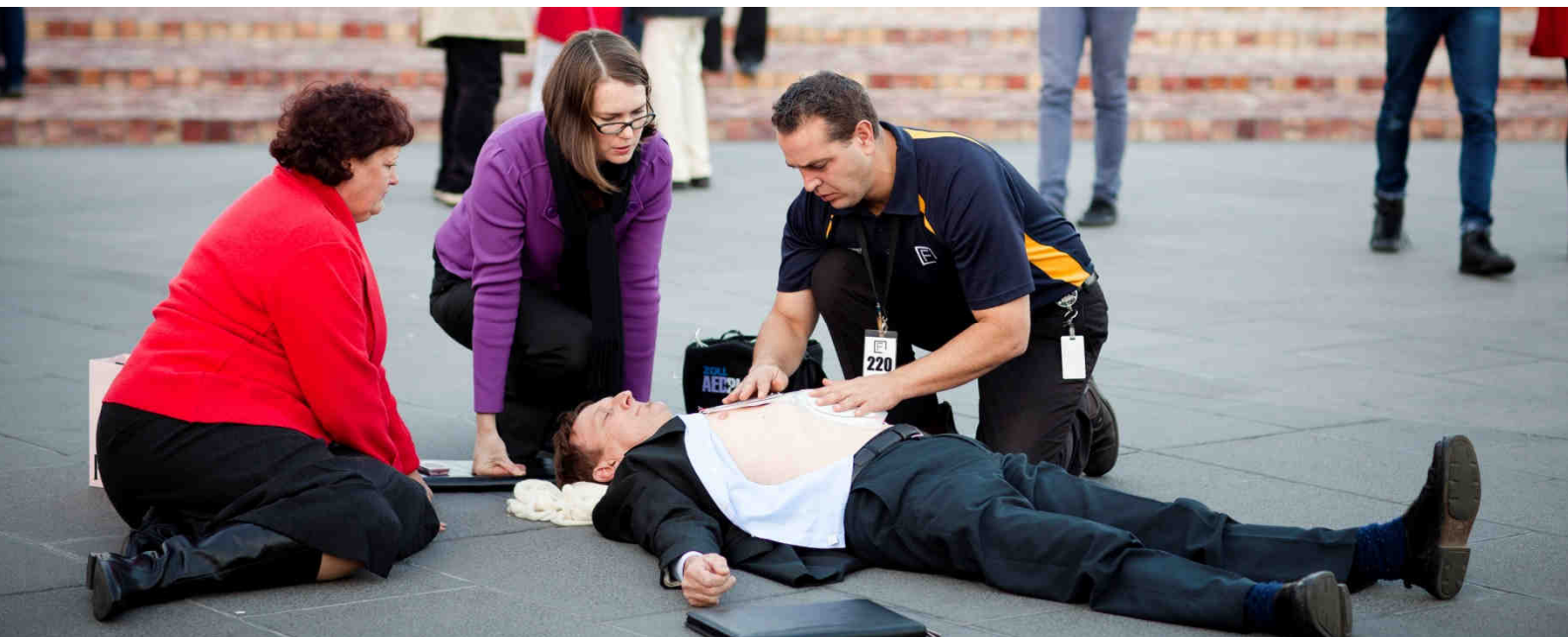



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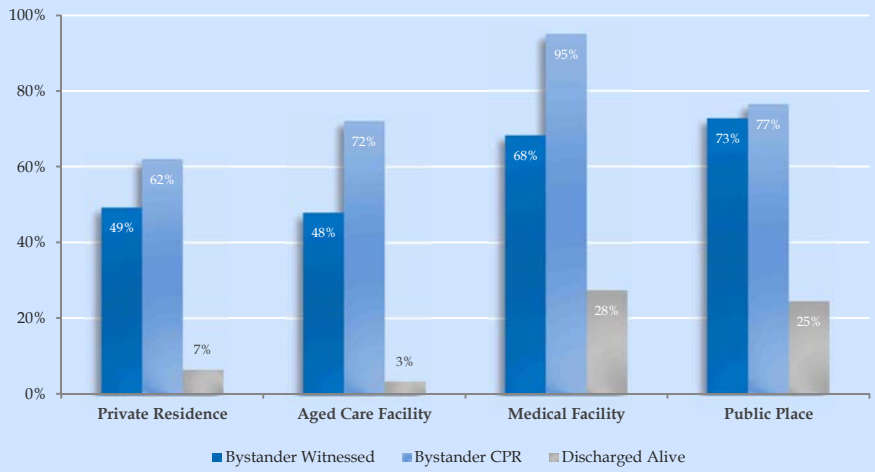
Figure 9: Proportion of EMS treated adult events that are bystander witnessed, receive bystander CPR and are discharged alive across arrest locations, 2012/13.



The presence of bystander action in public places, including bystander cardiopulmonary resuscitation, is a key factor influencing overall survival outcome following OHCA.

Arrest location for adults and paediatrics

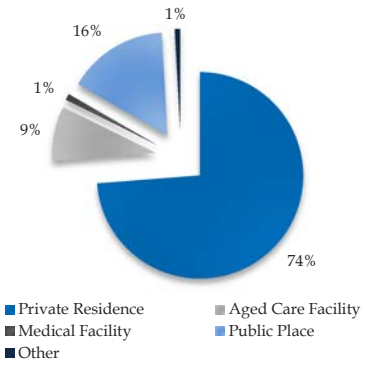


Figure 10: Location of arrest for EMS attended adult events, 2012/13.

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 10. Public places include places of work, streets or roads, shops, vehicles, and sporting/recreational facilities. In 2012/13, 74% of EMS attended adult OHCA events occurred within a private residence, while 16% occurred in a public place. Of the patients receiving an attempted resuscitation, 68% were in a private residence and 21% 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 9).

The presence of bystander action in public places has an important contribution on survival for adult events occurring in these locations. Survival to hospital discharge varied significantly between private residence and public place (7% vs. 25%, $p<0.001$).

The locations of arrest in paediatrics are similar to those in adults. In 2012/13, 80% of EMS attended paediatric events occurred in the home, while 17% occurred in a public place. The distribution of arrest locations for paediatrics was similar in both EMS attended and EMS treated populations.

Chain of Survival

Chain of Survival

The chain of survival is an internationally-recognised initiative aimed at maximising favourable outcomes 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 has demonstrated that inappropriate emergency call delays to neighbours, relatives, and the local doctor were associated with significantly poorer outcomes following OHCA (*Nehme et al. 2013*).

In 2012/13, the first bystander call for help was correctly directed to ambulance in 91% of cases. However, emergency call delays continue to exist in almost 1 in every 10 events attended, where the first call for help is instead directed to a relative/friend (3%), neighbour (2%), police (2%) or other person (1%).

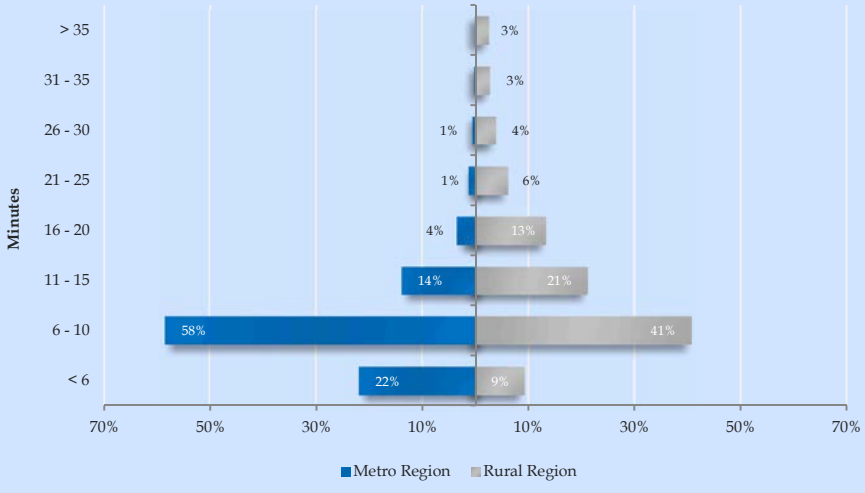
Accurate identification of cardiac arrest during the emergency call is also an important factor influencing the receipt of early dispatcher-assisted CPR instructions and the timely response of emergency medical teams. In 2012/13, 91% of all EMS attended OHCA events of presumed cardiac aetiology were correctly identified in the emergency call (metropolitan region only).

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. In 2012/13, there was a modest improvement in median response times to EMS treated events in metropolitan regions, reducing to 7.8 minutes from 8.1 minutes in 2011/12 (p=0.033). However, median response times in rural areas did not reduce from the previous year and remains at 11.0 minutes.

Unprecedented demand for ambulance services over the last decade has significantly impacted on EMS response time performance to OHCA patients. The proportion of EMS treated events receiving a response time less than 11 minutes has deteriorated significantly from 81% in 2003/04 to 72% in 2012/13 (p<0.001). Timely response by first responder teams (see The Emergency Medical Service, page 11) remains a key factor driving lower EMS response times in metropolitan and rural regions. In 2012/13, 29% and 3% of EMS treated events in metropolitan and rural regions respectively, received a quicker response from first responder teams.

Figure 11: Time from call to arrival of EMS on scene in the EMS treated population, 2012/13.



Bystander cardiopulmonary resuscitation

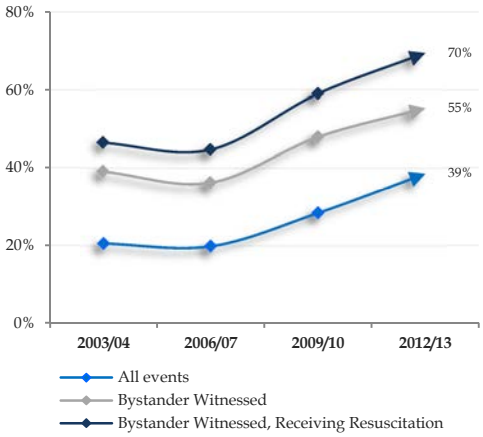


Figure 12: Bystander CPR rates.

Early effective bystander CPR increases the likelihood of an initial shockable rhythm, and greatly improves the chance of survival following OHCA. Over the decade, Victoria has observed significant increases in bystanders CPR rates, and can be partly attributed to accurate identification of OHCA during the emergency call and the delivery of dispatcher-assisted telephone instructions for CPR. In 2012/13, patients who were witnessed to collapse by bystanders had a 55% chance of receiving bystander CPR, in comparison to 39% in 2003/04 ($p<0.001$). Of the bystander witnessed events receiving an attempted resuscitation by EMS, 70% had received CPR by a bystander in 2012/13 (see Figure 12).

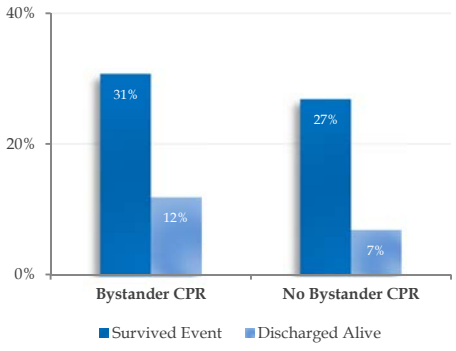


Figure 13: Survival outcomes after bystander CPR in the EMS treated population, 2012/13.

The unadjusted odds of survival were strongly associated with the presence of bystander CPR in 2012/13 (see Figure 13). In the EMS treated population, both event survival (31% vs. 27%, $p=0.073$) and survival to discharge (12% vs. 7%, $p<0.001$) were significantly higher in patients receiving bystander CPR compared to those with no bystander intervention.

Time to first defibrillation

The time from emergency call to first defibrillation for patients presenting in a shockable rhythm is a key quality and 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 shockable rhythms in Victoria. In fact, the proportion of cases where Ambulance Victoria performs the first defibrillation has reduced significantly since 2003/04, from 93% to 80% in 2012/13 ($p<0.001$). This decline has been driven by a 10-fold increase in the use of public automated external defibrillators (AED) by bystanders (from 1% to 10%), and a near two-fold increase in first defibrillations by first responders (from 6% to 11%) over the same period.

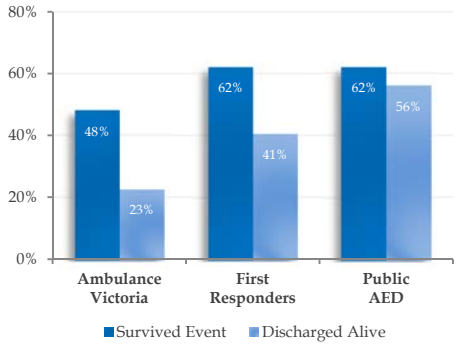
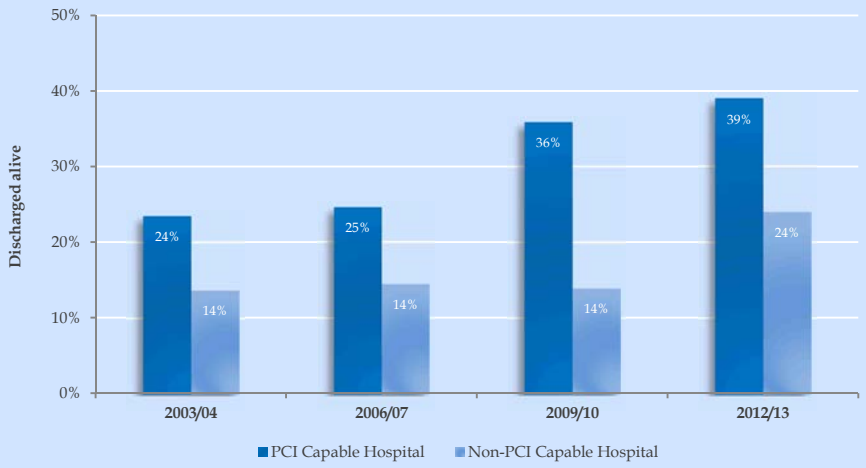


Figure 14: Survival outcome according to who shocked first in the EMS treated population with a shockable rhythm on or before EMS arrival, 2012/13.

It is widely accepted that reducing delays to defibrillation lead to better outcomes for patients in shockable rhythms. Unadjusted survival outcomes for patients presenting in shockable rhythms on or before EMS arrival vary significantly according to who performed the first defibrillation (see Figure 14). While fluctuations in survival proportions are commonly observed in this analysis (small samples sizes), 2012/13 demonstrated particularly rewarding outcomes for patients receiving first defibrillation by bystanders and first responders. The proportion of patients surviving the event when defibrillated by first responders or public AED was 62% for both groups, compared with 48% when shocked by paramedics. Similarly, survival to discharge was also improved in both first responders (41% vs. 23%, $p<0.001$) and public AED (56% vs. 23%, $p<0.001$) defibrillations when compared to defibrillation by paramedics.

The time to first defibrillation by EMS is recorded in EMS treated patients whose rhythm is shockable on EMS arrival, and not before. In 2012/13, the median time to defibrillation was 11.0 minutes and 13.8 minutes in the metropolitan and rural region respectively. The statewide time to defibrillation of 11.5 minutes was a modest improvement over the previous year's result of 12.0 minutes, albeit not statistically significant.

Figure 15: Propotion of adult presumed cardiac EMS treated events discharged alive according to transport to a PCI-capable hospital.



A discharged alive rate of 56% in 2012/13 for patients defibrillated by public AED represents the most rewarding outcomes for patients in shockable rhythms, and encourages improvements in outcomes for OHCA patients.

Despite the growing number of early defibrillations by first responders, the overall proportion of cases receiving a defibrillation attempt within 11 minutes has deteriorated significantly over the last decade. In rural regions, this proportion has reduced from 57% in 2003/04 to 24% in 2012/13 ($p<0.001$). Less drastic changes have been observed in metropolitan areas with 50% of patients receiving a defibrillation attempt with 11 minutes in 2012/13, compared to 56% in 2003/04 ($p=0.075$).

Time to defibrillation for patients in shockable rhythms correlates closely with EMS response time. Hence, a major factor involved in the long-term deterioration of defibrillation time performance is closely related to the growth in ambulance demand, and poorer response times to patients in OHCA (see 'Emergency response to the incident', page 27).

Transport to a speciality cardiac centre

Previous published research by VACAR has demonstrated that transport to a percutaneous coronary intervention (PCI)-capable hospital is associated with improved survival to discharge following OHCA *(Stub et al. 2011)*. In EMS treated adult presumed cardiac patients transported to hospital, 90% of metropolitan and 42% of rural cases were transported to a PCI-capable hospital (or 80% statewide). While this rate has remained relatively unchanged in metropolitan regions, rural trends experience yearly fluctuations and are predominantly associated with transport to two PCI-capable hospitals (Geelong Hospital and Ballarat Hospital).

In 2012/13, survival to discharge was significantly higher in patients transported to PCI-hospitals compared to hospitals without PCI capability (39% vs. 24%, $p=0.004$, see Figure 15). 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 such as therapeutic hypothermia.

Survival Outcomes

Survival Outcomes

Return of spontaneous circulation in adults

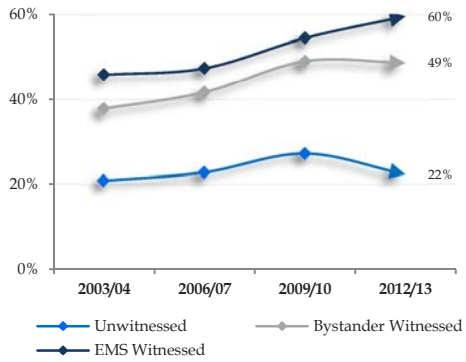


Figure 16: Proportion of adult EMS treated events with ROSC across witnessed status (includes EMS witnessed events).

Successful attempts at resuscitation following OHCA are often evaluated by the attainment of ROSC in the field. In 2012/13, ROSC was achieved in 37% of adult EMS treated events statewide. Metropolitan events observed significantly better ROSC outcomes when compared to rural events (39% vs. 30%, p<0.001). Reported ROSC outcomes vary significantly across witnessed status (see Figure 16). For adult events whose arrest was witnessed by EMS, ROSC outcomes increased to 60% in 2012/13 compared with 46% in 2003/04.

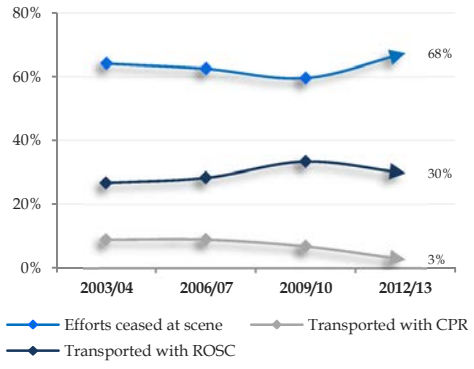


Figure 17: Scene outcomes for adult EMS treated events.

While ROSC outcomes in bystander witnessed and unwitnessed events also improved over the decade, outcomes for unwitnessed events were poorer in 2012/13 when compared to recent years (22% in 2012/13 vs. 25% in 2011/12).

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 17). The proportion of adult EMS treated events which were transported from the scene with ROSC was 30% in 2012/13, down from 32% in the previous year (p=0.06).

Adult survival from all-cause cardiac arrest

Adult survival from all-cause OHCA has increased steadily over the past 10 years. In 2003/04, event survival and survival to discharge for adult EMS treated events was 26% and 7% respectively. Survival outcomes observed their peak in 2009/10, where event survival increased to 34% and survival to discharge rose to 11%. Survival to discharge outcomes have since plateaued, and remains at 10% in 2012/13 compared with 11% in the previous year. Overall event survival was 30% in 2012/13, compared to 32% in the previous year.

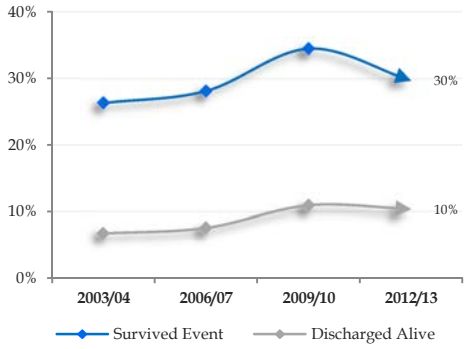


Figure 18: Survival outcomes for all-cause adult EMS treated events.

While both metropolitan and rural regions observed a decline in survival outcomes for 2012/13, the decline in event survival outcomes in rural areas was particularly marked, reducing from 27% in 2011/12 to 22% in 2012/13 (p=0.056). However, fluctuations in survival outcomes for rural regions are common, and are impacted by smaller sample sizes in this population.

The presence of a shockable rhythm on arrival of EMS is the single strongest predictor of survival from OHCA. In fact, 26% of patients in shockable rhythms survived to discharge compared with 8% and 1% for patients in PEA and asystole respectively.

Adult survival from shockable rhythms

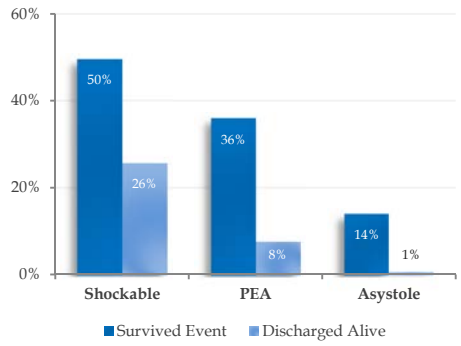


Figure 19: Survival outcomes for adult EMS treated events according to presenting rhythm on arrival, 2012/13.

The presence of a shockable rhythm on arrival of EMS is the single strongest predictor of survival from OHCA. Survival proportions for patients who presented to EMS in shockable rhythms are consistently better than those who presented in pulseless electrical activity (PEA) or asystole (see Figure 19). In fact, 26% of patients in shockable rhythms survived to discharge compared with 8% for patients in PEA. Seven patients (≈1%) who presented in asystole survived to hospital discharge in 2012/13.

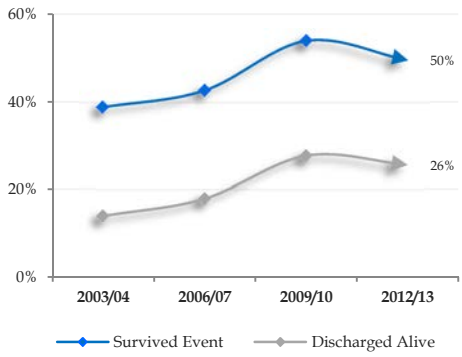


Figure 20: Survival outcomes for adult EMS treated events with a shockable rhythm on arrival.

In 2012/13, the proportion of adult EMS treated events that presented to EMS in a shockable rhythm was 28% of the overall population. Ten year outcomes for patients with shockable rhythms have demonstrated strong growth (see Figure 20). In 2012/13, outcomes for shockable rhythms experienced a modest decline in both overall event survival and survival to discharge when compared with the previous year. The overall event survival proportion was 50%, compared with 53% in 2011/12. A survival to discharge rate of 26% in 2012/13 is similar that observed in 2010/11, but lower than that observed in 2011/12 (30%).

Adult survival from EMS witnessed arrests

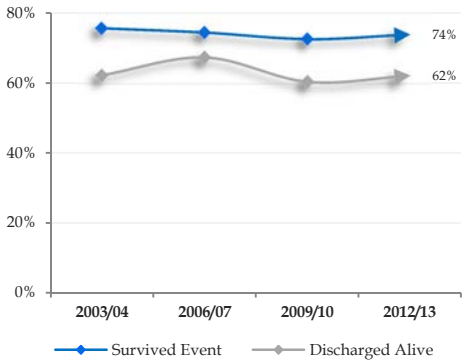
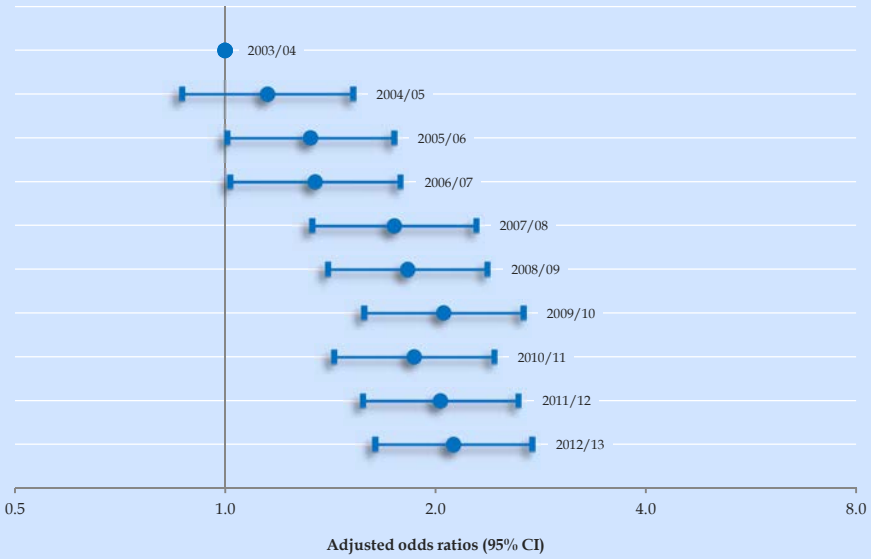


Figure 21: Survival outcomes for EMS witnessed, adult EMS treated events with a shockable rhythm on arrival.

The greatest survival benefit for patients in shockable rhythms is observed when immediate intervention is administered by paramedics. In 2012/13, event survival and survival to discharge for adult EMS witnessed events with a shockable rhythm were 74% and 62% respectively (see Figure 21). In adult EMS witnessed events from all rhythms, survival outcomes in 2012/13 were 50% and 28% for event survival and survival to discharge respectively. These findings are consistent with those observed over recent years.

Figure 22: Risk-adjusted odds of adult survival to hospital discharge by year in the overall EMS treated population.



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, with the frequency of these rhythms being 2% (n=1) in the paediatric EMS treated population. Asystole is the most common finding in paediatric OHCA, with almost 70% of the EMS treated population being found in this rhythm.

In 2012/13, 19% (n=10) of paediatric EMS treated patients survived the event, although less than a third were discharged alive (n=3). These findings were similar over the last decade.

A total of five EMS witnessed paediatric events were identified in 2012/13, of which two survived the event, and only one patient survived to discharge.

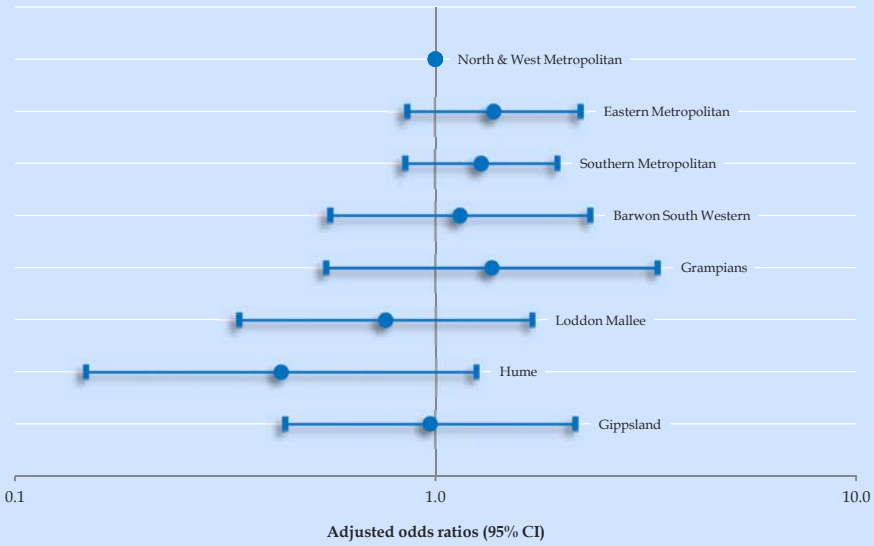
Yearly risk-adjusted odds of adult survival

The risk-adjusted odds of survival outcome provide a balanced method of measuring yearly trends in resuscitation performance. In the analysis presented in Figure 22, the odds of survival to discharge for the adult EMS treated population is evaluated across included years using a multivariate model adjusted for known predictors of survival. These predictors include: age, response time, gender, public location, shockable rhythm on arrival, bystander witnessed and bystander CPR.

The analysis demonstrates strong growth in the survival to discharge outcomes over the last decade. In 2012/13, the relative odds of survival to discharge increased two-fold when compared to outcomes observed in the reference category of 2003/04 (AOR 2.1, 95% CI 1.6-2.8, $p < 0.001$). Despite modest declines in survival proportions observed in this population in 2012/13, the relative odds of survival were equal to those observed in recent years.

Similarly, the risk-adjusted odds of survival to discharge for adult patients presenting in a shockable rhythms has observed significant improvements over the decade. In 2012/13, the risk-adjusted odds of survival to discharge for a patient presenting in VF/VT was 2.1 (95% CI 1.6-2.9, $p < 0.001$) when compared with 2003/04.

Figure 23: Risk-adjusted odds of adult survival to discharge across Department of Health regions in the EMS treated population.



Risk-adjusted odds of adult survival by region

Regional differences in cardiac arrest outcomes have been described across continents, cities, and population densities. Earlier work by VACAR *(Jennings et al. 2006)* demonstrated a significant disparity in survival outcomes across urban and regional areas of Victoria. Despite significant improvements in survival proportions over the last decade, regional variability in outcomes remain.

Risk-adjusted odds of adult survival to discharge across Department of Health regions of Victoria are presented in Figure 23 for 2012/13. Odds-ratios shown are adjusted for known predictors of survival including age, response time, gender, public location, shockable rhythm on arrival, bystander witnessed and bystander CPR.

Across both metropolitan and rural regions, no statistically significant differences in the risk-adjusted odds of survival can be observed for the adult EMS treated population. However, trends of decreasing odds of survival can be observed across rural regions with large confidence intervals reducing the accuracy of estimation of these findings. Larger sample sizes in these areas may improve the accuracy of these findings.

Discharge direction for all adult survivors

Discharge direction trends in adult survivors have observed modest improvement over the last decade (see Figure 24). In 2012/13, 86% of all adult OHCA survivors were discharged home compared with 78% in 2003/04 (p=0.053). This proportion equates to 83% for non-EMS witnessed events and 91% in events witnessed by EMS. The proportion of patients discharged to rehabilitation and nursing homes in all survivors was 9% and 4% respectively.

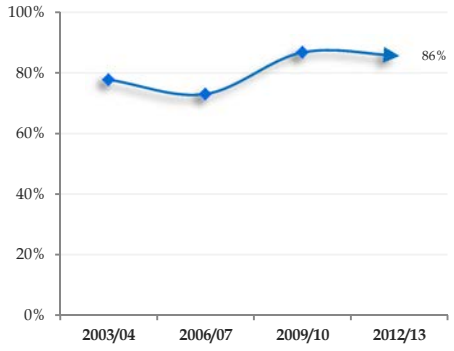


Figure 24: Proportion of adult discharged alive patients who are discharged to private residence (includes EMS witnessed events).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Research highlights

> "Our research agenda focuses on every aspect of the chain of survival, from the barriers following patient collapse to the optimisation of post-arrest care in hospitals, we're continually exploring new approaches to care."
>
> *A/Prof Karen Smith, VACAR Principle Investigator and Chair*

Exploring gender differences in survival outcome

A number of recent studies have suggested that gender differences in OHCA survival outcomes exist, and may favour women of younger age. This has led several investigators to postulate whether these outcomes are related to the protective effects of endogenous oestrogen or the "oestrogen effect". In this study published in *Resuscitation*, Bray et al. contributes to our understanding of this topic, and provides valuable insight into the gender difference in survival outcomes following OHCA.

Bray J, Stub D, Bernard S, et al. Exploring gender differences and the "oestrogen effect" in an Australian out-of-hospital cardiac arrest population. Resuscitation 2013;84(7):957-63.

Quality of life of young adult survivors

Cardiopulmonary resuscitation has the aim of returning patients to independent living, although relatively few authors have explored the quality of life of adult survivors following OHCA. In this study published by the *Emergency Medical Journal*, Deasy et al. provide the first insight into the quality of life telephone interviews conducted by VACAR. This preliminary study confirms that the majority of young survivors have good functional and quality of life outcomes.

Deasy C, Bray J, Smith K, et al. Functional outcomes and quality of life of young adults who survive out-of-hospital cardiac arrest. Emerg Med J. 2013;30(7):532-7.

Precordial thump or immediate defibrillation?

Since being first described by Schott in 1920 as a single sharp blow to a patient's chest, the efficacy of the precordial thump has been the subject of ongoing debate. In this study published in *Resuscitation*, Nehme & colleagues provide key insight into the effectiveness of an initial precordial thump for the treatment of OHCA from shockable rhythms and witnessed by EMS. The findings may suggest that a precordial thump is more commonly associated with rhythm deterioration than return of spontaneous circulation.

Nehme Z, Andrew E, Bernard SA, et al. Treatment of monitored out-of-hospital ventricular fibrillation and pulseless ventricular tachycardia utilising the precordial thump. Resuscitation. 2013; doi: 10.1016/j.resuscitation.2013.08.011.

Myocardial infarction complicated by OHCA

Patients with myocardial infarction complicated by OHCA remain at high risk of mortality, and may benefit from emergent percutaneous coronary intervention. In this study published in the *International Journal of Cardiology*, Lim et al. explore the clinical characteristics, procedural details and clinical outcomes of patients with myocardial infarction complicated by OHCA. The study demonstrates the strength of data linkage, including data from two large, prospective, multicentre registries in Victoria.

Lim H, Stub D, Ajani A, et al. Survival in patients with myocardial infarction complicated by out-of-hospital cardiac arrest undergoing emergency percutaneous coronary intervention. Int J Cardiol. 2013;166(2):425-30.

Peer-reviewed publications

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List of abbreviations

ACO	Ambulance Community Officers
ALS	Advanced Life Support
AV	Ambulance Victoria
CERT	Community Emergency Response Teams
CFA	Country Fire Authority
CPR	Cardiopulmonary Resuscitation
DH	Department of Health
ECG	Electrocardiogram
EMS	Emergency Medical Services
LGA	Local Government Areas
MFB	Metropolitan Fire Brigade
MICA	Mobile Intensive Care Ambulance
OHCA	Out-of-Hospital Cardiac Arrest
PCR	Patient Care Record
PEA	Pulseless Electrical Activity
ROSC	Return of Spontaneous Circulation
VACAR	Victorian Ambulance Cardiac Arrest Registry
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.
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).

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