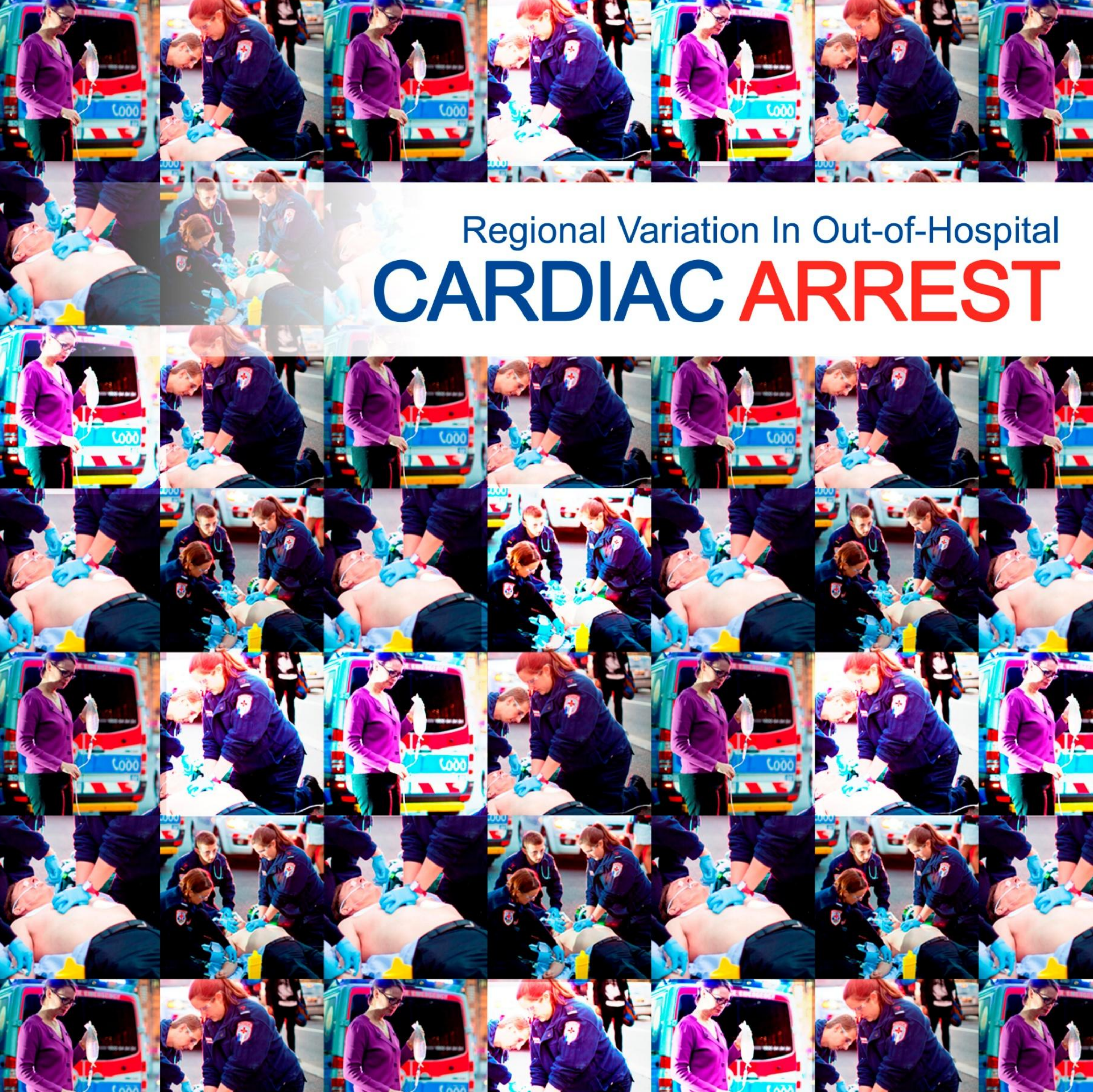

Regional Variation In Out-of-Hospital

CARDIAC ARREST

Victorian Ambulance Cardiac Arrest Registry (VACAR)

<u>REPORT FOR CONSULTATION</u>

REGIONAL VARIATION IN OUT-OF-HOSPITAL CARDIAC ARREST OUTCOMES IN VICTORIA

November 2012

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This document has been prepared by the Victorian Ambulance Cardiac Arrest Registry, Department of Research & Evaluation at Ambulance Victoria.

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About this report

The following report details the findings from an evaluation using the Victorian Ambulance Cardiac Arrest Registry (VACAR) to explain the variation in out-of-hospital cardiac arrest (OHCA) outcomes between metropolitan and rural regions of Victoria.

This research follows on from previous reports conducted on cardiac arrests occurring between 2002 and 2006, which identified poorer survival from OHCA in rural areas, with various regional differences accounting for some of the variation observed. Since that time a number of changes have occurred within Emergency Medical Services (EMS) in Victoria, including the amalgamation of the Metropolitan Ambulance Service (MAS) and the Rural Ambulance Service (RAV) to form Ambulance Victoria in July 2008.

Furthermore, previous reports failed to account for hospital-based variables which may have impacted on survival from OHCA, such as availability of cardiac interventions at receiving hospitals. As a result, previous reports may have overestimated the impact of region on survival from OHCA. Given these factors, it is timely to revisit this issue and re-examine known and novel factors that may explain the disparity in regional cardiac arrest outcomes.

The purpose of this research was to conduct a comprehensive epidemiological evaluation of the regional disparity in cardiac arrest outcomes using data extracted from the VACAR.

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When Reading this Report

On 1 July 2008 the Metropolitan Ambulance Service, Rural Ambulance Victoria, and Alexandra and District Ambulance Service merged to form Ambulance Victoria (AV). Data within this report is derived from both metropolitan and rural regions - this division is defined within the report as cardiac arrests attended by "Metro" Ambulance Victoria and "Rural" Ambulance Victoria. Geospatial mapping show the AV metropolitan and rural boundaries to strongly correlate with the Melbourne UCL boundary (Metro=94%; Rural=0%) and Department of Health's metropolitan boundary (Metro=99.6%; Rural=0.02%).

Data on survival from hospital should be treated with caution as the database is continually updated with discharge information. Hospital follow-up data remains pending in as many as 32 cases for 2011. While this number may appear small, it can have a significant impact on observed outcomes for low incidence groups, including and especially, rural region events (refer to Appendix, Figure 18).

Definitions

Adults	Cases aged > 17 years of age.
Any ROSC	Cases in which the resuscitation attempt results in a return of spontaneous circulation (i.e. detectable pulse) at any time.
Attempted EMS Resuscitation	Cases where either paramedics or first responders attempted to revive a patient in cardiac arrest, regardless of duration.
Dead on Arrival	Cases which are deceased on arrival as determined by paramedics.
Died at Scene	Cases 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.
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 etc.) as acquired from the patient care record (PCR).
Survival to Hospital	Cases that have a palpable pulse on arrival at hospital as documented on the PCR.
Survival to Hospital Discharge	Cases who are discharged from hospital alive
Transported with CPR	Cases who at the time of scene departure are administered ongoing CPR.
Transported with ROSC	Cases that at the time of scene departure have a ROSC (i.e. detectable pulse).

Executive summary

1. Survival to hospital following OHCA has improved significantly since 2003 for both metropolitan and rural regions. Although survival remains significantly higher in metropolitan cases, this effect appears to be narrowing after observing an improving survival trend in rural regions after 2008. In 2011, survival to hospital remains 7% higher in the metropolitan region, while survival to discharge remains 6% higher. Survival to hospital and hospital discharge favours the metropolitan region even after adjusting for response time.
2. The metropolitan region was associated with a higher incidence of achieving ROSC and departing the scene having achieved ROSC. Rural cases were associated with a higher incidence of departing the scene with CPR ongoing, and survival in this group was comparably lower to the metropolitan equivalent.
3. When metropolitan and rural regions were compared, the proportion of cases with attempted resuscitation remained significantly higher in the metropolitan region for every year ($p<0.001$ for all years). In 2011, the annual exposure to resuscitation practice for rural AV was 12 cases per week in comparison with 33 cases per week in the metropolitan region. A crude analysis demonstrated that rural ALS teams were exposed to an average of 4 attempted resuscitation cases in 2011, compared with 12 cases per team in the metropolitan region.
4. A computerised call-taking system introduced into rural regions has significantly increased the proportion of cardiac arrests identified in the emergency call. This was associated with an increase in bystander CPR rates, and may have a positive effect on the presence of MICA paramedics dispatched to rural OHCAs. While identification of cardiac arrests in the emergency call remains significantly higher in the metropolitan region, it is expected that this margin will continue to narrow following the implementation of the electronic call-taking system in all rural areas.
5. The presence of four or more paramedics at the scene of a cardiac arrest was positively associated with survival, and to some degree explains the disparity in survival benefit attributed to the metropolitan region. Skill level was also positively associated with survival. Following similar reports from Queensland, the presence of a MICA paramedic at an OHCA was significantly associated with improved survival to hospital and hospital discharge in both metropolitan and rural regions. However, this analysis should be treated with caution due to likely uncontrolled bias.
6. The conveyance of patients directly to PCI-capable hospitals is of significant survival benefit following OHCA. Previous research by VACAR suggests that patients transported to PCI capable hospitals are 40% more likely to survive to hospital discharge.[1] Patients who suffer an OHCA in a rural region had a 60% less likelihood of being conveyed to a PCI-capable service in 2011. This finding is likely to represent the limited access to Ballarat and Geelong PCI services rather than reflecting a difference in clinical practice across regions. Adjusting for the transportation of

patients to PCI-capable hospitals can partly explain the survival benefit observed in the metropolitan region.

7. Statistical modelling of survival to hospital discharge has described epidemiological and clinical predictors which are strongly associated with outcome. These analyses have identified that age, public location, bystander witnessed, rhythm of arrest into VF/VT, and rural location are all valuable predictors of survival to hospital discharge from OHCA. Importantly, other variables such as bystander CPR, response times, and transport to a PCI-capable hospital, were also significant predictors of outcome from OHCA.
8. Standardisation of the OHCA population allows us to optimise epidemiological and clinical variables across both regions. While these analyses diminish the external validity of the results, they draw relevant hypotheses for further investigation. This report has established that the effect of rural location on survival to hospital discharge can be partly explained by the influence of suboptimal conditions, such as paramedic resourcing, longer response times and transport destination. Furthermore, our analyses also demonstrate that comparable levels of survival to hospital discharge are observed for cases that are transported to PCI-capable hospitals.

Recommendations

1. **To monitor the quality of resuscitation and post-ROSC practice within existing quality assurance systems to ensure statewide uniformity in cardiac arrest care.**
   Clinical exposure to cardiac arrest remains significantly higher on average in the metropolitan area, with some major rural centres exposed to extremely low levels of resuscitation practice. While this report was unable to investigate the true impact of exposure on survival from OHCA, it is plausible that some of the survival benefit observed in the metropolitan region can be attributed to higher levels of clinical exposure to resuscitation practice. A more detailed evaluation of clinical exposure and its impact on survival from OHCA should be considered.

2. **To evaluate the feasibility of a statewide cardiac arrest transport algorithm allowing paramedics to convey patients directly to hospitals with access to percutaneous coronary intervention (PCI) facilities.**
   This report and previous work by VACAR has demonstrated a significant improvement in survival to discharge for patients conveyed to PCI-capable hospitals. In addition, the survival benefit observed in the metropolitan area can be partly explained by the balance in access to PCI-capable centres. This report supports the equitable access to PCI facilities in rural areas including the expansion of services in the Ballarat and Bendigo urban centres as recommended by the Cardiac Service Framework for Victoria.[2] The Medical Advisory Committee should investigate the feasibility of establishing a safe and feasible statewide transport pathway allowing cardiac arrest patient's equitable access to PCI facilities.

3. **To establish a statewide minimum level of paramedic resourcing to cardiac arrest events, including skill level and staffing numbers.**
   The survival benefits observed in the metropolitan region were partly explained by the increased number of paramedics attending an OHCA event. However, this disparity is narrowing with recent trends showing comparable numbers of paramedics between regions. The presence of a MICA paramedic during resuscitation may also be associated with survival from OHCA. This report would support the continuation of minimum standards in resource dispatch to cardiac arrest events.

4. **To monitor electronic call-taking protocols to ensure the consistent capture of true cardiac arrest events across the state.**
   The metropolitan region is consistently more likely to identify true cardiac arrest events in the emergency call. This observation is likely to lead to improved participation in bystander CPR and may be associated with an increased survival benefit in metropolitan areas. Significant improvements in the identification of cardiac arrest were observed in rural regions after 2006, and the recent implementation of an electronic call-taking protocol should continue to improve recent trends in the identification of OHCA. VACAR will continue to monitor and evaluate these trends outside of the study period.

5. **To undertake a more detailed epidemiological analysis of survival from OHCA across metropolitan, urban and rural areas of Victoria using sophisticated geospatial mapping techniques.**

   Whilst this report has provided some insight into the regional survival disparity, the analysis was based solely on VACAR data and did not involve a detailed review of patient care. The question remains whether specific location factors and clinical practice factors (such as adherence to clinical practice guidelines and resuscitation technique) can account for the observed survival difference, after controlling for variables such as response time, bystander intervention and patient characteristics. Geospatial analysis using sophisticated mapping software supports robust analytical techniques, allowing for the mapping of cardiac arrest events by population density and determining the importance of ambulance, geographic and socio-demographic factors on survival.

Background & Methodology

Background

This research follows on from previous reports using the Victorian Ambulance Cardiac Arrest Registry (VACAR) by Jennings et al.[3] and Fridman and Smith[4]. These investigations had previously reported significant differences in out-of-hospital cardiac arrest (OHCA) survival outcomes between rural and metropolitan regions of Victoria.

In a report published by Jennings et al.[3], differences in survival for metropolitan and rural OHCA patients were investigated in a cohort of 1,790 adult patients who suffered a bystander-witnessed cardiac arrest of presumed cardiac aetiology from 2002-3. The report identified that survival to hospital discharge was 7.4% in urban regions, compared with 1.9% in rural regions. The authors concluded that reduced survival in rural areas was associated with unavoidably longer EMS response times, attributable to the spread of population over a vast rural area.

By the end of 2006, sufficient data was captured by VACAR to attempt to investigate the disparity in urban and rural survival in more detail. Using a sample of 6,966 OHCA cases of presumed cardiac aetiology where EMS attempted resuscitation, Fridman and Smith[4] reported survival to hospital for OHCA in urban and rural regions. The authors identified that survival to hospital was 14.3% in patients attended by the former Rural Ambulance Service (RAV) compared to 28.9% for patients attended by the former Metropolitan Ambulance Service (MAS). Similarly, survival to hospital discharge was 3.8% for patients attended by RAV compared with 8.7% when attended by the MAS. The authors hypothesised a range of factors to explain these differences:

- Inherit differences in the operations between the two EMS;
- Response times, presenting cardiac rhythm and hospital care did not completely explain the difference in regional outcomes.
- The number of EMS personnel on the scene at an arrest was lower in rural regions and was estimated to account for over a fifth of the difference in regional survival.

The assumed "MAS and RAV" disparity in survival could also represent other regional differences not accounted for in the analysis at that time, such as the access to cardiac interventions. Furthermore, a number of changes have occurred within the ambulance service since that time:

- The amalgamation of ambulance services in Victoria;
- The broader resourcing and access to Advanced Life Support (ALS) paramedics across Victoria;
- Changes to resuscitation guidelines and practices, including access to improved post-resuscitation management (e.g. therapeutic hypothermia, blood pressure support, etc.);
- The advent of electronic protocol-based emergency call taking in rural regions.

Given the breadth of changes to EMS in Victoria since 2006, the aim of this report is to re-examine the state of OHCA survival in the state of Victoria, by comparing regional differences in survival. The first part of this report examines differences in survival outcomes between regions, while the latter part of the report explores the impact of known and novel factors that may explain the disparity in OHCA outcomes in Victoria, including: 1) regional differences in incidence & exposure to OHCA; 2) impact of emergency response call taking and identification of calls; 3) paramedic resourcing at OHCAs including skill level, and; 4) patient access to cardiac interventions at receiving hospitals.

Setting

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 mobile intensive care ambulance (MICA) paramedics who are authorised to perform endotracheal intubation, rapid sequence induction, Pneumocath® insertion and administer a wider range of drugs. 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 Medical Priority Dispatch System (MPDS) is operational in Victoria. MICA paramedics are dispatched to patients with critical illness, including patients with cardiac arrest. A first responder program for early defibrillation by fire-fighters operates for suspected cardiac arrest patients in the inner and peripheral areas of Melbourne. In addition, AV co-responds with 29 volunteer community teams in smaller, predominately rural communities across the state. The cardiac arrest protocols follow the recommendations of the Australian Resuscitation Council. Ambulance Victoria paramedics are not obliged to commence resuscitation when the clinical presentation are inconsistent with life. This includes decapitation, presence of rigor mortis, decomposition or post mortem lividity, where death has been declared by a Medical Officer who is or has been at the scene and where the presenting rhythm was monitored as asystole for greater than 30 seconds, and there has been more than 10 minutes downtime with no evidence of hypothermia, drug overdose or family/bystander objections. 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 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.

Methodology

Data Sources

The VACAR contains information from patient care records (PCR) dating back to October 1999, for all patients in Victoria who suffer a cardiac arrest and have ambulance attendance. VACAR identifies cases via an electronic data filter and via a manual sort of paper PCR. The registry is based on internationally recognised data variables and definitions.[5] Clinical and operational data is extracted from PCRs (for both Ambulance Victoria records and those of first responders) and from ambulance operational databases (e.g. computer-aided dispatch generated response times). Prehospital data is supplemented with hospital discharge data and discharge direction. The Victorian Registry of Births, Deaths and Marriages is searched for death information within 12-months of cardiac arrest survivors being discharged from hospitals.

VACAR is one of the largest cardiac arrest registries in the world and has the advantage of reduced heterogeneity due to data being obtained from a single ambulance service (previously two services prior to June 2008). Data is subject to rigorous quality control procedures including mandatory fields, range validations, rhythm confirmation from ECG, retrospective audits and senior paramedic audit of key cases. VACAR contains over 60,000 patients and has relatively little missing data.

Eligibility Criteria

In order to compare similar cases between regions, this report restricts its focus to a similar cohort used in the previous reports.[4] The cohort included:

1. Adults (age > 17 years);
2. Cases occurring between 2003 and 2011;
3. Cases occurring within Victoria;
4. Cases that were presumed to be of cardiac aetiology (70-80% of all OHCA);
5. Cases in cardiac arrest on arrival of EMS (excluding EMS witnessed arrests).

EMS witnessed cardiac arrests are explored separately to cases in arrest on EMS arrival because of the availability of immediate EMS resuscitation and the difference in factors that influence survival (e.g. EMS response times, location of the arrest and bystander CPR). A preliminary report for EMS witnessed OHCA is underway, investigating the survival outcomes for these patients in the metropolitan region.

The majority of this report focuses on cases where EMS attempted resuscitation.

Data Analysis

All cases in the study were mapped via the longitude (x) and latitude (y) coordinates of the OHCA event. A geospatial analysis was performed using Mapping Software (MapInfo). This software allows the geographical presentation of data from different sources and can display them in various combinations. Locations of cardiac arrest patients were mapped by location and matched to VACAR data.

Logistic regression analysis allows us to explore the relationship between survival outcomes by regions (MAS and RAV) while adjusting for the confounding effects of other factors that also influence survival and may be different between the regions. These variables were previously defined for the VACAR data in an OHCA survival-to-discharge model[6]. Logistic regression analysis used in this report typically adjusted for the variables: age, gender, response times, bystander witnessed, bystander CPR, and VF/VT.[6]

Cases with missing data for any variables cannot be entered into the logistic regression models. To include the maximum number of cases in the regression modelling, cases with missing response times (RAV =1.8% and MAS = 0.1%) were given the median response time for the corresponding year in which the arrest occurred.[7] Replacement of these times did not alter the median response times, or interquartile ranges, for either metropolitan or rural regions.

Survival outcomes

Main Findings Regional Differences in Survival Outcomes

The previous report by Fridman and Smith[4] identified that survival to hospital and survival to hospital discharge increased two-fold when patients were attended by MAS in comparison to RAV. This observation highlights a dramatic difference in outcomes for rural OHCA patients compared to those in metropolitan and urban regions. However, we know from internal reporting that survival rates have since increased and this has occurred irrespective of locality.

In cases where EMS attempted resuscitation, the proportion of patients dying at the scene varied annually in the metropolitan region between 59% and 64% and in the rural region between 60% and 68% (Table 2), with no statistical difference detected between the regions or over time. Over the years there is a downward trend in the proportion of patients transported to hospital with on-going CPR in both regions ($p<0.001$) and a significant improvement, particularly in rural regions, in the proportion of patients transported to hospital with ROSC ($p<0.001$). However, regional differences remain in patients transported to hospital, with less RAV cases transported from the scene with ROSC (e.g. 2011: 26% vs. 35%, $p<0.001$), and a greater portion of RAV cases transported with on-going CPR (e.g. 2011: 10% vs. 2%, $p<0.001$).

Because of these regional differences in transported patients, survival rates were also explored in these patients (i.e. excluding those who died at the scene). As can be seen in Table 3, rates of survival to hospital in patients transported differed regionally overall (mean: Metro 88% vs. Rural 57%; $p<0.001$). When examined by the two transport possibilities (i.e. transported with ROSC or transported with CPR), this difference was only seen in patients transported with CPR (mean: MAS 25% vs. RAV 9%, $p<0.001$), with no difference seen in patients transported with ROSC (mean: MAS 97% vs. RAV 97%, $p=0.92$). Survival to hospital discharge was significantly greater in MAS overall and in both transport categories.

Given the majority of survivors have an initial shockable rhythm of either VF or VT (~85%), a separate analysis was performed in this group. As can be seen in Figure 2, survival rates have improved over time in cases with an initial rhythm of VF/VT in both metropolitan and rural regions. Although the gap between MAS and RAV has narrowed, in 2011 survival was still statistically higher in the metropolitan region:

- Survival to hospital: Metro= 56% / Rural=42% ($p=0.004$);
- Survival to discharge: Metro= 31% / Rural=17% ($p=0.001$).

In recent years, metropolitan VF/VT survival rates have remained relatively stable with the exception of 2009 (Figure 2). A closer examination of these years showed survival has not statistically decreased. However, in examining at scene outcomes in this group (Table 4), there appears to be a slight but growing gap between achieving any ROSC and surviving to hospital, particularly since 2007 (Figure 3). For example, survival to hospital in 2007 for metropolitan VF/VT cases who achieved any ROSC was 96% but in 2011 was 86% ($p<0.001$). This discrepancy is not seen in rural regions (87% vs. 88%; $p<0.54$).

Table 5 and Table 6 demonstrate the impact of locality on survival from OHCA. The results from these multivariate regression analyses are displayed using odds ratios (OR), where the impact of locality (metropolitan versus rural) can be compared. The OR is calculated by dividing the odds of survival in the metropolitan region by the odds of survival in the rural region. When the OR is equal to 1, it indicates that locality does not contribute to a survival outcome. When the OR is less than 1, the odds of survival in the metropolitan region is poorer than the rural region, and similarly when the OR is greater than 1 it indicates that survival in the metropolitan region is better than the rural region. A shift in the OR towards a value of 1 indicates that the contribution of locality on survival outcome becomes diminished. Confidence intervals (95% CI) provide a region of uncertainty or error within the data. In other words, this range is where the contribution of locality on survival would lie in 95% of observed cases. Confidence intervals which intercept a value of 1 indicate no difference between localities on survival outcome.

Table 5 indicates that a significant survival benefit was observed in metropolitan region across the study period, with the exception of 2010 and 2011. These results highlight that a patient in the metropolitan region has at least a 2.16 times greater chance of survival to hospital and 1.5 times greater chance of survival to hospital discharge when compared to a patient in the rural region. Table 6 reaffirms this observation in patients presenting to EMS in VF/VT.

The previous report by Fridman and Smith[4] explored survival using the Australian Bureau of Statistics "Section of State Range (SOSR)", which assigns localities to population categories based on population size. These categories provide a useful breakdown to explore whether the improvement in survival has occurred uniformly across the state and to explore survival between metropolitan and rural regions by degree of urbanisation. Examples of cities, town and localities in each category are provided in Table 1.

Due to small number of annual cases in some population categories, the timeframe of 2003 and 2011 is divided into two groups - with 2003 to 2007 compared with 2008 to 2011. As can be seen in Table 7, survival to hospital has improved over time in most population categories in both metropolitan and rural regions of AV. This should be interpreted with caution as some population indexes have low sample sizes. This analysis also shows higher survival in metropolitan regions in almost every population index, albeit most differences were not statistically significant (interpret with caution as some populations had very small sample sizes). When OHCA survival across metropolitan and rural regions was compared for the period between 2003 and 2011, the only population categories where survival was statistically different were:

- Population 20,000 to 49,999: Survival to hospital discharge, Metro= 11% vs. Rural= 5% ($p=0.02$), and;

- Population 'Remainder of State': Survival to hospital, Metro= 28% vs. Rural= 16% ($p<0.001$); and Survival to hospital discharge, Metro= 13% vs. Rural= 4% ($p<0.001$).

Mapping of the location of rural OHCA events between 2003 and 2011 was performed to depict the spread of cases where EMS attempted resuscitation, and its association with survival. The preliminary exercise showed that survival to hospital outside of rural townships is rare (maps not shown). Figure 4 depicts all VACAR cases (no restrictions) occurring in 2011. This figure clearly illustrates the influence of remoteness on cardiac arrest survival.

Table 1: Examples of cities, towns and localities for metropolitan and rural regions of Ambulance Victoria

Population Size	Metropolitan Region	Rural Region
200-499	Don Valley, Cape Schanck	Marlo, Tangambalanga, Glenrowan, Tallygaroopna, Tylden, Port Welshpool
500-999	Flinders, Lang Lang	Mortlake, Tallangatta, Kaniva, Wahgunyah, Birchip, Trentham.
1,000-4,999	Gembrook, Cockatoo, Beaconsfield Upper, Bunyip	Cobram, Gisborne, Leongatha, Kyneton, Daylesford, Numurkah, Camperdown
5,000-9,999	Emerald, Healesville	Swan Hill, Portland, Hamilton, Benalla, Torquay, Maryborough, Ararat, Seymour
10,000-19,999	Pakenham, Bacchus Marsh	Traralgon, Wangaratta, Moe-Yallourn, Morwell, Horsham, Sale, Ocean Grove
20,000-49,999	Sunbury, Melton	Shepparton, Mildura, Wodonga, Warrnambool
50,000-99,999	-	Ballarat, Bendigo
100,000-249,999	-	Geelong
Greater than 1 million	Melbourne	-

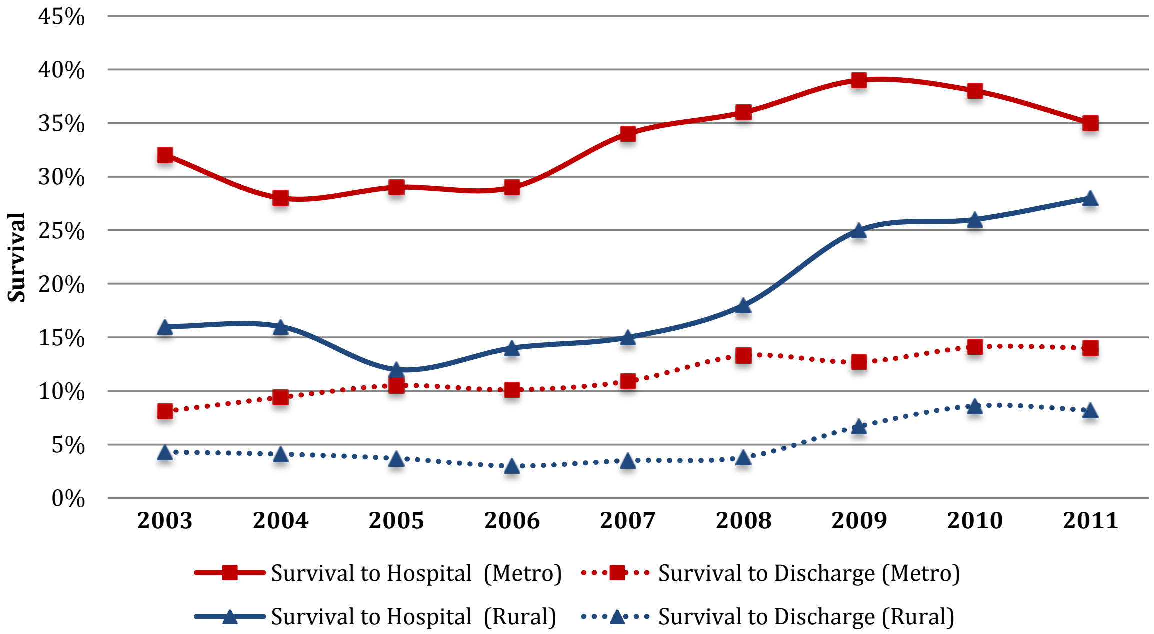
Recently, investigators conducted a pooled analysis of survival rates published between1984-2008 in adult OHCAs of presumed cardiac aetiology whom received an attempted EMS resuscitation.[8] This large study involving 142,740 pooled cases reported a rate of survival to hospital of 24% (95%CI 21%-27%) and hospital discharge of 7.6% (95%CI 6.7%-8.4%). Importantly, this meta-analysis observed no significant improvement in survival rates over this period.[8]

Variation in OHCA survival rates have been reported worldwide, with disparities reported between continents, countries, states and cities.[9-11] Survival is generally a reflection of the implementation of the "chain of survival" by the EMS and hospitals, including: rapid access to EMS, bystander cardiopulmonary resuscitation (CPR), early defibrillation programs, early advanced life support and optimal prehospital and hospital post-resuscitation care.[8] Over the last decade AV have managed to target and optimise some of the elements within the chain of survival.

In comparison, significant increases in survival rates have been observed in Victorian adult OHCA patients. Both metropolitan and rural regions of AV have observed significant increases in survival over the last decade and current rates are above the averages reported in the pooled analysis. Metropolitan survival rates of AV are above the 95^{th} percentile of the global pooled rate.

It also must be noted that the proportion of cases with missing survival to discharge data in the rural region is greater than in the metropolitan region (Metro=1.3% vs. Rural= 3.8%). A sensitivity analysis, where missing survival data is coded as all alive and all dead, showed the smaller numbers of cases in rural areas meant missing data has a greater impact – one missing patient can greatly affect survival rates. However, when the best case scenario (all missing are alive) are compared between metropolitan and rural regions over time, survival in metropolitan cases remains statistically higher.

Figure 1: Regional survival from OHCA of presumed cardiac aetiology where EMS attempted resuscitation



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Survival to Hospital	32%	28%	29%	29%	34%	36%	39%	38%	35%
Survival to Discharge	8%	9%	11%	10%	11%	13%	13%	14%	14%
Rural Region									
Survival to Hospital	16%	16%	12%	14%	15%	18%	25%	26%	28%
Survival to Discharge	4%	4%	4%	3%	4%	4%	7%	9%	8%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Survival to hospital is indicated by a palpable pulse at arrival to hospital as reported on the paramedic PCR. Excludes EMS witnessed arrests. Survival to hospital discharge excludes cases where hospital outcome data is missing. Survival data for 2011 was incomplete at the time of this report and therefore results should be interpreted with caution.*

Section 2 Regional Scene and Survival Outcomes from OHCA of Presumed Cardiac Aetiology

Table 2: Regional scene outcomes for adult presumed cardiac aetiology where EMS attempted resuscitation

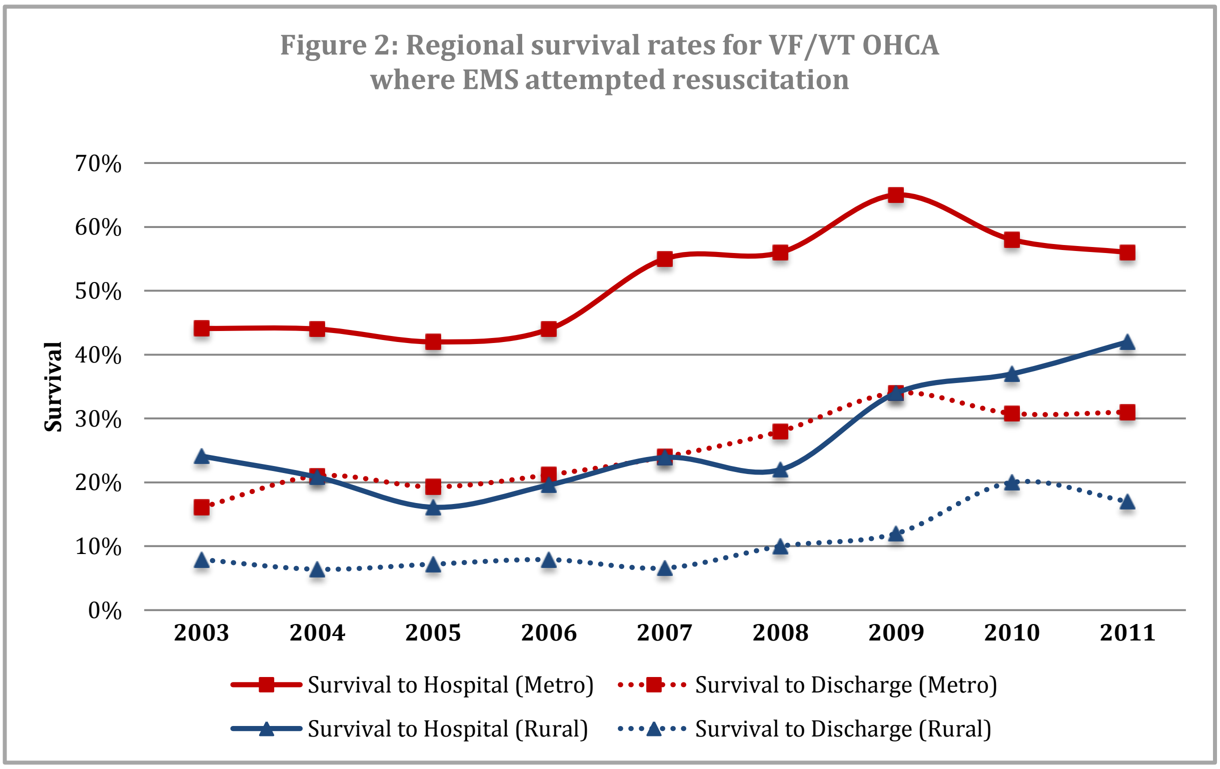
	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Died at Scene	59%	63%	63%	64%	60%	59%	58%	60%	63%
Any ROSC	39%	36%	34%	36%	38%	42%	44%	45%	42%
Transport ROSC	33%	29%	28%	31%	35%	35%	38%	37%	35%
Transport CPR	8%	8%	9%	6%	5%	6%	4%	3%	2%
Rural Region									
Died at Scene	63%	65%	68%	64%	67%	65%	60%	61%	64%
Any ROSC	23%	20%	14%	19%	19%	22%	29%	32%	34%
Transport ROSC	18%	18%	12%	14%	15%	17%	24%	26%	26%
Transport CPR	19%	17%	20%	22%	19%	18%	16%	14%	10%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

Table 3: Regional survival rates in patients transported to hospital after OHCA of presumed cardiac aetiology where EMS attempted resuscitation

		2003	2004	2005	2006	2007	2008	2009	2010	2011
All Transported										
Metro	Survival to Hospital	79%	81%	81%	84%	88%	90%	92%	96%	95%
	Survival to Discharge	20%	27%	28%	28%	28%	32%	31%	35%	39%
Rural	Survival to Hospital	47%	50%	42%	45%	49%	56%	64%	70%	77%
	Survival to Discharge	14%	14%	12%	10%	11%	13%	17%	23%	22%
Transported with ROSC										
Metro	Survival to Hospital	93%	97%	96%	96%	98%	97%	100%	100%	98%
	Survival to Discharge	24%	33%	34%	31%	31%	35%	33%	38%	40%
Rural	Survival to Hospital	94%	96%	97%	92%	93%	98%	100%	100%	99%
	Survival to Discharge	24%	24%	24%	20%	22%	24%	29%	33%	28%
Transported with CPR										
Metro	Survival to Hospital	14%	19%	31%	19%	15%	46%	22%	44%	28%
	Survival to Discharge	1%	4%	9%	13%	6%	18%	7%	7%	13%
Rural	Survival to Hospital	4%	4%	10%	12%	10%	13%	7%	9%	18%
	Survival to Discharge	5%	2%	5%	5%	2%	4%	2%	5%	7%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Survival to Hospital	44%	44%	42%	44%	55%	56%	65%	58%	56%
Survival to Discharge	16%	21%	19%	21%	24%	28%	34%	31%	31%
Rural Region									
Survival to Hospital	24%	21%	16%	20%	24%	22%	34%	37%	42%
Survival to Discharge	8%	6%	7%	8%	7%	10%	12%	20%	17%

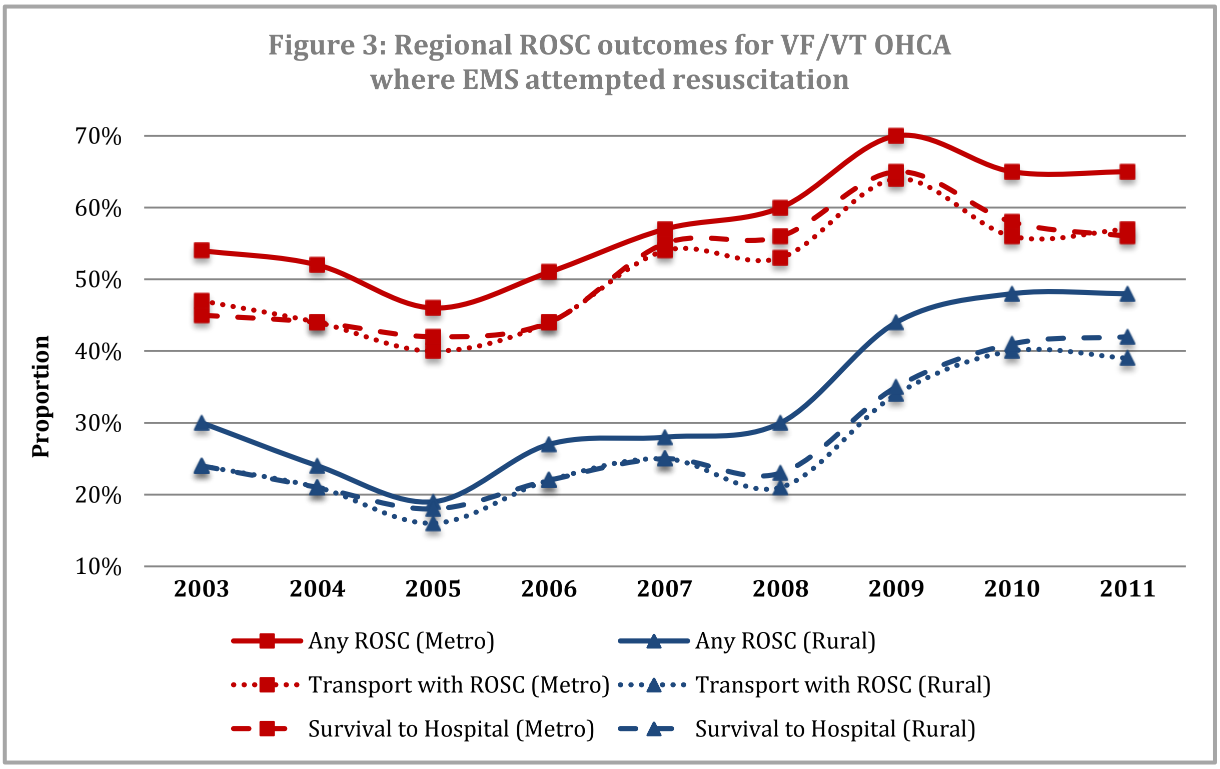
1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation and the presenting rhythm was VF or VT. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Survival to hospital is indicated by a palpable pulse at arrival to hospital as reported on the paramedic PCR. Excludes paramedic witnessed arrests. Survival to hospital discharge excludes cases where hospital outcome data is missing. Survival data for 2011 was incomplete at the time of this report and therefore results should be interpreted with caution.*

Table 4: Regional scene outcomes for VF/VT OHCA where EMS attempted resuscitation

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Died at Scene	43%	47%	50%	47%	38%	39%	31%	39%	41%
Any ROSC	54%	52%	46%	51%	57%	60%	70%	65%	65%
Transport ROSC	47%	44%	40%	44%	54%	53%	64%	56%	57%
Transport CPR	10%	9%	10%	10%	8%	8%	5%	4%	2%
Rural Region									
Died at Scene	52%	58%	58%	51%	51%	51%	41%	39%	49%
Any ROSC	30%	24%	19%	27%	28%	30%	44%	48%	48%
Transport ROSC	24%	21%	16%	22%	25%	21%	34%	40%	39%
Transport CPR	24%	21%	26%	27%	24%	28%	24%	21%	12%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation and the presenting rhythm was VF or VT. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Any ROSC	54%	52%	46%	51%	57%	60%	70%	65%	65%
Transport with ROSC	47%	44%	40%	44%	54%	53%	64%	56%	57%
Survival to Hospital	45%	44%	42%	44%	55%	56%	65%	58%	56%
Rural Region									
Any ROSC	30%	24%	19%	27%	28%	30%	44%	48%	48%
Transport with ROSC	24%	21%	16%	22%	25%	21%	34%	40%	39%
Survival to Hospital	24%	21%	18%	22%	25%	23%	35%	41%	42%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation and the presenting rhythm was VF or VT. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

Section 6 Regional Adjusted Odds Ratios for Survival from OHCA

Table 5: Adjusted odds ratios for survival from regional OHCA (all rhythms) where EMS attempted resuscitation

Year	Sample Size	Survival to Hospital	Survival to Discharge
2003	1060	2.58 (1.72-3.86); p<0.001	2.02 (1.01-4.80); p=0.05
2004	1199	2.42 (1.66-3.54); p<0.001	3.25 (1.62-6.50); p=0.001
2005	1225	3.08 (2.05-4.64); p<0.001	3.38 (1.70-6.73); p=0.001
2006	1220	2.16 (1.48-3.15); p<0.001	3.09 (1.48-6.48); p=0.003
2007	1272	3.26 (2.24-4.73); p<0.001	4.06 (1.96-8.41); p<0.001
2008	1236	2.34 (1.65-3.34); p<0.001	2.80 (1.43-5.47); p=0.003
2009	1331	2.23 (1.62-3.08); p<0.001	3.15 (1.79-5.55); p<0.001
2010	1295	1.76 (1.30-2.39); p<0.001	1.50 (0.91-2.48); p=0.116
2011	1328	1.36 (0.99-1.85); p=0.06	2.52 (1.49-4.26); p=0.001

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Excludes missing data for any variable. Adjusted odds ratios are for Metro versus Rural by year groups (adjusting for age, gender, witnessed, bystander CPR, VF/VT, response time, and arrest location).*

Table 6: Adjusted odds ratios for survival from regional OHCA of presumed cardiac aetiology (VF/VT only) where EMS attempted resuscitation

Year	Sample Size	Survival to Hospital	Survival to Discharge
2003	447	2.57 (1.49-4.42); p=0.001	2.77 (1.09-7.07); p=0.03
2004	524	3.47 (2.07-5.82); p<0.001	4.34 (1.01-9.61); p<0.001
2005	537	3.43 (2.06-5.72); p<0.001	2.91 (1.43-5.94); p=0.003
2006	493	2.84 (1.66-4.86); p<0.001	3.21 (1.49-7.12); p=0.004
2007	467	3.90 (2.37-6.41); p<0.001	4.53 (1.96-10.42); p<0.001
2008	500	3.46 (2.08-5.75); p<0.001	2.68 (1.30-5.50); p=0.007
2009	494	3.32 (2.12-5.20); p<0.001	4.20 (2.23-7.90); p<0.001
2010	524	1.97 (1.29-3.01); p=0.002	1.45 (0.85-2.50); p=0.18
2011	552	1.57 (1.05-2.36); p=0.03	2.64 (1.50-4.62); p=0.001

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation and the presenting rhythm was VF or VT. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Excludes missing data for any variable. Adjusted odds ratios are for Metro versus Rural by year group (adjusting for age, gender, witnessed, bystander CPR, response times and arrest location).*

Table 7: Regional survival from OHCA across population densities

Population Category	Survival to Hospital Metro vs. Rural (%)		Survival to Discharge Metro vs. Rural (%)	
	2003-7	2008-11	2003-7	2008-11
Remainder of State	21% vs. 11%*	36% vs. 20%*	8% vs. 3%*	19% vs. 6%*
200-499	25% vs. 7%	40% vs. 14%	0% vs. 0%	0% vs. 0%
500-999	9% vs. 8%	30% vs. 13%	0% vs. 0%	20% vs. 5%
1,000-4,999	17% vs. 11%	20% vs. 20%	8% vs. 3%	7% vs. 7%
5,000-9,999	31% vs. 15%	29% vs. 30%	8% vs. 5%	0% vs. 6%
10,000-19,999	17% vs. 15%	39% vs. 24%	8% vs. 6%	3% vs. 7%
20,000-49,999	22% vs. 17%	35% vs. 25%	8% vs. 5%	13% vs. 5%*
50,000-99,999	22% (Rural)	31% (Rural)	4% (Rural)	9% (Rural)
100,000-249,999	24% (Rural)	34% (Rural)	6% (Rural)	10% (Rural)
Greater than 1 million	32% (Metro)	37% (Metro)	10% (Metro)	13% (Metro)

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Results should be treated with caution due to small sample sizes in certain population categories.*

3 **p-value <0.05*

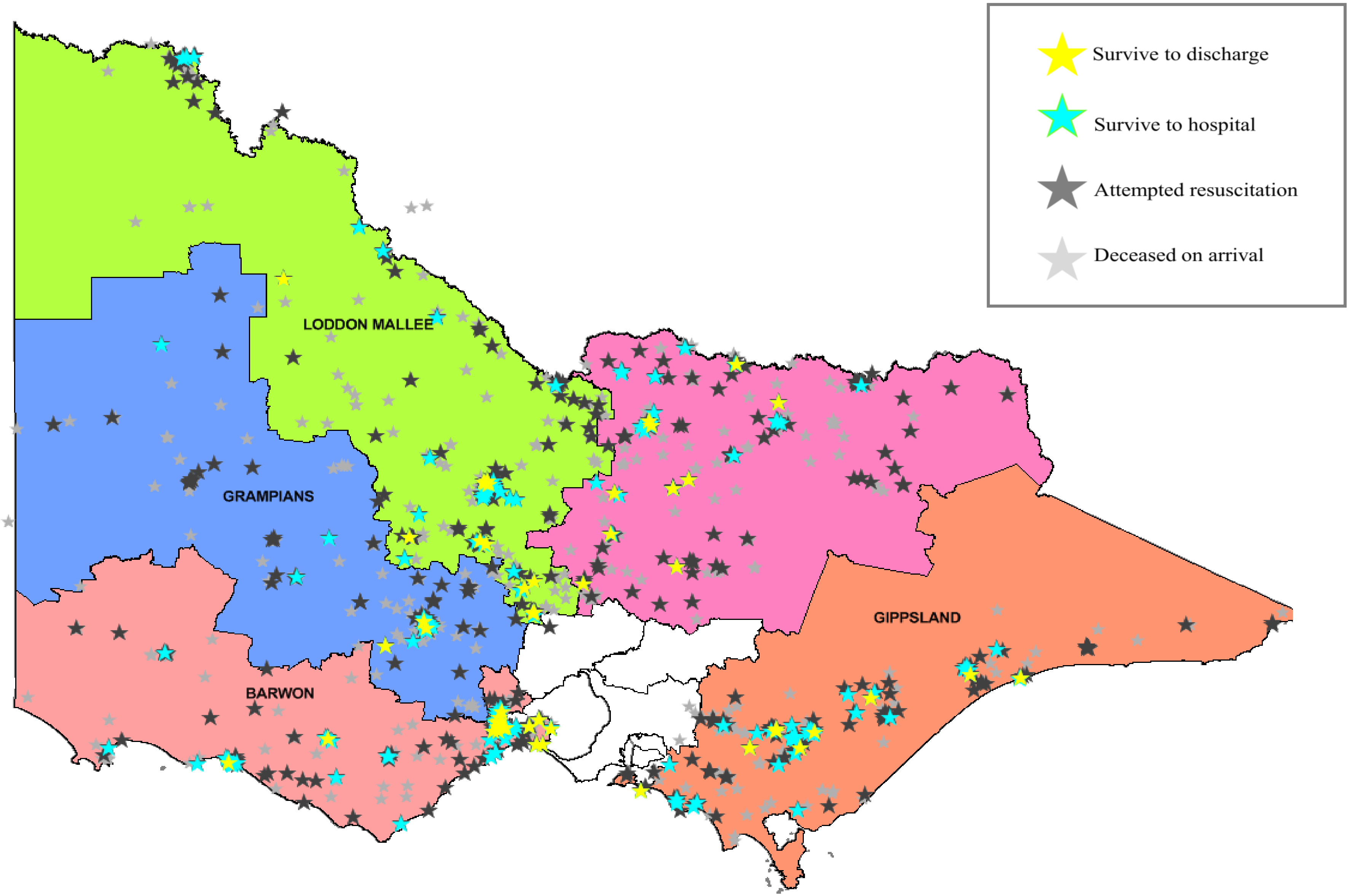
Table 8: Regional survival from OHCA across major urban localities

Locality	2003 - 2007			2008 - 2011		
	n	Survival to Hospital	Survival to Discharge	n	Survival to Hospital	Survival to Discharge
Bendigo	87	17%	1%	82	32%	11%
Ballarat	106	26%	6%	82	31%	7%
Geelong	182	24%	6%	146	34%	10%
Melbourne	4,762	32%	10%	3,888	37%	13%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Locality classified according to the Australian Bureau of Statistics Urban Centre/Locality (UCL) reference.*

Figure 4: Cluster mapping of OHCA events occurring in rural regions in 2011



Clinical exposure

Main Findings   Regional Differences in Incidence & Exposure

Between 2003 and 2011, paramedics attended 27,723 cases of adult OHCA presumed to be of cardiac aetiology in Victoria. The average annual number of cases attended for the metropolitan region was 2,207 and the rural region was 872.

Despite a steadily growing Victorian population over the study period,[12] the annual number of presumed cardiac OHCA attended by metropolitan AV has remained relatively stable (Figure 5). A heatwave experienced across the state in the summer of 2009 is the likely cause of the transient peak in numbers for that year[13]; this is supported by an increase in the number arrests in the summer of 2009, compared to previous and recent years, that occurred across most regions of the state.

When metropolitan and rural regions were compared, the proportion of cases with attempted resuscitation remained significantly higher in metropolitan AV for every year, $p<0.001$ (Figure 6). The proportion of MAS cases receiving an attempted resuscitation has remained stable, varying between 44% and 48% of presumed cardiac OHCA. In comparison, the proportion of rural cases receiving an attempted resuscitation declined to 32% in 2008 and has since increased in 2011 to 40%. This proportion equates to 357 cases or 7 cases per week (metropolitan average 19 cases per week).

Focusing broadly on all cases which received EMS attempted resuscitation (all aetiologies) in 2011, the annual exposure to resuscitation practice for rural AV was 651 cases or 12 cases per week in comparison with the metropolitan region of 1,738 cases or 33 cases per week. The rural region experienced an exposure range between 77 to 155 cases per year across rural regions (Loddon Mallee, Grampians, Barwon South West, Gippsland and Hume), with cases requiring defibrillation ranging from 22 to 78 cases per year.

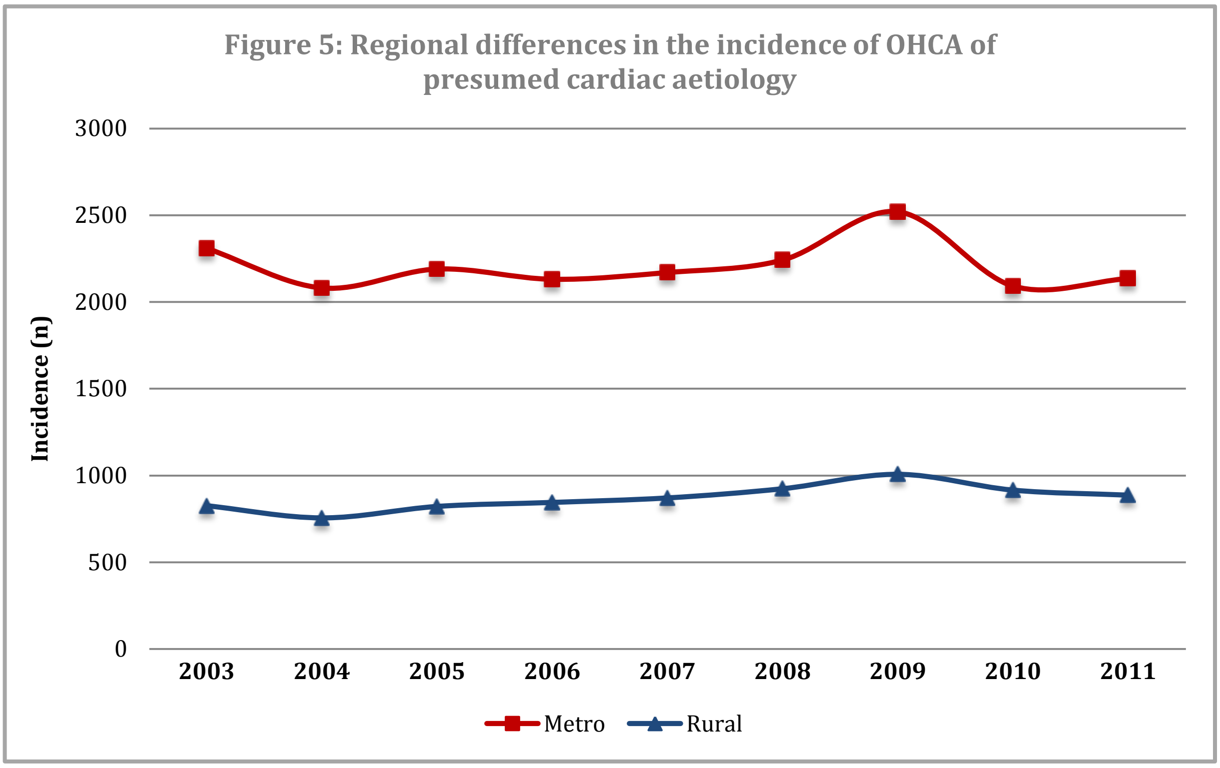
The annual characteristics of all adult presumed cardiac OHCA cases are given in Tables 9 and 10. Similarities between regions were observed:

- In recent years, adult OHCA of presumed cardiac aetiology are younger in both metropolitan and rural regions;
- Although the proportion of rural bystander witnessed arrest has decreased (26% in 2011), bystander CPR rates are on the rise (37% in 2011);
- The proportion of RAV cases with an initial rhythm of VF/VT, which decreased between 2006 and 2009, has increased to similar proportions seen in the metropolitan region.

Approximately 48% of metropolitan OHCA receive an attempted EMS resuscitation (Figure 6); with the exception of 2009 when the rate decreased to 44%, and likely associated to the summer heatwave experienced in that year. A lower rate of EMS attempted resuscitation, averaging 35%, is seen in rural regions and can be attributed to numerous factors including: increased response times, less bystander witnessed arrests, and reduced likelihood of being presented VF/VT (Table 10). Rural paramedics were also more likely to observe an initial rhythm of asystole, a rhythm associated with poor survival rates (<1%). This is likely to explain some of the disparity in overall survival between metropolitan and rural regions.

A crude analysis was conducted to determine the maximal number of arrests ALS teams would attend annually. This analysis involved dividing the number of arrests receiving an attempted resuscitation by the number of ALS teams in both metropolitan and rural regions. From this analysis, we identified that in 2011, rural ALS teams attended an average of 4 attempted resuscitation cases (interquartile range 1-5), while teams in the metropolitan region were exposed to 12 cases (interquartile range 7-17). This rudimentary analysis, not accounting for regional variation, reflects team exposure and not individual exposure. Given the current size of the AV ALS workforce individual exposure would be significantly lower. This raises the hypothesis of whether the level of exposure to resuscitation practice in rural regions (and some metropolitan regions), is sufficient to maintain competence of knowledge and skills.

Evidence of the impact of exposure to resuscitation practice in OHCA is scant. In one study, conducted in a UK EMS servicing a population of 1 million, the authors reported that the majority of paramedics were exposed to 4 to 8 resuscitations per year. However, this study did not examine the impact of exposure on survival.[14] A previous AV report by Fridman and Smith[4], determined the two-year exposure of the most experienced paramedic on scene and found BLS/ALS paramedics were involved in an average of 11 resuscitations in the metropolitan region and 5 in rural regions. This report showed no association between case exposure and survival. Another study also found no difference in outcomes when examining recent exposure in a physician-led EMS.[15] Other studies, have attempted a different approach, examining the length of experience of the most senior paramedic on scene. Results of these studies are conflicting,[14, 16] and in one study outcomes were not related to the paramedics directing the resuscitation (i.e. the most senior) but to the level of experience of the paramedics performing the resuscitation procedures.[16] Furthermore, studies involving hospital staff have shown increased experience improves resuscitation practice;[17-19] but how much exposure or experience is required remains unknown.



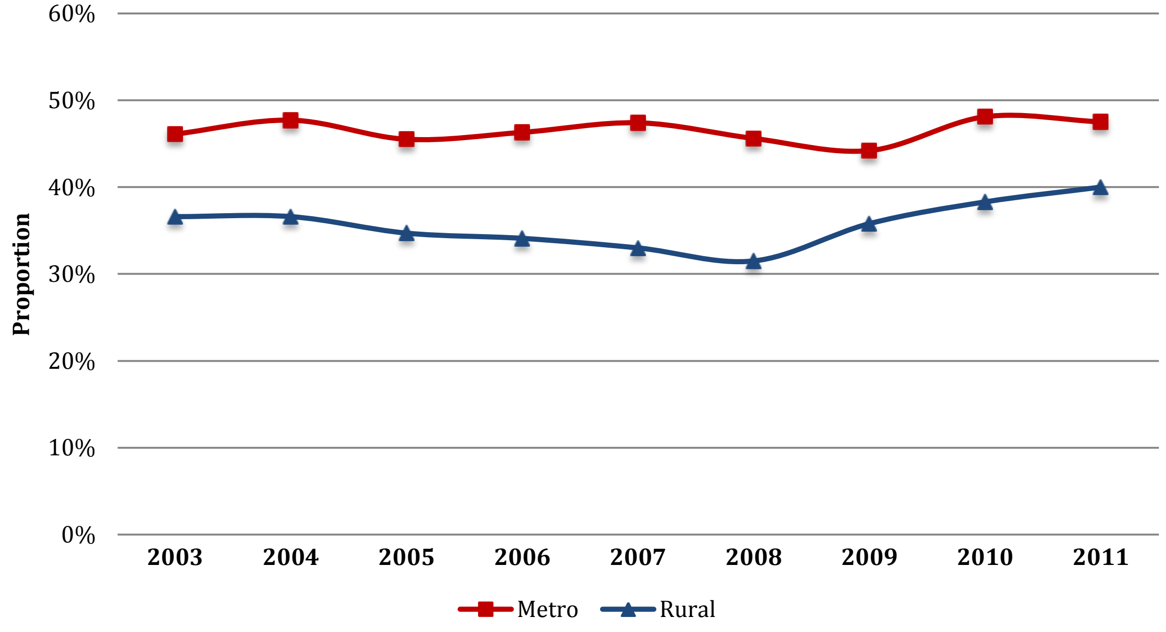
	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region	2309	2081	2190	2131	2170	2242	2520	2092	2135
Rural Region	826	756	822	845	871	924	1007	916	887

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Statewide record heatwave occurred in 2009 and may be responsible for the increase in cardiac arrest incidence.*

Section 2 Proportion of OHCA of Presumed Cardiac Aetiology where EMS Attempted Resuscitation

Figure 6: Proportion of adult OHCA of presumed cardiac aetiology which received EMS attempted resuscitation



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region	46%	48%	46%	46%	47%	46%	44%	48%	48%
Rural Region	37%	37%	35%	34%	33%	32%	36%	38%	40%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

Table 9: Characteristics of adult presumed cardiac OHCA attended by Ambulance Victoria

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Age (median)	73	74	74	74	75	74	74	73	72
Female	36%	35%	36%	34%	36%	37%	38%	37%	35%
Public Location	10%	13%	12%	11%	11%	12%	10%	12%	13%
Bystander Witnessed	34%	35%	33%	32%	31%	32%	32%	32%	32%
Bystander CPR	27%	26%	23%	23%	25%	31%	32%	34%	39%
Resp. Time (median)	7.0	7.0	7.0	7.0	8.0	8.0	8.0	8.0	8.0
VF/VT	18%	20%	19%	19%	17%	18%	15%	19%	19%
Rural Region									
Age (median)	73	73	73	74	72	73	73	71	71
Female	34%	34%	36%	34%	31%	34%	36%	35%	30%
Public Location	10%	15%	14%	10%	13%	10%	12%	13%	13%
Bystander Witnessed	36%	34%	29%	29%	22%	31%	31%	30%	26%
Bystander CPR	24%	22%	19%	18%	20%	20%	28%	30%	37%
Resp. Time (median)	9.0	8.0	9.0	10.0	10.0	10.0	11.0	11.0	10.0
VF/VT	16%	17%	17%	13%	13%	12%	14%	15%	18%

1 *Adult patients aged >17 years, presumed cardiac aetiology. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

Table 10: Characteristics of adult presumed cardiac OHCA by region where EMS attempted resuscitation

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Age (median)	71	72	71	71	72	70	71	69	70
Female	31%	29%	29%	28%	30%	30%	33%	30%	30%
Public Location	19%	22%	23%	22%	21%	22%	20%	22%	24%
Bystander Witnessed	64%	62%	65%	61%	57%	60%	62%	58%	59%
Bystander CPR	51%	46%	44%	42%	45%	56%	59%	57%	64%
Resp. Time (median)	7.0	7.0	8.0	8.0	8.0	8.0	8.0	8.0	7.9
VF/VT	40%	43%	43%	41%	36%	40%	35%	41%	41%
Rural Region									
Age (median)	71	68	68	72	67	67	70	68	67
Female	30%	30%	27%	26%	25%	26%	32%	28%	25%
Public Location	21%	28%	26%	22%	25%	22%	21%	23%	26%
Bystander Witnessed	74%	68%	67%	64%	52%	68%	66%	61%	53%

Bystander CPR	59%	49%	46%	41%	52%	52%	63%	63%	74%
Resp. Time (median)	8.0	8.0	9.0	9.0	10.0	10.0	10.0	10.0	10.0
VF/VT	44%	47%	50%	39%	40%	40%	40%	39%	45%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

Emergency response

Main Findings

Regional Differences in Emergency Response

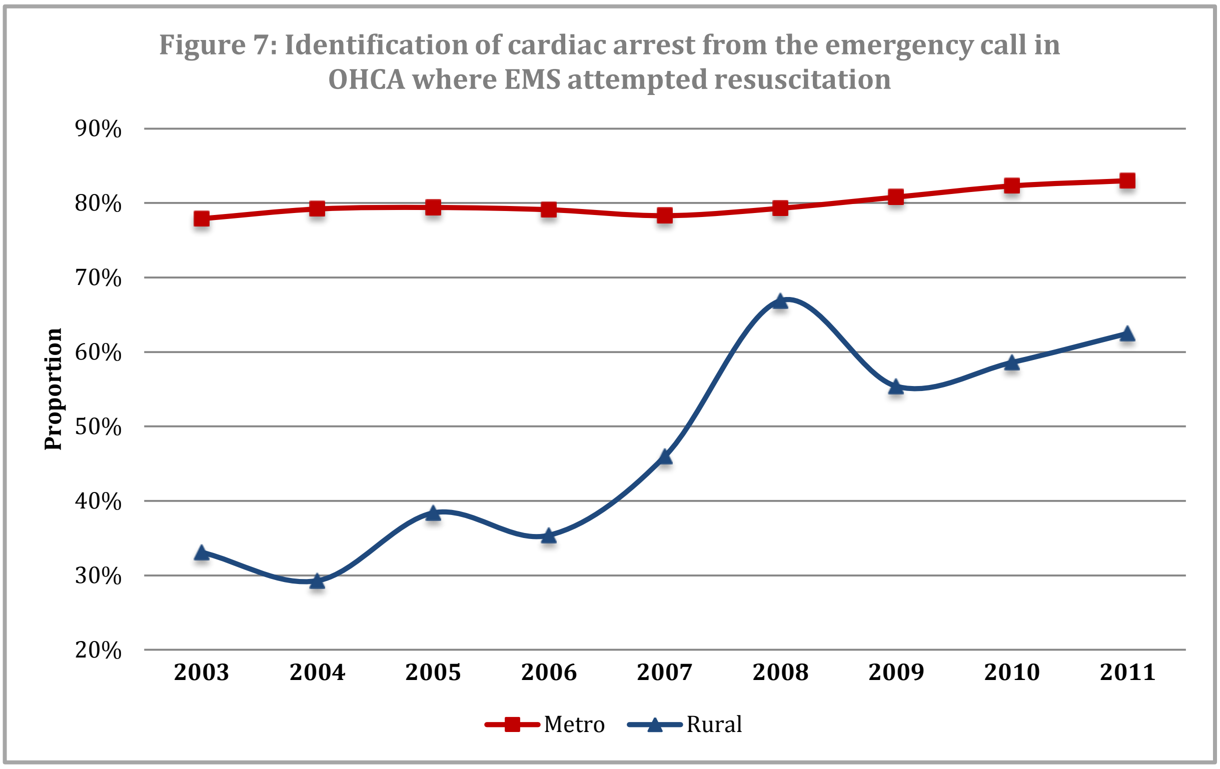
The identification of cardiac arrest in the emergency call has not been previously studied comparing metropolitan and rural regions of Victoria. Emergency calls in Victoria are assessed and prioritised using standardised "protocols" known as the Medical Priority Dispatch System (MPDS). Using MPDS, the call-taker asks the caller prescripted questions to identify the case's event type (e.g. major problem with the patient). Event types then have their own set of additional questions to allocate a priority to the ambulance response. A suspected cardiac arrest is one such event type which is allocated and receives the highest emergency response.

There are important differences in the way call taking is processed over the study period. Metropolitan cases use electronic-based protocols for call taking, whereas the rural regions of AV have implemented a staged roll-out of this feature over the last two years (June 2010 to October 2011). Prior to this time, rural regions of AV were processed using a manual or paper-based protocol.

It is also worth noting that there are important differences in the way that VACAR records dispatch data for rural and metropolitan cardiac arrest events. Metropolitan data is derived from recorded event registers while rural events are coded directly from the patient care record. The descriptive analysis shown in Figure 7 attempts to highlight only the cases where the dispatch description is clearly indicative of a suspected cardiorespiratory arrest. These dispatch descriptions relate predominantly to codes featured within card 9 of the MPDS. There is a potential for classification bias in the samples collected, and therefore this analysis should be interpreted with caution.

Figure 7 shows that less rural cases are identified as cardiac arrest in the emergency call compared to metropolitan cases. There has been some improvement in recent years, particularly following the MPDS protocol upgrade occurring in rural regions in 2007. In rural cases, a statistically significant improvement in the identification of cardiac arrest from the emergency call was noted for cases processed through the electronic format (which was identified by the extra digit in the case number). For cases who received an attempted EMS resuscitation between 2008 and 2011, the manual protocol correctly identified 59% of cardiac arrests (n=1023), while the electronic protocol identified 66% (n=338) (p=0.03). Furthermore, a significant increase was observed in the proportion of cases receiving bystander CPR using the electronic protocol (66% vs. 81%, p=0.001; see Figure 8).

As response times vary considerably between regions, it was plausible to compare the effect size of survival between regions by response time groups, after adjusting for known confounders. Table 11 demonstrates that a significant survival benefit associated with the metropolitan region was observed across most response time groups. This survival benefit increases in the metropolitan region as response time increases, particularly between 2003 and 2007. However, the survival benefit observed in the metropolitan region diminishes slightly for cases occurring after 2008, with no significant differences in outcome observed in cases beyond 12 minutes.

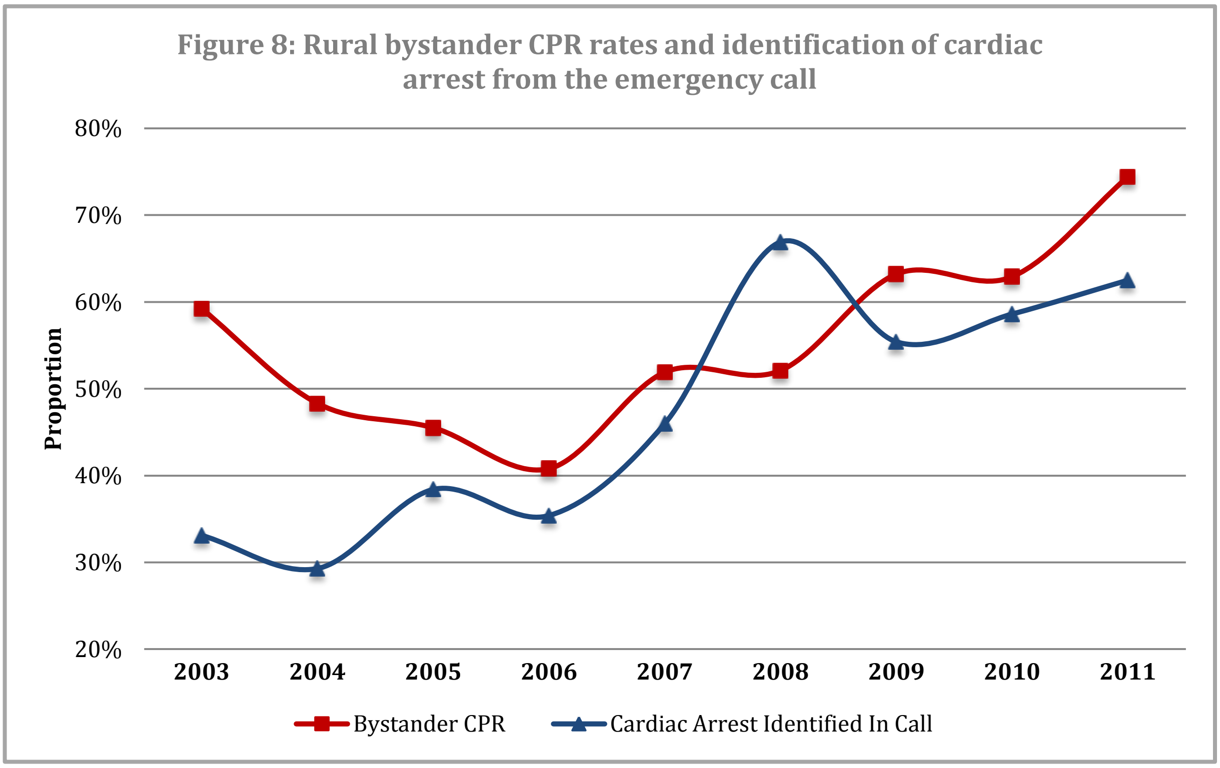


	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region	78%	79%	79%	79%	78%	79%	81%	82%	83%
Rural Region	33%	29%	38%	35%	46%	67%	55%	59%	63%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Cardiac arrest identification during the emergency call has been interpreted as suspected cardiac arrest events which would routinely lead to the administration of Dispatcher Life Support (DLS).*

3 *Collection of dispatch data in VACAR varies according to metropolitan and rural cases. Metropolitan data is derived from recorded event registers while rural events are coded directly from the crew's patient care record. This may lead to uncontrolled bias in the samples collected.*



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bystander CPR	59%	48%	46%	41%	52%	52%	63%	63%	74%
Cardiac Arrest Identification in Call	33%	29%	38%	35%	46%	67%	55%	59%	63%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Cardiac arrest identification during the emergency call has been interpreted as suspected cardiac arrest events which would routinely lead to the administration of Dispatcher Life Support (DLS).*

Table 11: Adjusted odds ratios for survival by response time groups

Response times	Sample Size	Survival to Hospital Metro vs. Rural	Survival to Discharge Metro vs. Rural
2003-2007			
0-4 minutes	463	2.26 (1.38-3.70); p=0.001	2.86 (1.45-5.63); p=0.002
5-8 minutes	3,075	2.61 (2.01-3.39); p<0.001	3.58 (2.16-5.91); p<0.001
9-12 minutes	1,655	2.49 (1.75-3.54); p<0.001	2.58 (1.30-5.12); p=0.007
13-16 minutes	428	3.47 (1.80-6.67); p<0.001	5.26 (1.16-23.93); p=0.32
17+ minutes	327	4.37 (2.10-90.07); p<0.001	-
2008-2011			
0-4 minutes	190	4.30 (1.56-11.60); p=0.004	0.92 (2.93-2.93); p=0.90
5-8 minutes	1,903	2.20 (1.65-2.94); p<0.001	2.56 (1.59-4.13); p<0.001
9-12 minutes	1,100	1.74 (1.25-2.41); p=0.001	2.90 (1.50-5.61); p=0.002
13-16 minutes	333	1.68 (0.97-2.91); p=0.06	1.02 (0.39-2.72); p=0.96
17+ minutes	333	2.17 (1.20-3.94); p=0.01	3.19 (0.81-12.52); p=0.1

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Adjusted for age, gender, bystander witnessed, bystander CPR, VF/VT, arrest location, and year of arrest.*

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Paramedic resourcing

Main Findings

Regional Differences in Paramedic Resourcing

In cases where resuscitation was attempted in metropolitan regions, the median number of paramedics attending OHCAs has remained unchanged since 2003 (4 paramedics per event). However, the rural median has increased, from a median of 2 paramedics per event between 2003 and 2006 to a median of 4 paramedics per event thereafter (Figure 9). Additionally, the proportion of cases with 4 or more paramedics in attendance is now equivalent between metropolitan and rural regions (e.g. in 2011, Metro= 63% and Rural= 69%).

The impact of the number of paramedics attending arrests on the disparity in regional survival was analysed by comparing logistic regression models with and without the addition of a variable controlling for the number of paramedics on scene. For the whole study period the metropolitan adjusted odds ratio for survival to hospital was 2.21 (95%CI 1.97-2.48); a result which was more than twice that of the rural region. When the number of paramedics on scene is included in the model, the odds ratio of survival to hospital decreases by 0.22 (95%CI 0.20-0.24). Only a minor change was observed for survival to hospital discharge after adjusting for this variable.

Over the study period, there were three different types of paramedic skill levels attending OHCAs across the state, including mobile intensive care ambulance (MICA) paramedics, advanced life support (ALS) paramedics and basic life support (BLS) paramedics. ALS differs significantly from BLS care in the setting of a cardiac arrest. ALS care involves the use of advanced airway techniques and the administration of intravenous fluid and pharmacology, including adrenaline, which has been associated with an increase in return of spontaneous circulation.[20]

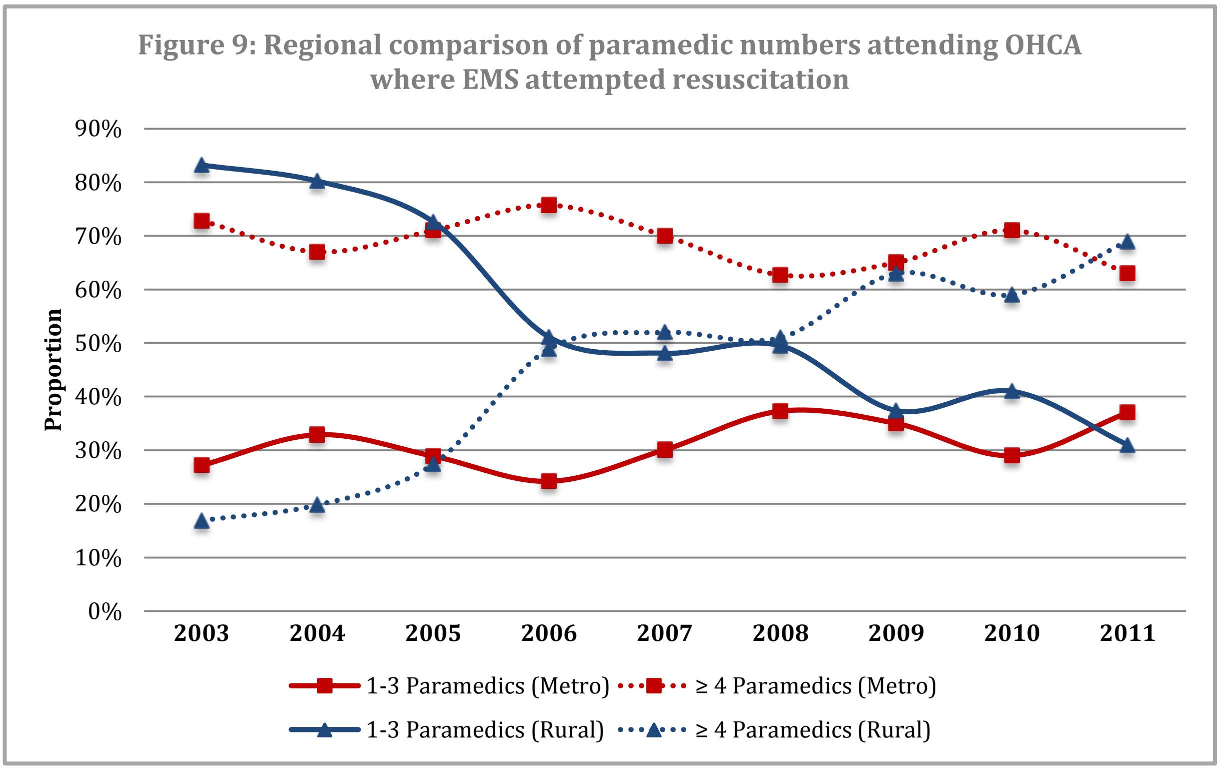
A recent review of 26 studies, including seven in cardiac arrest, found the literature is divided about whether ALS skills have any impact on patient survival.[21] There was no evidence supporting the ALS skill level in cardiac arrests, so long as a defibrillator was used in BLS care.[21] However, the majority of OHCA studies used small samples (less than 500 cases) and were conducted in very different EMS system to Victoria's. In comparison, an analysis into the impact of intensive care paramedics on survival from OHCA was conducted by Woodall and colleagues in a large two-tier EMS in Queensland.[22] In a sample of 2,975 cardiac arrests of presumed cardiac aetiology, the authors demonstrated that the presence of an intensive care paramedic was associated with a 40% increase in the chance of survival to hospital discharge (OR 1.43, 95% CI 1.02-1.99).[22]

In this report, we compared the regional skill level of paramedics attending OHCA annually from 2006, and included an analysis of survival according to the "highest" skill set in attendance. We note that until recently VACAR relied solely on PCR data to capture rural teams in attendance, while metropolitan team were often cross-validated using ESTA event registers. To explore the potential bias in this method, we correlated the annual proportion of MICA personnel within the rural region (Source: Annual Reports) to the number of MICA personnel attending OHCAs. This showed strong correlation (r = 0.83) for cases between 2004 and 2008 (data after 2008 is reported as AV).

Figure 10 shows a change in skill levels attending OHCAs over time. Compared to metropolitan cases, where the majority (~80%) were attended by crews consisting of MICA & ALS/BLS, a greater proportion of rural cases (17% vs. 43%, $p<0.001$) were attended by single skill level crews (i.e. MICA only or ALS/BLS only). When the highest skill level in attendance is explored (Figure 11), MICA attendance at metropolitan cases was high and has remained relatively stable over time (~88% of cases). In rural OHCAs, MICA attendance was observed in 82% of cases occurring in 2011, and may have increased in recent years after the implementation of electronic-based protocols for emergency call-taking which has increased the identification of cardiac arrest events (refer to 'Emergency Response' page 35).

It may be plausible that the survival benefit observed in rural regions over recent years may be associated with an increased MICA presence to OHCAs. A multivariate analysis was performed adjusting for factors known to predict survival from OHCA. From this analysis, we identified no skill benefit between rural BLS and ALS crews for survival to hospital or to hospital discharge. However, we observed a significant increase in the odds of survival in cases where MICA attended for both metropolitan and rural regions (Table 13). It is difficult to distinguish whether MICA skills, experience or exposure to OHCA are responsible for the higher survival in this analysis. Other authors have observed similar findings by introducing a higher paramedic skill level to OHCA response.[23] Interpreting these results should be done with caution, due to the potential effect of heterogeneity in the groups being compared.

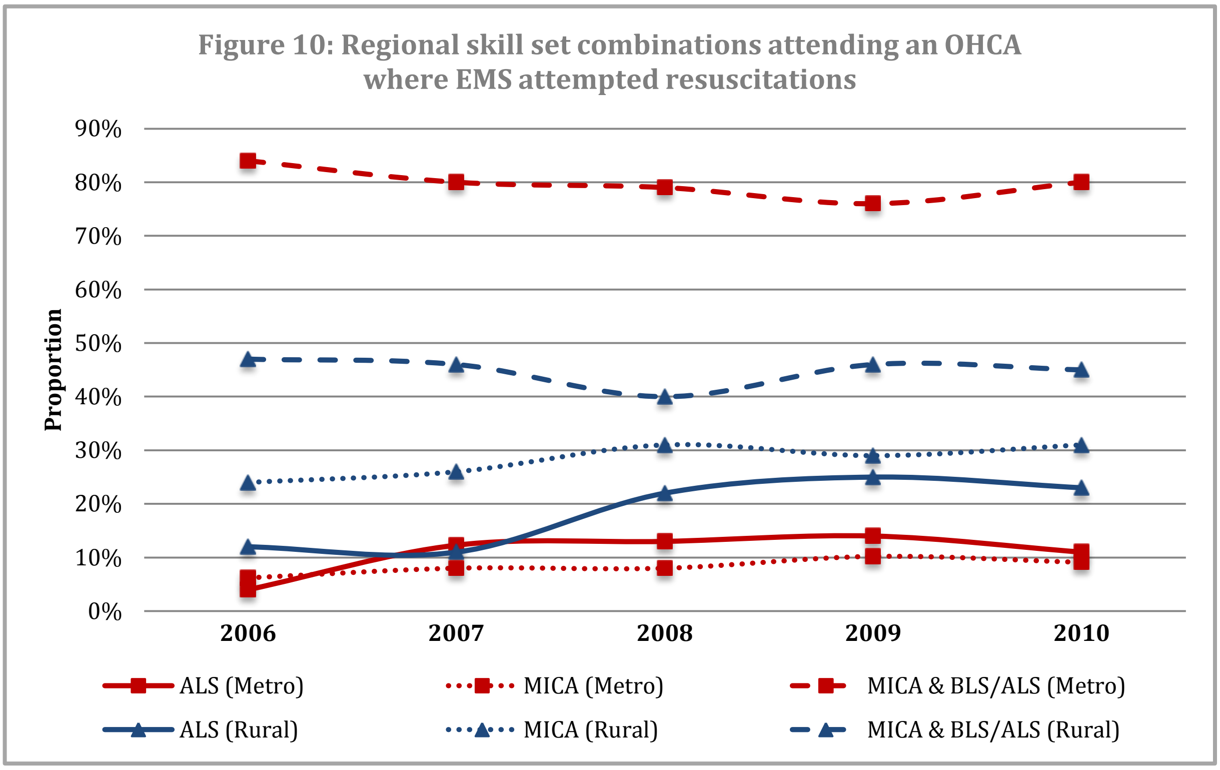
There are several limitations in this analysis. Firstly, it is possible that the survival attributed to MICA is overestimated by using the highest skill mix in attendance. In some cases the first crew on scene may have been responsible for achieving ROSC prior to the arrival of a MICA resource. Secondly, there are likely to be cases attended by ALS or BLS teams where resuscitation was commenced only to be ceased prior to the arrival of a higher skilled team. In addition, cardiac arrests without MICA attendance are in the minority, and while the analysis adjusted for some confounders the comparison is most likely between two heterogeneous patient groups.



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
1-3 Paramedics	27%	33%	29%	24%	30%	37%	35%	29%	37%
≥ 4 Paramedics	73%	67%	71%	76%	70%	63%	65%	71%	63%
Rural Region									
1-3 Paramedics	83%	80%	73%	51%	48%	50%	37%	41%	31%
≥ 4 Paramedics	17%	20%	27%	49%	52%	51%	63%	59%	69%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

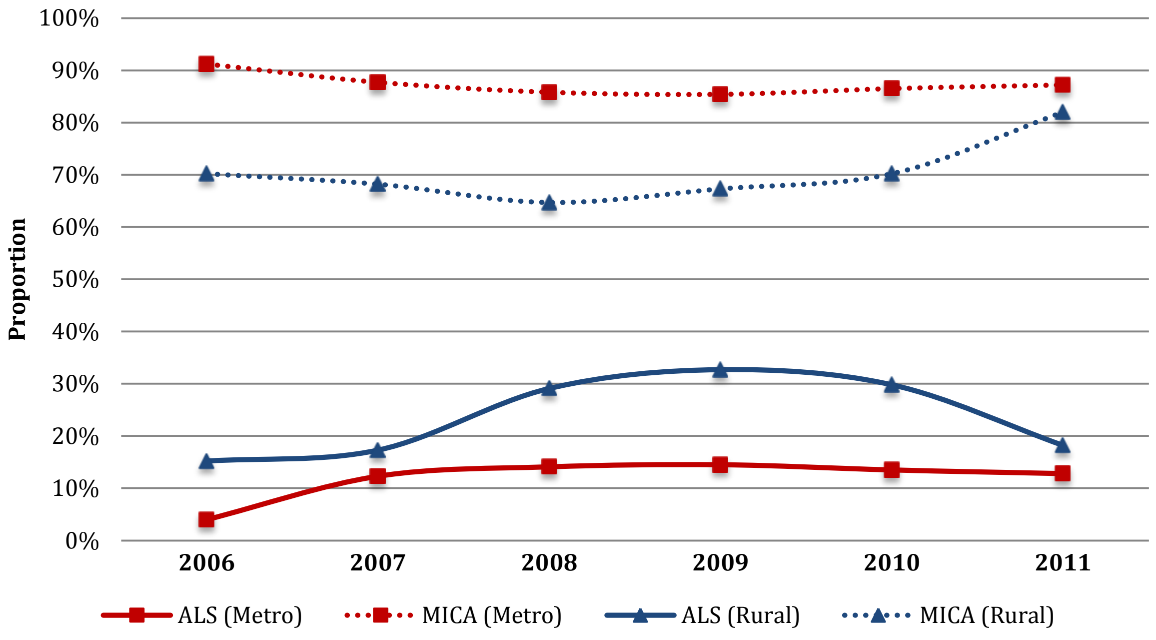
2 *This analysis does not take into consideration the presence of first responders.*



1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *BLS & ALS & MICA combination was rare and is not shown.*

Figure 11: Highest paramedic skill level attending an OHCA where EMS attempted resuscitation



	2006	2007	2008	2009	2010	2011
			Metropolitan Region			
BLS	5%	0%	0%	0%	0%	0%
ALS	4%	12%	14%	15%	14%	13%
MICA	91%	88%	86%	85%	87%	87%
			Rural Region			
BLS	15%	15%	6%	0%	0%	0%
ALS	15%	17%	29%	33%	30%	18%
MICA	70%	68%	65%	67%	70%	82%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

Section 4 Modelling the Impact of Paramedic Numbers and Skill Level on Survival from OHCA

Table 12: Adjusted odds ratios for survival from OHCA before and after adjusting for number of paramedics on scene#

		Adjusted Odds Ratios (95% CI)	AOR Difference
Survival to Hospital	**Metro vs. Rural** Paramedics ≥ 4 not included	2.21 (1.97-2.48)	0.22 (0.20-0.24)
	Metro vs. Rural Paramedics ≥ 4 included	1.99 (1.77-2.24)	
Survival to Hospital Discharge	**Metro vs. Rural** Paramedics ≥ 4 not included	2.57 (2.10-3.32)	0.01 (0.02-0.17)
	Metro vs. Rural Paramedics ≥ 4 included	2.56 (2.08-3.15)	

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Models are adjusted for age, gender, year of arrest, VF/VT, bystander witnessed, bystander CPR, arrest location, and response time.*

3 *#Interpreting these results should be done with caution, due to the potential effect of heterogeneity in the groups being compared.*

Table 13: Adjusted odds ratios for survival from OHCA before and after adjusting for highest skill level on scene#

		Adjusted Odds Ratios (95% CI)
Survival to Hospital	**Metro** MICA In Attendance	22.62 (13.13-38.99)
	Rural MICA In Attendance	2.99 (2.14-4.21)
Survival to Hospital Discharge	**Metro** MICA In Attendance	4.39 (2.19-8.80)
	Rural MICA In Attendance	2.48 (1.26-4.89)

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Models are adjusted for age, gender, year of arrest, VF/VT, bystander witnessed, bystander CPR, arrest location, and response time.*

3 *#Interpreting these results should be done with caution, due to the potential effect of heterogeneity in the groups being compared.*

Access to cardiac interventions

Main Findings

Regional Differences in Access to Cardiac Interventional Facilities

The previous report conducted a regional survival comparison using the Australian Bureau of Statistics "Section of State Range (SOSR)", which assigns localities based on population size. That analysis found higher survival in metropolitan cases in population categories covered by both former ambulance services in Victoria. This analysis took into consideration ambulance (e.g. response time) and cardiac arrest (e.g. bystander witnessed) differences in these populations. However, it did not consider other measurable differences, such as hospital capabilities, and therefore may have overestimated the impact of the EMS on survival.

For example, in the 20,000 to 49,000 population category, survival to discharge was 7.5% for metropolitan regions and 3.2% for rural regions. However, we should note that metropolitan regions with these population indexes are likely to have better access to percutaneous coronary intervention (PCI) capable hospitals. Further exploration shows that no rural cases within these population boundaries were transported to a PCI capable hospital, in comparison to 100% of metropolitan cases.

Significant differences are seen between metropolitan and rural cases transported to cardiac interventional capable hospitals (Figure 12). Furthermore, there are significant differences in survival to hospital discharge both for both metropolitan and rural cases transported to hospitals with and without PCI-capabilities (Figure 13).

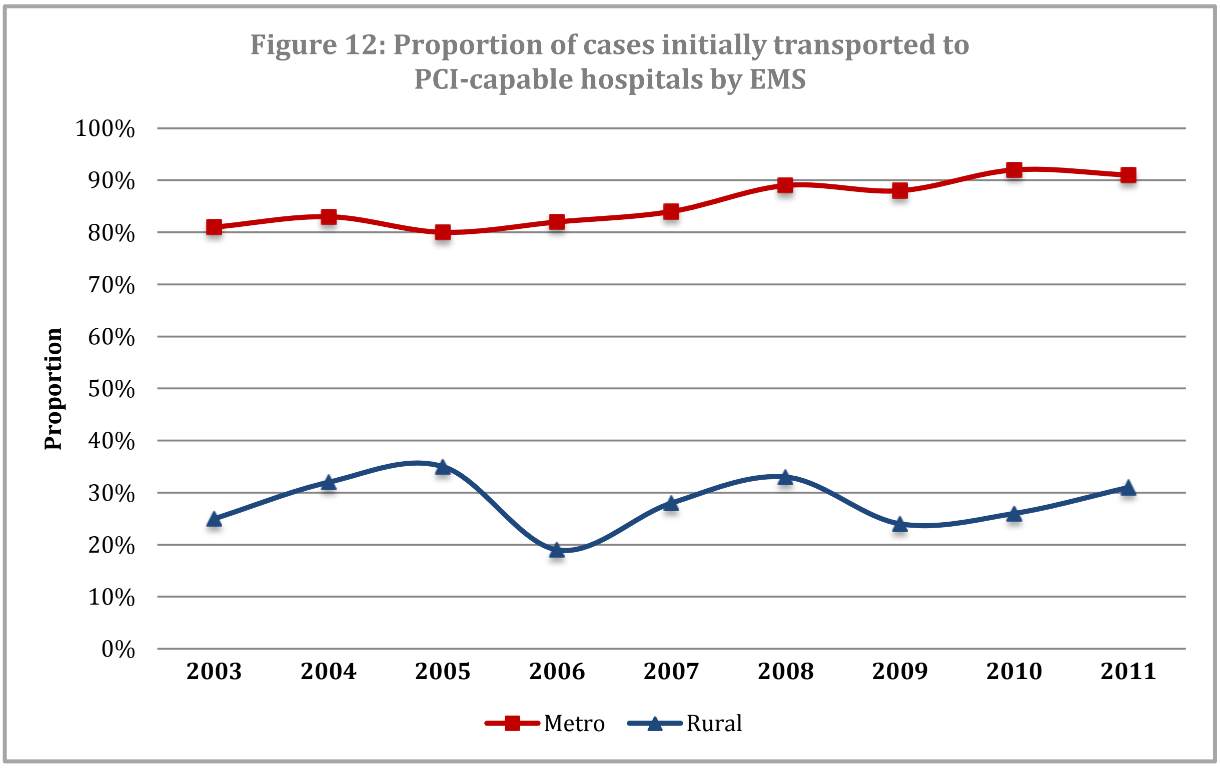
The impact of this difference on the survival to hospital discharge was assessed by comparing two logistic regressions models. After adjusting for known predictors, the survival disparity between metropolitan and rural regions decreased from an AOR of 2.55 (2.05-3.16, $p< 0.001$) to 2.13 (1.67-2.73, $p< 0.001$) when controlling for transportation to a cardiac interventional capable hospital. A shift in the OR towards a value of 1 indicates that the contribution of locality on survival outcome becomes diminished. Previous research by VACAR suggests that patients transported to PCI capable hospitals are 40% more likely to survive to hospital discharge (AOR 1.40, 95%CI: 1.12-1.74 for transported patients).[1]

The survival benefit observed in patients conveyed to PCI-capable hospitals has already led to changes in EMS practices internationally. In 2010, the London Ambulance Service implemented a new pathway for cardiac arrest patients who had been stabilised on scene by paramedics, to be conveyed to one of eight PCI-capable centres in London.[24] The eligibility criteria for this pathway was: patients aged 18 years or over, ROSC achieved after an initial rhythm of VF or pulseless VT, evidence of ST-elevation on a 12 lead ECG and where the cause of arrest was of a presumed cardiac aetiology. The safety and feasibility of implementing similar pathways in Victoria are yet to be examined further.

OHCAs attended by rural AV generally have poor access to PCI-capable hospitals. The distance from a PCI-capable service provides a novel way of exploring the concept of "remoteness", particularly in the two population categories where survival was significantly different between regions: "Remainder of the State" and 20,000 to 49,000 population categories. Once adjustments are made for usual predictors of survival and distance to PCI capable services the difference between metropolitan and rural survival becomes non-significant within some population categories (Table 14). However smaller sample sizes may also contribute to the loss of significance.

Other hospital factors could also be responsible for the differences in survival observed in these regions. These could include differences in prognostication and the quality of post-resuscitation care received (i.e. the administration of therapeutic hypothermia).

Section 1 Proportion of OHCA Transported to PCI-capable Hospitals by EMS

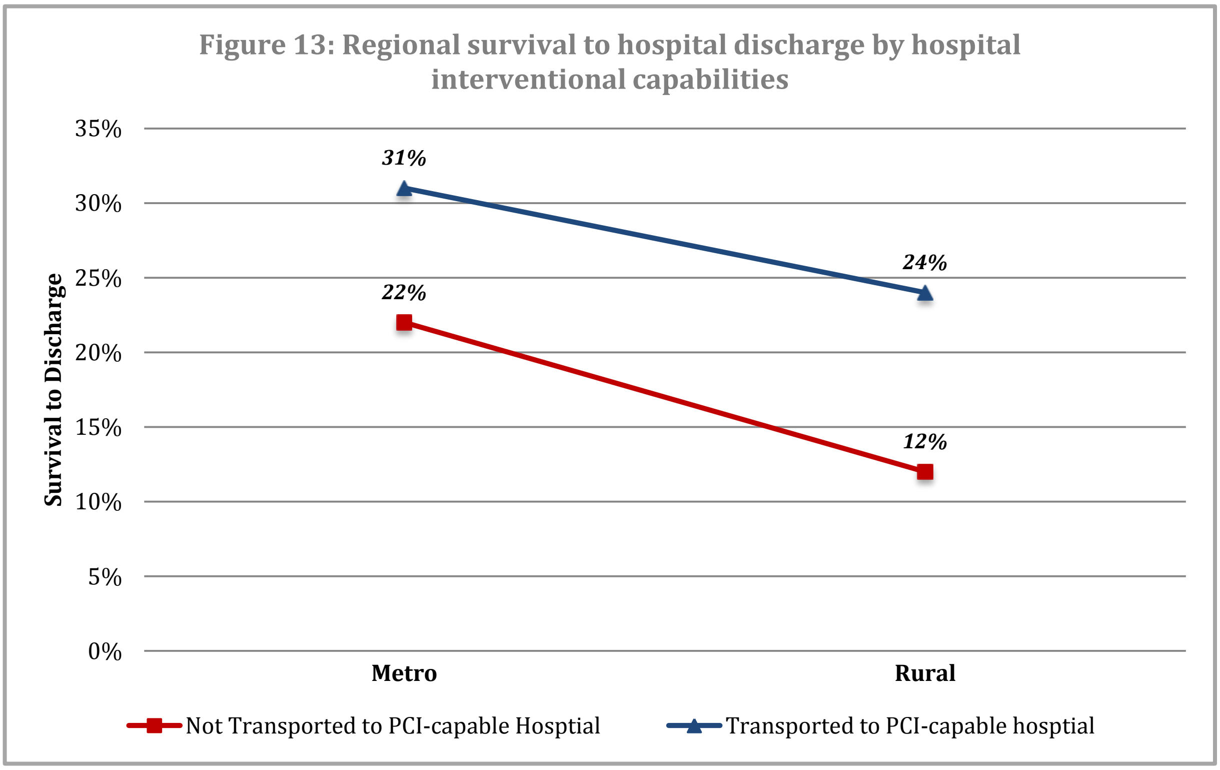


	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region	81%	83%	80%	82%	84%	89%	88%	92%	91%
Rural Region	25%	32%	35%	19%	28%	33%	24%	26%	31%

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Percutaneous Coronary Intervention (PCI) capable hospital represents either part-time or 24-hour facilities.*

Section 2 Regional Survival to Hospital Discharge by Hospital Interventional Capability



1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

2 *Percutaneous Coronary Intervention (PCI) capable hospital represents either part-time or 24-hour facilities.*

Table 14: Adjusted odds ratios for survival before and after accounting for distance to PCI-capable hospital

Population Category	Adjusted OR (95% CI)		Adjusted OR (95% CI) + Distance to PCI	
	Survival to Hospital	Survival to Discharge	Survival to Hospital	Survival to Discharge
Remainder of State	1.68 (1.08-2.61) p=0.02	2.78 (1.42-5.39) p=0.003	1.53 (0.89-2.60) p=0.02	2.11 (0.91-4.86) p=0.08
20,000-49,999	1.61 (0.97-2.68) p=0.07	5.84 (2.10-16.20) p=0.001	1.15 (0.55-2.40) p=0.70	2.26 (0.50-10.17) p=0.29
All Cases where EMS Attempted Resuscitation	2.21 (1.97-2.48) p<0.001	2.57 (2.10-3.32) p=0.001	1.73 (1.48-2.03) p<0.001	1.91 (0.44-2.52) p<0.001

1 *Adult patients aged >17 years, presumed cardiac aetiology, where EMS attempted resuscitation. EMS denotes AV, and first responders (fire-fighters and community response teams). Excludes EMS witnessed events.*

Modelling regional survival

Main Findings   Predicting Survival to Discharge from Regional OHCA

The report by Fridman and Smith[4] had established that operational variables may partly explain the survival difference observed across regions. They highlighted that lower response times, a higher proportion of paramedics on scene, and a higher proportion of patients presenting in VF/VT may partly explain the survival benefit observed in the metropolitan region.

Similarly, earlier sections of this report have evaluated the impact of epidemiological and clinical variables on survival from OHCA. These analyses have identified that survival from cardiac arrest is strongly affected by region, with factors such as clinical exposure, resourcing of paramedics, response times and access to cardiac interventions, all providing novel ways of evaluating the survival disparity across metropolitan and rural areas of Victoria. While these analyses are useful for generating hypotheses regarding the association of a single variable on survival from cardiac arrest, they are equally limited by failing to adequately adjust for other known confounders.

This section focuses on undertaking further statistical analyses to establish the value of previously introduced predictors on survival, after adjusting for known confounders. In this section, we use the odds ratios (OR) to demonstrate the effect size or contribution of certain variables on survival. When the OR for a particular variable is equal to 1, it indicates no contribution of that variable on survival outcome. When the OR is less than 1, it indicates that a variable has a negative association with survival, and similarly when the OR is greater than 1 it indicates a positive or beneficial association of that variable with survival outcome. Confidence intervals (95% CI) provide a region of uncertainty or error within the data. In other words, this range is where the contribution of each variable on survival would lie in 95% of observed cases. Confidence intervals which intercept a value of 1 indicate no significant contribution of a variable on survival outcome.

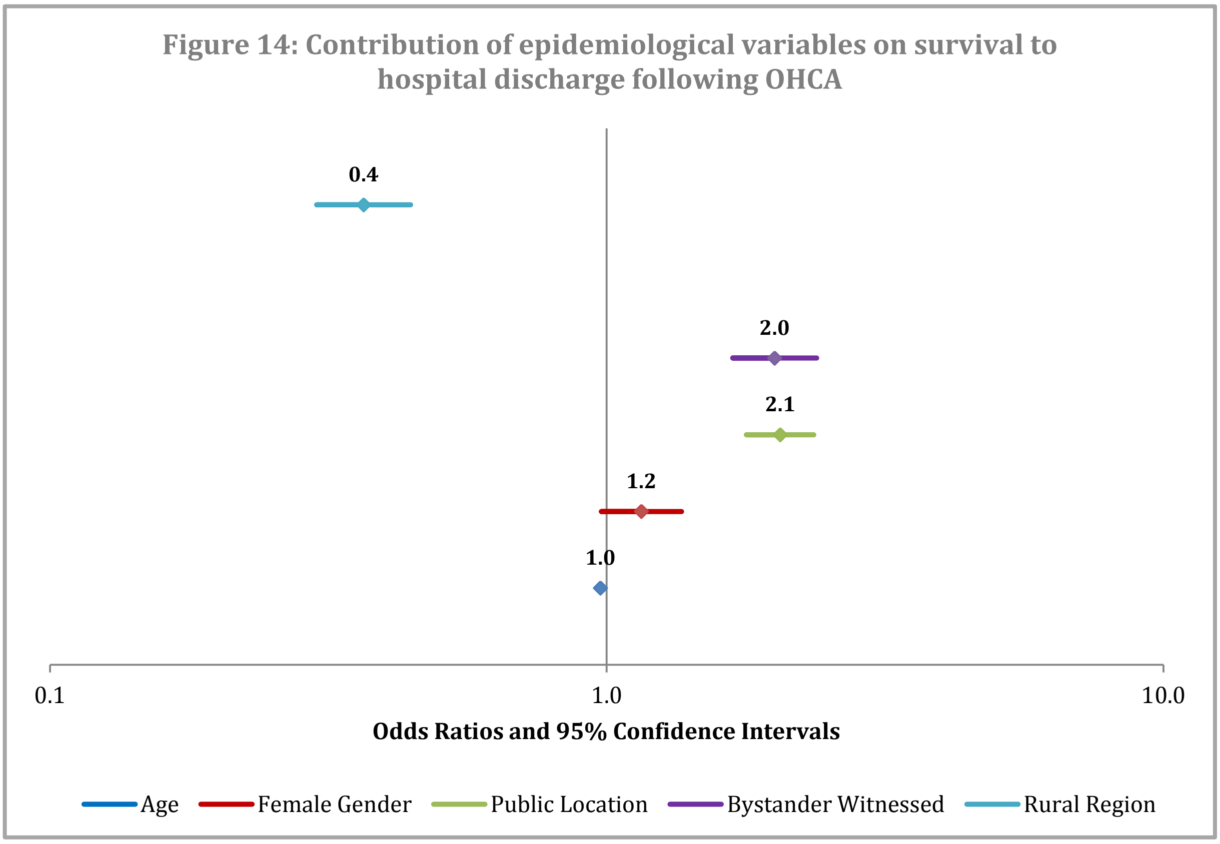
Figure 14 demonstrates the contribution of epidemiological variables on survival to discharge following OHCA. From this logistic regression model we have identified that age, public location, bystander witnessed, rhythm of arrest into VF/VT, and rural region are all valuable predictors of survival to hospital discharge. The value of these predictors is maintained even after accounting for previously established clinical variables, including response times, bystander CPR, MICA on scene, four or more paramedics on scene, and transport to a PCI-capable hospital (see Figure 15). While resourcing of paramedics on scene did not significantly contribute to predicting survival to hospital discharge, this analysis observed that bystander CPR, response times, and transport to a PCI-capable hospital, were the most significant clinical variables predicting survival from OHCA.

Figure 16 provides a novel way of modelling survival to discharge by standardising all cases to a uniform criterion. These criteria included all adult patients which underwent an attempted resuscitation, where four or more paramedics were on scene including a MICA paramedic, and where the response time was less than or equal to 15 minutes. This analysis forces us to consider the survival disparity across regions under "ideal" circumstances, whereby operational conditions are optimised across regions. This analysis demonstrates that under standardised conditions the negative association of the rural region on survival to discharge reduces significantly from an adjusted odds of 0.5 (95% CI 0.4 to 0.7) to 0.7 (95% CI 0.5 to 0.9). This analysis infers that once operational conditions are optimised across the population (or reflect those likely observed in the metropolitan region), survival to discharge outcomes appear to be less affected by rural location.

Figure 17 expands on this novel approach to modelling cardiac arrest outcomes by demonstrating the conditional probabilities of survival to discharge before and after standardisation. In this analysis, we have optimised a logistic regression model to predict survival to discharge in a male patient, who is aged 63 years, who is witnessed to suffer a cardiac arrest in his home and presents to EMS in VF/VT. This analysis observes an increase of 4% in the predicted probability of survival for this patient after standardising for response time and paramedic resourcing and skill level. The greatest affect in standardisation is observed after the inclusion of transport to a PCI-capable hospital, and therefore intentionally limiting rural cases transported to Geelong Hospital or Ballarat Hospital. This analysis demonstrates comparable predicted probabilities of survival for this patient across both regions, implying that similar survival outcomes may be observed after standardisation of the population to optimistic conditions.

It is worth noting that modelling cardiac arrest using regression models caries inherit limitations. The contribution of individual predictors may help to identify correlational relationships with outcome from OHCA, although this does not necessarily imply causality. Furthermore, not all the models in this analysis were optimised to predict survival to hospital discharge and therefore its ability to predict outcome is yet to be robustly tested. While standardisation provides a novel way of comparing outcomes across regions, it also significantly reduces the sample size included and weakens the external validity of these results. Therefore, these analyses should be interpreted with some caution.

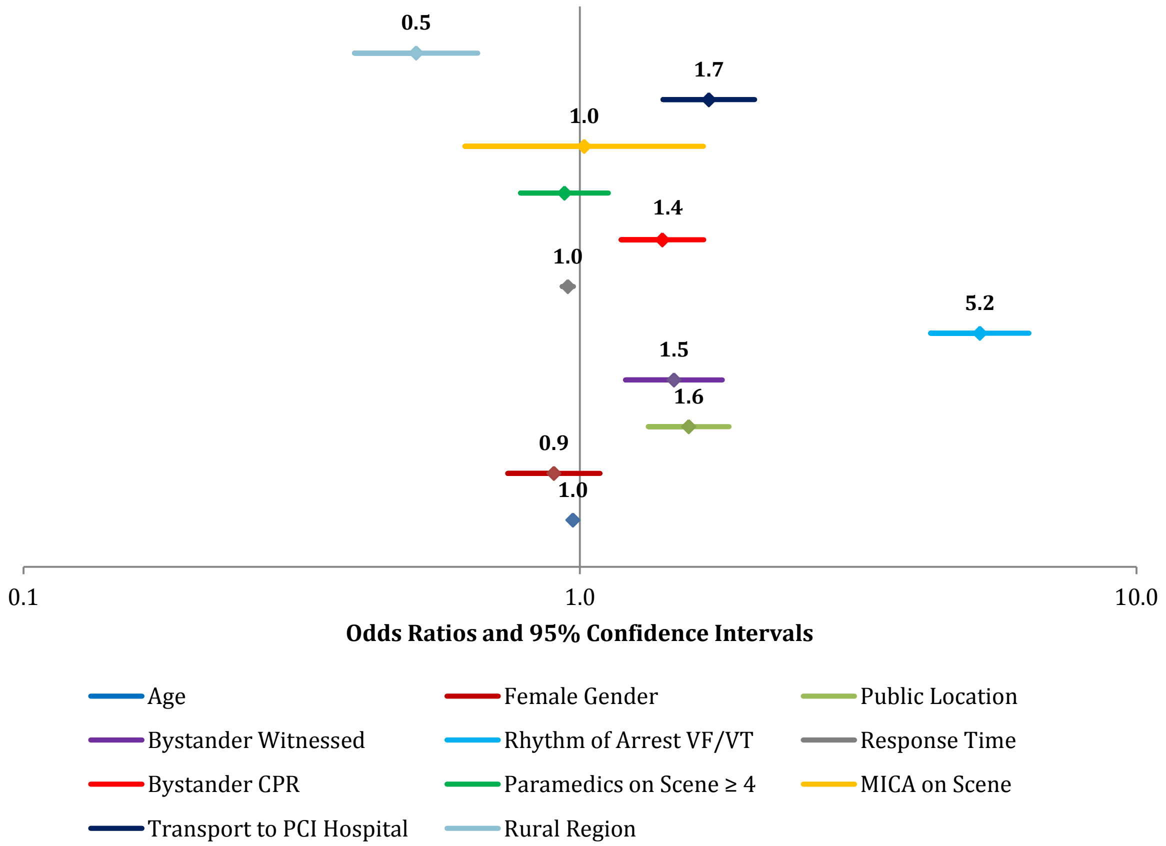
While the approach used to model cardiac arrest survival in this section carries inherit limitations, some preliminary conclusions can be draw. Firstly, known epidemiological and clinical variables contribute strong correlational relationships with survival to discharge in OHCA. Secondly, standardisation of the population to reflect optimised conditions partly explains the negative association observed between the rural region and survival outcomes. Lastly, while standardisation significantly reduces sample sizes, it has observed similar predict probabilities of survival for patients transported to PCI-capable hospitals across both regions. These findings indicate that the survival outcomes observed in the rural region are likely to be heavily affected by uncontrollable variables, including long response times and transport to hospitals without PCI-capability.



Logistic Regression Model (n=11,579)				
	Odds Ratio	**95% Confidence Intervals** Lower Limit	Upper Limit	**P-Value**
Age	1.0	1.0	1.0	< 0.0001
Female Gender	1.2	1.0	1.4	NS
Public Location	2.1	1.8	2.4	< 0.0001
Bystander Witnessed	2.0	1.7	2.4	< 0.0001
Rhythm of Arrest VF/VT	8.4	7.0	10.1	< 0.0001
Rural Region	0.4	0.3	0.4	< 0.0001

1 *Logistic regression model not yet optimised to predict survival to hospital discharge. Hosmer and Lemeshow Test (χ^2= 10.2, p = NS).*

Figure 15: Contribution of epidemiological and clinical variables on survival to hospital discharge following OHCA

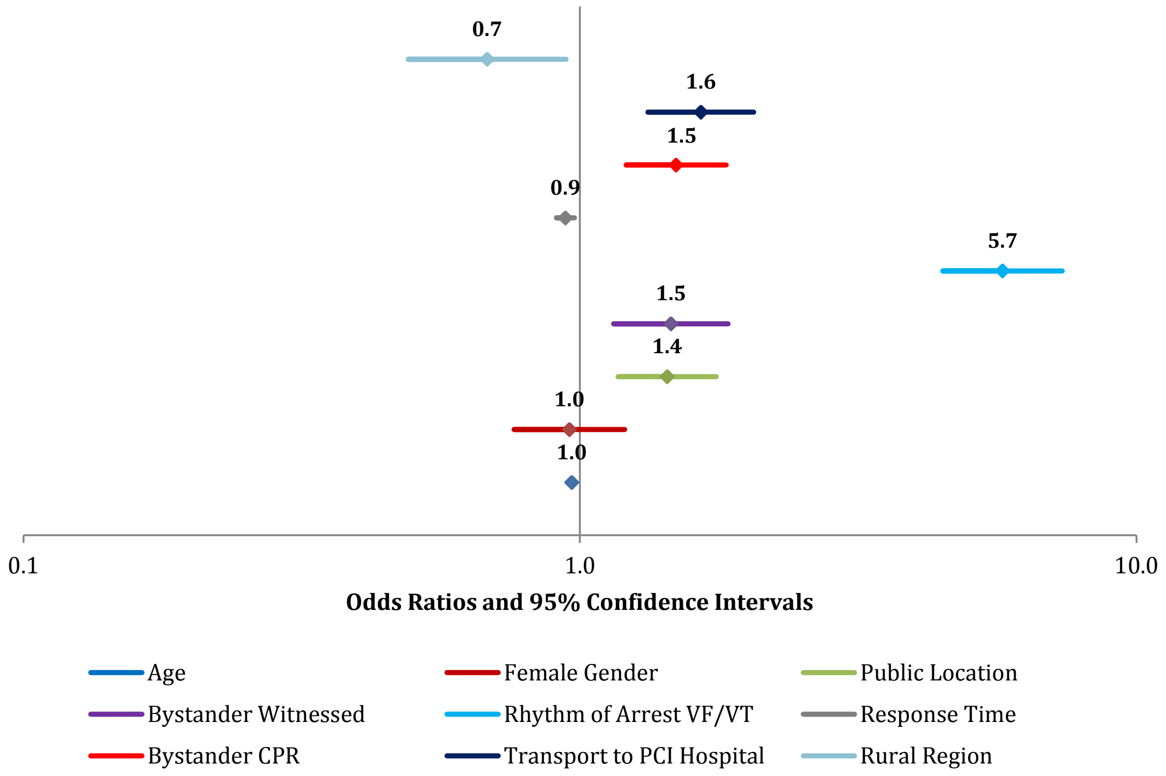


Logistic Regression Model (n= 4,081)				
	Odds Ratio	95% Confidence Intervals		P-Value
		Lower Limit	Upper Limit	
Age	1.0	1.0	1.0	< 0.0001
Female Gender	0.9	0.7	1.1	NS
Public Location	1.6	1.3	1.9	< 0.0001
Bystander Witnessed	1.5	1.2	1.8	< 0.0001
Rhythm of Arrest VF/VT	5.2	4.3	6.4	< 0.0001
Response Time	1.0	0.9	1.0	< 0.0001
Bystander CPR	1.4	1.2	1.7	< 0.0001
Paramedics on Scene ≥ 4	0.9	0.8	1.1	NS
MICA on Scene	1.0	0.6	1.7	NS
Transport to PCI Hospital	1.7	1.4	2.1	< 0.0001
Rural Region	0.5	0.4	0.7	< 0.0001

1 *Logistic regression model not yet optimised to predict survival to hospital discharge. Hosmer and Lemeshow Test (χ^2= 24.6, p = 0.002).*

Contribution of Epidemiological and Clinical Variables on Survival to Discharge after Standardisation of OHCA#

Figure 16: Contribution of epidemiological and clinical variables on survival to hospital discharge after standardisation of OHCA#



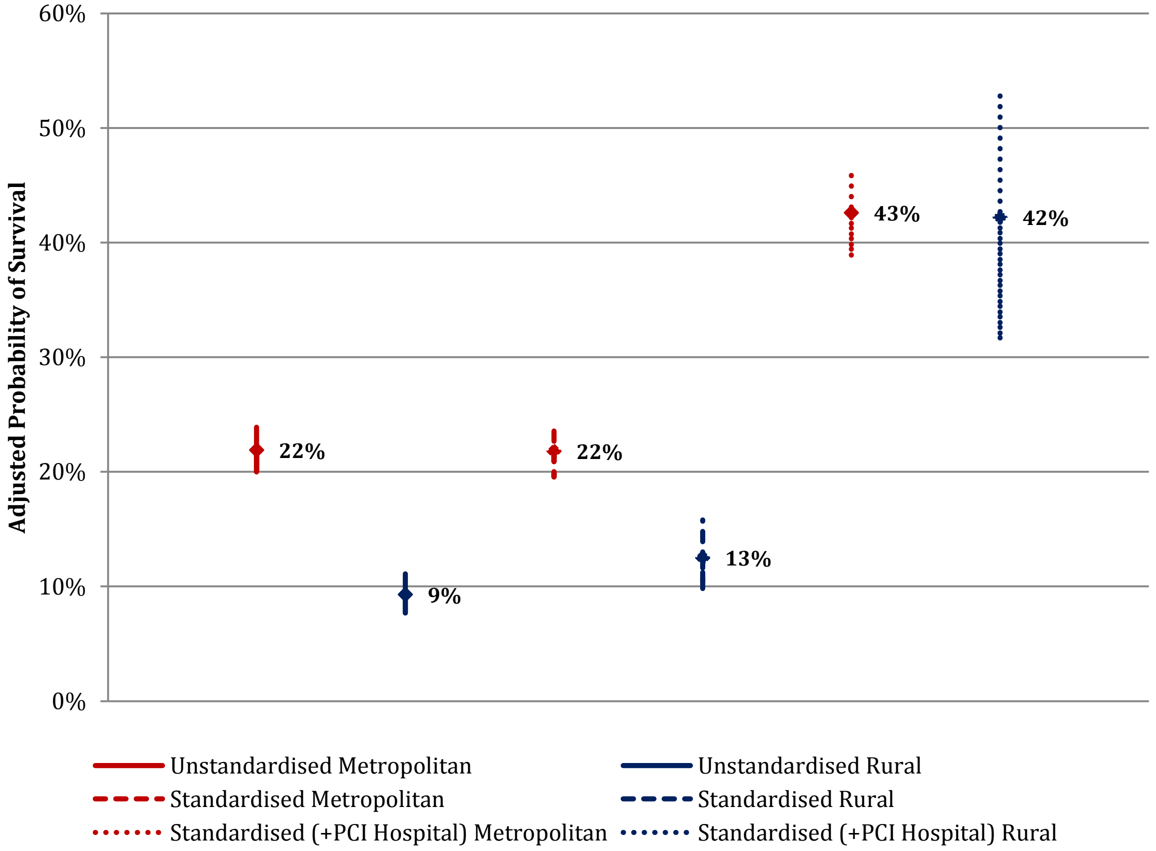
Logistic Regression Model (n= 2,770)				
	Odds Ratio	**95% Confidence Intervals**		**P-Value**
		Lower Limit	Upper Limit	
Age	1.0	1.0	1.0	< 0.0001
Female Gender	1.0	0.8	1.2	NS
Public Location	1.4	1.2	1.8	< 0.0001
Bystander Witnessed	1.5	1.2	1.8	0.002
Rhythm of Arrest VF/VT	5.7	4.5	7.4	< 0.0001
Response Time	0.9	0.9	1.0	0.002
Bystander CPR	1.5	1.2	1.8	< 0.0001
Transport to PCI Hospital	1.6	1.3	2.1	< 0.0001
Rural Region	0.7	0.5	0.9	0.021

1 *Logistic regression model not yet optimised to predict survival to hospital discharge. Hosmer and Lemeshow Test (χ^2= 29.9, $p < 0.0001$).*

2 *#Standardisation of cases includes: adults; attempted resuscitation; MICA on scene; paramedics on scene ≥ 4; response time ≤ 15 minutes.*

Conditional Probability of Survival According to Region before and after Standardisation of OHCA#

Figure 17: Conditional probability of survival across regions before and after standarisation of OHCA#.



Adjusted Probability of Survival					
	n	Region	Point Estimate	95% Confidence Intervals Lower Limit	95% Confidence Intervals Upper Limit
Unstandardised	11,579	Metropolitan	22%	20%	24%
		Rural	9%	8%	11%
Standardised#	6,699	Metropolitan	22%	20%	24%
		Rural	13%	10%	16%
Standardised + PCI Hospital##	2,266	Metropolitan	43%	39%	47%
		Rural	42%	32%	54%

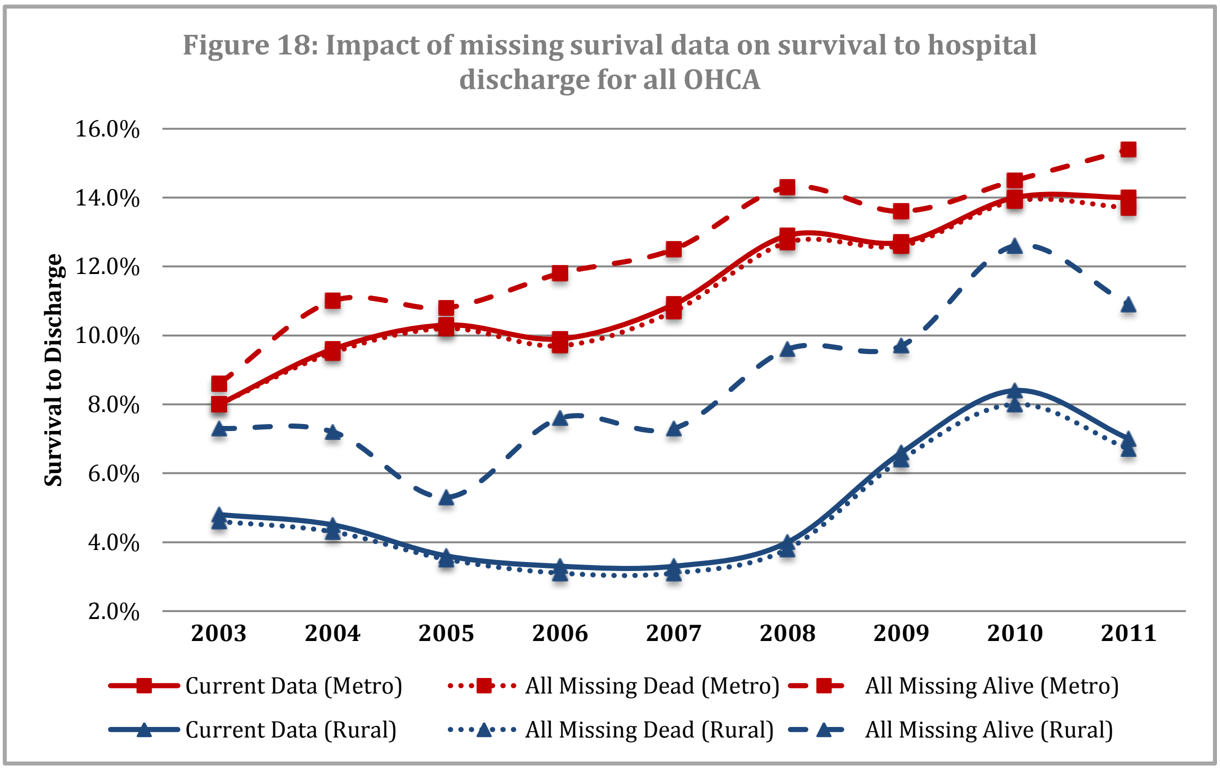
1 *Logistic regression model optimised to predict survival to hospital discharge. Hosmer and Lemeshow Test (χ^2= 10.2, p = NS), Area under ROC = 0.835.*

2 *Conditional probabilities provided are average responses for a male patient, aged 63 years, who suffers a witnessed cardiac arrest at home and presents to EMS in VF/VT.*

3 *#Standardisation of cases includes: adults; attempted resuscitation; MICA on scene; paramedics on scene ≥ 4, and response time ≤ 15 minutes. ##"Standardisation (+PCI Hospital)" includes transport to PCI-capable hospital in addition to standardisation variables.*

Appendices

Appendix 1 Potential Impact of Missing Data on Survival



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Metropolitan Region									
Current Data	8.0%	9.6%	10.3%	9.9%	10.9%	12.9%	12.7%	14.0%	14.0%
All Missing Dead	8.0%	9.5%	10.2%	9.7%	10.7%	12.7%	12.6%	13.9%	13.7%
All Missing Alive	8.6%	11.0%	10.8%	11.8%	12.5%	14.3%	13.6%	14.5%	15.4%
Rural Region									
Current Data	4.8%	4.5%	3.6%	3.3%	3.3%	4.0%	6.6%	8.4%	7.0%
All Missing Dead	4.6%	4.3%	3.5%	3.1%	3.1%	3.8%	6.4%	8.0%	6.7%
All Missing Alive	7.3%	7.2%	5.3%	7.6%	7.3%	9.6%	9.7%	12.6%	10.9%

Appendix 2 VACAR Research Team

Table 15: VACAR Chief Investigators

Person	Position
A/Prof Karen Smith	Manager Research and Evaluation Ambulance Victoria
A/Prof Stephen Bernard	Medical Director Ambulance Victoria

Table 16: VACAR Research Team

Person	Position
A/Prof Karen Smith	Manager Research and Evaluation
Dr Marijana Lijovic	Senior Research Fellow
Dr Resmi Nair	Clinical Analyst
Marian Lodder	Research Officer
Ziad Nehme	Research Assistant
Davina Vaughan	Data Processor
Emily Andrew	Data Processor

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