Out-of-hospital cardiac arrest in Victoria: rural and urban outcomes

Paul A Jennings, Peter Cameron, Tony Walker, Stephen Bernard and Karen Smith

ABSTRACT

Objective: To compare the survival rate from out-of-hospital cardiac arrest in rural and urban areas of Victoria, and to investigate the factors associated with these differences.

Design: Retrospective case series using data from the Victorian Ambulance Cardiac Arrest Registry.

Setting: All out-of-hospital cardiac arrests occurring in Victoria that were attended by Rural Ambulance Victoria or the Metropolitan Ambulance Service.

Participants: 1790 people who suffered a bystander-witnessed cardiac arrest between January 2002 and December 2003.

Results: Bystander cardiopulmonary resuscitation was more likely in rural (65.7%) than urban areas (48.4%) ($P = 0.001$). Urban patients with bystander-witnessed cardiac arrest were more likely to arrive at an emergency department with a cardiac output (odds ratio [OR], 2.92; 95% CI, 1.65–5.17; $P < 0.001$), and to be discharged from hospital alive than rural patients (urban, 125/1685 [7.4%]; rural, 2/105 [1.9%]; OR, 4.13; 95% CI, 1.09–34.91). Major factors associated with survival to hospital admission were distance of cardiac arrest from the closest ambulance branch (OR, 0.87; 95% CI, 0.82–0.92), endotracheal intubation (OR, 3.46; 95% CI, 2.49–4.80), and the presence of asystole (OR, 0.50; 95% CI, 0.38–0.67) or pulseless electrical activity (OR, 0.73; 95% CI, 0.56–0.95) on arrival of the first ambulance crew.

Conclusions: Survival rates differ between urban and rural cardiac arrest patients. This is largely due to a difference in ambulance response time. As it is impractical to substantially decrease response times in rural areas, other strategies that may improve outcome after cardiac arrest require investigation.

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The mortality rates for heart disease outside Australian capital cities are 30% higher in men and 21% higher in women than rates in the cities, and the average life expectancy for rural residents is about 1 year less than for their metropolitan counterparts.[1,2]

Several causes for these mortality differences have been suggested, including older age distribution, higher proportions of Indigenous people, and decreased socioeconomic status.[3] Decreased access to immediate emergency medical care might also be partly responsible.

Many deaths from heart disease occur outside the hospital and present as sudden cardiac arrest (SCA). The reported survival rates for out-of-hospital SCA in Australia vary from 3% to 71%,[4-13] but few studies have specifically examined whether there are differences in outcomes between urban and rural cardiac arrests.

Our aim was to compare outcome after out-of-hospital SCA in urban and rural areas in Victoria, and investigate the factors that may be associated with any difference.

METHODS

Ambulance services

Victoria has an area of 227 000 square kilometres and a population of 4.6 million, of whom most (3.0 million) live in the capital city, Melbourne.[14] The ambulance service in Victoria comprises Rural Ambulance Victoria (RAV) and the Metropolitan Ambulance Service (MAS). Both RAV and MAS use a two-tier system of ambulance paramedics, most of whom have some advanced life support skills (laryngeal mask airway, intravenous adrenaline), and intensive care paramedics, who are authorised to perform endotracheal intubation and administer a range of cardiac drugs. The cardiac arrest protocols follow the recommendations of the Australian Resuscitation Council.[15,16]

There are operational differences between MAS and RAV. MAS uses computerised dispatching (Advanced Medical Priority Dispatch System, Priority Dispatch Corporation, Salt Lake City, Utah, USA) and RAV uses a manual call-taking and dispatch system. In addition, MAS and the Metropolitan Fire and Emergency Services Board operate a joint emergency medical response first-response program.[17] Finally, MAS dispatches intensive care paramedics to all suspected cardiac arrests, whereas this level of skill is variably available in RAV.

Data

We obtained data from the Victorian Ambulance Cardiac Arrest Registry (VACAR) database for out-of-hospital SCAs that occurred between January 2002 and December 2003. The VACAR includes data from the ambulance patient care record and hospital medical records for all patients who suffer an out-of-hospital SCA in Victoria and who are attended by the ambulance service.

We analysed data from the VACAR complying with the Utstein methods of reporting[18] for adults (> 17 years), in cardiac arrest on arrival of the emergency medical service (EMS), with collapse witnessed by a bystander, and with cardiac arrest of presumed cardiac cause. The dataset included variables considered to be associated with outcome, including EMS response time, the application of bystander cardiopulmonary resuscitation (CPR), EMS interventions (including the insertion of an endotracheal tube), return of spontaneous circulation (presence of a pulse for > 30 seconds after EMS arrival), arrival at the emergency department with a palpable pulse, and survival to hospital discharge.

The patients were defined as urban or rural based on the Australian Bureau of Statistics Australian Standard Geographical Classification (ABS-ASGC). Case locality assignment was undertaken using geospatial information system software (MapInfo Professional, version 7.5, MapInfo Corporation, Sydney, NSW), and ABS-ASGC Urban Centre/Locality Structure boundaries were applied using ABS-ASGC datasets.[19]

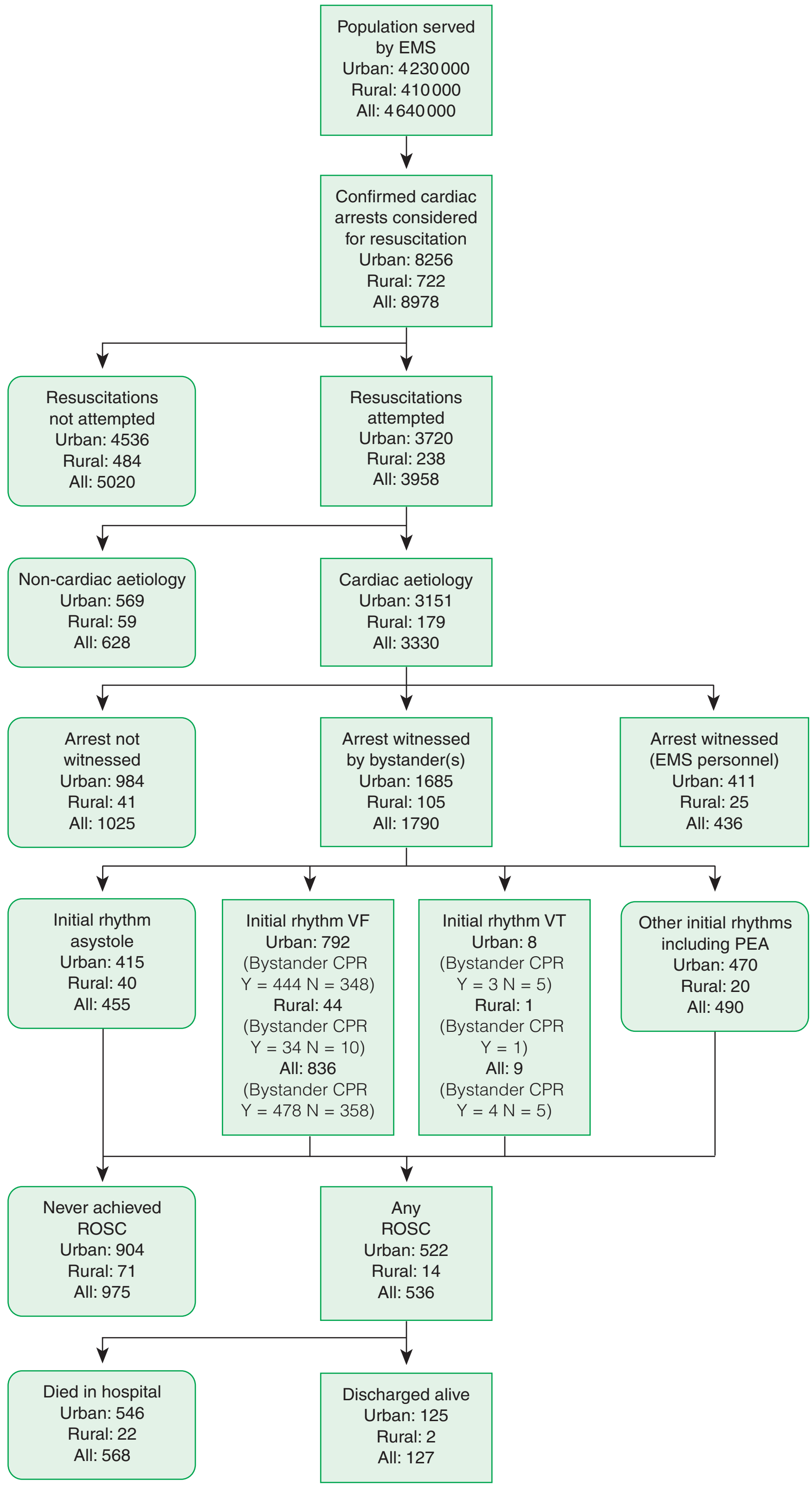
Ethics approval

Ethics approval was obtained from the Monash University Standing Committee on Ethics in Research Involving Humans. The Medical Standards Committees of MAS and RAV also approved the study.

Statistical analysis

Data were analysed with Stata statistical software, release 8.0 (StataCorp, College Station, Tex, USA). Continuous variables were

1 Adapted Utstein templates for out-of-hospital cardiac arrests in Victoria from January 2002 to December 2003



CPR = cardiopulmonary resuscitation. EMS = emergency medical services. PEA = pulseless electrical activity. ROSC = return of spontaneous circulation. VF = ventricular fibrillation. VT = ventricular tachycardia. ◆

2 Precipitating event causing cardiac arrest other than cardiac aetiology

Precipitating event	Number (%)
Trauma (including hanging and electrocution)	205 (32.6%)
Terminal illness	151 (24.0%)
Respiratory	109 (17.4%)
Overdose/poisoning	79 (12.6%)
Neurological	14 (2.2%)
Drowning	13 (2.1%)
Exsanguination	11 (1.8%)
Sepsis	6 (1.0%)
Unknown	23 (3.6%)
Other	17 (2.7%)
Total	**628 (100%)**

described using means and standard deviations, or median and interquartile range (IQR) for non-parametric data, and differences between independent groups were compared using Student's *t* test. Categorical variables were compared for differences between groups using χ^2 analysis. Where the distribution of frequencies was non-parametric, the Mann–Whitney *U* test was used.

Univariate analysis was undertaken to identify independent variables that may affect survival to hospital and survival to discharge. Independent variables included in the model were considered statistically significant at $P < 0.05$, and are reported as odds ratios (OR) with 95% confidence intervals and associated *P* values. Multivariate analysis was conducted using a stepwise selection procedure and validated using a backward elimination procedure. Crude rates of cardiac arrest are described per 100 000 persons per year.

The proportion of patients surviving to the emergency department following out-of-hospital cardiac arrest was about 30%. Retrospective power calculations indicated that a sample of 100 rural and 1000 urban subjects would have a power of 90% to detect a 14% difference with a two-sided *P* value of 0.05. Our study included 1790 subjects, and the actual difference observed between rural and urban locality was 17.7%.

RESULTS

During the 24 months, RAV and MAS attended 8978 cardiac arrests (Box 1). The overall rate of cardiac arrest was 147.8/100 000 persons per year (rural, 119.1/100 000 persons per year; urban, 149.3/100 000 persons per year). The disparity between urban and rural rates may be due to

3 Demographic characteristics of people who suffered bystander-witnessed cardiac arrests of cardiac aetiology over a 2-year period

	Urban (n = 1685)	Rural (n = 105)	Combined (n = 1790)	P Urban v Rural
Age (years) (mean ± SD)	68.4 ± 14.4	65.2 ± 13.4	68.2 ± 14.4	0.025
Male	71.0%	80.0%	71.5%	0.046
Bystander CPR initiated	48.4%	65.7%	49.4%	< 0.001
Endotracheal tube inserted	78.8%	56.2%	77.5%	< 0.001
Initial rhythm on ambulance arrival				
Ventricular fibrillation	47.1%	42.0%	46.8%	0.010
Ventricular tachycardia	0.5%	1.0%	0.5%	
Asystole	24.6%	37.1%	25.5%	
Pulseless electrical activity	27.8%	21.0%	27.1%	
Response time (min) (IQR)	8 (6–10)	14 (9–18)	8 (6–10)	< 0.001*
Place of cardiac arrest				
Home	67.0%	53.3%	66.2%	0.001
Work	2.4%	2.9%	2.4%	
Public place	10.9%	15.3%	11.2%	
Nursing home	5.4%	2.9%	5.3%	
Shop	1.3%	0	1.2%	
Medical centre or hospital	3.5%	1.0%	3.4%	
In car or at road	2.4%	4.8%	2.5%	
Sports venue	4.2%	12.4%	4.7%	
Hotel, club or casino	2.2%	4.8%	2.4%	
Other	0.9%	2.9%	1.0%	

* Mann–Whitney U test. CPR = cardiopulmonary resuscitation. IQR = interquartile range. ◆

an ambulance not being called in the more rural or remote settings.

Of the 8978 cardiac arrests, resuscitation was commenced in 3958 (44%). Of these, 3330 (37%) were of presumed cardiac aetiology. Other causes are summarised in Box 2.

There were 1790 (20%) bystander-witnessed cardiac arrests. The median age for men was 69 years (IQR, 58–77 years) and for women was 74 years (IQR, 65–82 years). Demographic characteristics for these patients are summarised in Box 3. There was a significant difference in the rate of bystander-initiated CPR between urban and rural localities (urban, 48.4% [95% CI, 46.0%–50.8%]; rural, 65.7% [95% CI, 56.5%–74.9%]). The urban group were significantly older (P = 0.025). Patients in the urban group were more likely than those in rural areas to have an endotracheal tube inserted as part of their management (P < 0.001).

The median ambulance response time was shorter (P < 0.001) and the median distance from cardiac arrest location to the closest ambulance station was shorter (P < 0.001) in urban than in rural areas. Rural patients were a median distance of 6 km (IQR, 4–11 km) from the ambulance station, compared with 2 km (IQR, 1–3 km) for urban patients. There was also a difference in the distance between cardiac arrest location and the closest hospital (rural, 12 km [IQR, 7–18 km]; urban, 4 km [IQR, 2–7 km]; P < 0.001). Overall, patients who survived to hospital arrival demonstrated a significant difference in median response times (urban, 7 min [IQR, 6–9 min]; rural, 8 min [IQR, 6–11 min]; P < 0.001).

The initial cardiac rhythm was ventricular fibrillation in 46.8% of patients on arrival of ambulance (Box 3). This rhythm was more common in urban areas than in rural areas (urban, 47.1%; 95% CI, 44.9%–49.6%; rural, 42.0%; 95% CI, 32.6%–52.0%). Ventricular tachycardia was very rare as the presenting cardiac rhythm.

The overall rate of spontaneous circulation on arrival at hospital was 29.9% (536/1790). In urban areas, 522/1685 patients (31.0%) had a pulse on arrival at hospital, compared with 14/105 (13.3%) rural patients (univariate analysis OR, 2.9; 95% CI, 1.65–5.17; P < 0.001). A further 10 rural and 149 urban patients were transported to hospital with CPR in progress.

Overall survival to hospital discharge was 7.1% (127/1790). Patients who had an urban cardiac arrest were more likely to be discharged from hospital alive (125/1685; 7.4%) than rural patients (2/105; 1.9%) (OR, 4.13; 95% CI, 1.09–34.91; P = 0.033). Of those who were discharged alive from hospital, 92 were discharged to their own home (72.4%) and 27 (21.3%) were discharged to a rehabilitation or nursing facility for ongoing care. The discharge direction of eight survivors (6.3%) was unknown.

Because of the small numbers of survivors to hospital discharge, the analysis of baseline variables in a logistic regression model used survival to hospital as the dependent variable rather than hospital discharge. Regression analysis identified a number of factors associated with survival to hospital (Box 4 and Box 5). Independent factors associated with survival were distance to ambulance station, sex, endotracheal tube insertion, and presenting rhythm.

DISCUSSION

Our study has shown that survival from out-of-hospital sudden cardiac arrest is significantly lower in rural areas than in urban areas in Victoria.

Patients in rural areas may have been expected to have worse outcomes because of longer times between collapse and defibrillation, but few studies have specifically examined the locality of the SCA, or compared rural and urban arrests. In one study, the overall survival rate to hospital was 13.9% (110/793), and survival rates were 9% in rural areas, 14% in suburban areas, and 23% in urban areas.[20] On the other hand, a study of 137 SCA patients found no difference in survival to hospital when patients were grouped by "city arrest" (10 survivors) or "country arrest" (12 survivors) (P = 1.0) or hospital discharge (3 survivors each group; P = 1.0), although that study had small patient numbers.[21] A third study of 1956 patients with SCA in Scotland compared survival rates in different postcode districts with different ambulance response times.[22] Survival to hospital admission was greater in areas where the median response time was less than 10 minutes (13.5% v 8.1%; P < 0.05). There was greater survival to discharge in these areas, but this was not significant (4.1% v 3.2%; P = 0.42). There was also a close correlation between distance travelled and response time (P < 0.01).

Improving outcomes following cardiac arrest in rural areas requires improvements in

4 Factors associated with survival to hospital: univariate analysis*

Factor	OR	95% CI	*P*
Locality (reference: rural)			
Urban	2.92	1.65–5.17	<0.001
Response time	0.94	0.91–0.96	<0.001
Distance to ambulance station	0.86	0.81–0.91	<0.001
Distance to hospital	0.95	0.93–0.98	<0.001
Age	1.00	1.00–1.01	0.327
Sex (reference: female)			
Male	0.89	0.71–1.11	0.298
Bystander CPR (reference: no CPR)			
Initiated	1.05	0.86–1.28	0.66
Endotracheal tube (reference: no tube)			
Tube inserted	4.01	2.91–5.53	<0.001
Rhythm on arrival of EMS (reference: VF)			
VT	1.46	0.39–5.49	0.573
Asystole	0.43	0.33–0.57	<0.001
PEA	0.79	0.62–1.01	0.060

* Bystander-witnessed, adult cardiac arrests of presumed cardiac aetiology.
CPR = cardiopulmonary resuscitation.
EMS = emergency medical service.
OR = odds ratio.
PEA = pulseless electrical activity.
VF = ventricular fibrillation.
VT = ventricular tachycardia. ◆

each link of the "chain of survival".[23] The first link is the call to the ambulance. In rural areas in Victoria, manual call-taking and dispatching is used, and this might be associated with delays or inaccuracy in dispatch time recording. Computerised dispatching may improve ambulance responses to cardiac arrest. One study comparing computerised dispatch with standard call-taking procedures found a doubling in the number of cardiac arrests correctly identified compared with a non-computerised system.[24] It would be expected that a case identified as suspected cardiac arrest at dispatch would have a faster ambulance response and concurrent allocation of intensive care paramedic support.

The second link in the chain of survival is the performance of bystander CPR. Interestingly, we found that bystander CPR did not appear to improve outcomes. Because public health programs that teach CPR to large numbers of the public are expensive, additional emphasis on widespread CPR teaching in rural areas would not appear to be worthwhile.

The third link in the chain of survival is early defibrillation. This usually depends on ambulance response time. In rural areas, there was a mean response time of 14 minutes, compared with 8 minutes in urban areas. Decreasing ambulance response times by several minutes across a large, sparsely populated area would be very costly, and more cost-effective means of delivering rapid defibrillation need to be considered. For example, in the urban areas serviced by MAS, firefighters also respond to cardiac arrests.[17,25] Because of the inner-urban location of this program, there was a minimal difference in the response times of firefighters compared with EMS, and only a small effect on survival rate.[17] However, a firefighter or police first-responder program implemented where ambulance response times are longer may have a more beneficial effect.[26]

For cardiac arrests outside the home, public access defibrillation programs reduce the time to defibrillation and increase survival.[27] We found that cardiac arrest outside the home was more frequent among the rural group (46.4%) than among the urban patients (33%). However, one study found that few rural places have sufficient SCAs to justify placement of defibrillators for public use.[28] Alternatively, defibrillators could be placed in the homes of patients at high risk of SCA; this strategy is currently under investigation.[29]

Finally, the use of advanced cardiac life support (defined as endotracheal intubation and intravenous adrenaline) by paramedics may increase the number of patients who are transported alive to hospital, although this may not result in improved survival to hospital discharge. We found those who were intubated had a significantly higher chance of surviving to hospital than those who were not (adjusted OR, 3.46; 95% CI, 2.49–4.80; $P < 0.001$). One study examined the effect of the introduction of advanced cardiac life support for SCA patients in 17 cities in Ontario, Canada.[30] The researchers enrolled 5638 patients, and the rate of survival to hospital after SCA improved significantly (from 10.9% before introduction of advanced cardiac life support to 14.6% after; $P < 0.001$). However, the rate of survival to hospital discharge was not changed (before, 5.0%; after, 5.1%; $P = 0.83$). On the other hand, in a study that examined timing of endotracheal intubation and outcome,[31] survival was 46% for patients with SCA who were intubated in less than 12 minutes, compared with 23% for patients intubated after 12 minutes. The adjusted odds ratio of survival for the late intubation group compared with the early intubation group was 0.42 (95% CI, 0.26–0.69). These results indicate there may be a benefit in the widespread training of ambulance paramedics in endotracheal intubation of SCA patients in rural areas, and this warrants further research.

There may be subtle but important differences in ambulance management in urban compared with rural areas that we were unable to measure. For example, there are fewer (usually two) ambulance staff at a rural cardiac arrest, compared with urban cardiac arrests (generally four, plus firefighters), which limits the number of interventions that can be performed concurrently. One strategy to address this issue is the introduction of a portable machine that performs external chest compression (eg, Autopulse Resuscitation System, Zoll Medical Australia Pty Ltd, Lane Cove, NSW). This device may allow the ambulance staff to focus on defibrillation and advanced life-support measures. This machine has been used by the San Francisco ambulance service.[32] When applied in SCA patients after a mean (SD) response time of 15 (5) minutes, more patients arrived with a pulse at hospital when Autopulse had been used (39%) compared with manual CPR (29%) ($P = 0.003$). However, the article did not report differences in outcomes at hospital discharge.

A limitation of our study is the retrospective data collection and analysis. In addition, too few rural patients survived to hospital discharge to allow multivariate analysis of factors that affect outcome at hospital discharge. Therefore, we were required to use

5 Factors associated with survival to hospital: multivariate analysis*

Factor	OR	95% CI	*P*
Distance to ambulance station	0.87	0.82–0.92	< 0.001
Sex (reference: female)			
Male	0.77	0.61–0.98	0.032
Endotracheal tube (reference: no tube)			
Tube inserted	3.46	2.49–4.80	< 0.001
Rhythm on arrival of EMS (reference: VF)			
Asystole	0.50	0.38–0.67	< 0.001
PEA	0.73	0.56–0.95	0.018

* Multivariate analysis of factors identified in univariate analysis for bystander-witnessed, adult cardiac arrests of presumed cardiac aetiology.
EMS = emergency medical service. OR = odds ratio.
PEA = pulseless electrical activity.
VF = ventricular fibrillation. ◆

survival to hospital as a surrogate end-point for analysis of variables that are associated with outcomes. Furthermore, there could have been a selection bias in patients who were intubated compared with those who were not, as intensive care paramedics may only intubate patients whom they deem viable, partially resulting in the strong OR for this intervention in the multivariate analysis. On the other hand, the strength of our study is the accurate classification of patients as urban or rural based on population density and exact location of the SCA, and the relatively large numbers of patients for analysis.

Our findings confirm that longer response times decrease survival rates in rural patients after out-of-hospital sudden cardiac arrest. There is a practical limit to decreasing ambulance response times by increasing ambulance numbers. Possible alternative strategies which require further evaluation to improve outcomes include computerised ambulance dispatch, first-responder and public access defibrillation programs, home defibrillation in selected patients, increased availability of advanced life support measures, and new technologies for external cardiac massage.

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COMPETING INTERESTS

None identified.

AUTHOR DETAILS

Paul A Jennings, BN, MClinEpi, Clinical Educator[1]
Peter Cameron, MB BS, MD, Head, Prehospital, Emergency and Trauma Research[2]
Tony Walker, BParamedStud, GDipEd, Manager Operations, Clinical and Education Services[1]
Stephen Bernard, MB BS, FACEM, Senior Medical Advisor,[3] Senior Lecturer[2]
Karen Smith, BSc(Hons), PhD, Project Manager, Strategic Planning[3]
1 Rural Ambulance Victoria, Geelong, VIC.
2 Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, VIC.
3 Metropolitan Ambulance Service, Melbourne, VIC.
Correspondence: paul.jennings@rav.vic.gov.au

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