2017 ANNUAL REPORT

Out of Hospital Cardiac Arrest in Queensland

The Importance of Bystander Interventions

Queensland Government

2017 ANNUAL REPORT

This report is authored by the Information Support, Research and Evaluation Unit (ISRE), Queensland Ambulance Service.

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Abbreviations

AED	Automated External Defibrillator
AOR	Adjusted Odds Ratio
CAD	Computer-Aided Dispatch
CCP	Critical Care Paramedic
CI	Confidence Interval
CPR	Cardiopulmonary Resuscitation
dARF	Digital Ambulance Report Form
DCARF	Death and Cardiac Arrest Report Form
ECG	Electrocardiogram
EDC	Emergency Data Collection
LASN	Local Ambulance Service Network
OHCA	Out-of-Hospital Cardiac Arrest
QAS	Queensland Ambulance Service
QHAPDC	Queensland Hospital Admitted Patient Data Collection
ROSC	Return of Spontaneous Circulation
RSQ	Retrieval Services Queensland
STEMI	ST-Segment Elevation Myocardial Infarction
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia

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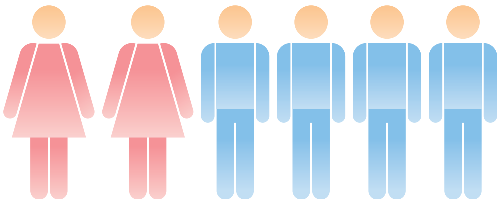
Executive summary

1741 cases*

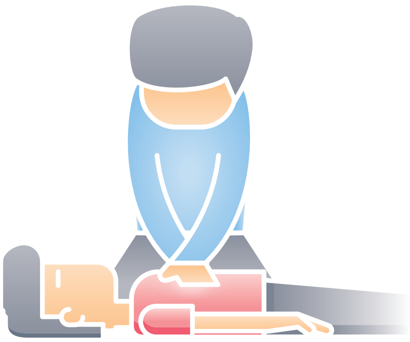


67% male

* had resuscitation attempted, and arrest was not witnessed by paramedics

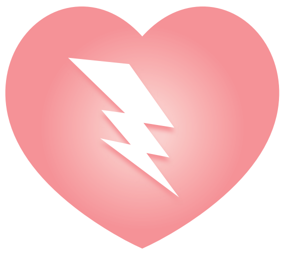
75%

occurred in **residential homes**



76%

of patients receiving **bystander CPR** had resuscitation attempts, compared to 14% for those without bystander CPR

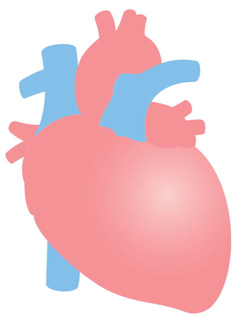


7%

of arrests in public locations received **bystander defibrillation**

51%

of patients receiving **bystander CPR** survived to hospital arrival, compared to 37% for those without bystander CPR



75%

of patients who arrested due to a STEMI survived to hospital discharge

1 Introduction

Out-of-hospital cardiac arrest (OHCA) is a common medical emergency in the community.[1] Despite variations in mortality statistics, the survival rate of OHCA is consistently low worldwide, at approximately 10% for 30-day survival.[2-4] The prognosis and outcomes after OHCA are highly time-dependent; accordingly, early interventions are crucial to survival.[5]

The chain-of-survival strategy for OHCA treatment emphasises a system-of-care approach, in which early interventions can be achieved through bystander-initiated actions, including early recognition of patients suffering OHCA, immediate activation of emergency medical services, and immediate basic life support (cardiopulmonary resuscitation [CPR], defibrillation).[6] These early interventions by bystanders prior to paramedic arrival are critical for improving patient outcomes.[7] In fact, bystander CPR has been shown to improve OHCA survival by twofold compared to no bystander CPR.[8] It is also associated with better long-term neurological outcomes and lower rates of nursing home admission.[9] Despite these proven benefits and substantial efforts to improve the rate of early interventions by bystanders, less than half of OHCA patients globally receive bystander CPR.[9,10]

Coronary artery disease is the predominant cause of OHCA, and ST-segment elevation myocardial infarction (STEMI) is a profoundly life-threatening medical emergency caused by coronary artery disease.[11] As with all OHCA cases, early interventions are crucial for survival from OHCA in the context of STEMI. OHCA following STEMI is challenging to manage, and is associated with substantial mortality and morbidity.[12] To date, data on the rate and determinants of survival in the prehospital phase of this important subset of OHCA patients are limited. A better understanding of the characteristics and survival outcomes of these patients will facilitate timely implementation of appropriate actions by bystanders and paramedics.

This report presents information on the epidemiology, management and outcomes of all OHCA incidents attended by Queensland Ambulance Service (QAS) paramedics between 1st January and 31st December 2017. The focus of this report is on early intervention through bystander CPR and defibrillation for OHCA patients, and early reperfusion treatment for a subset of these patients who suffered OHCA in the context of STEMI. With the exception of patients who suffered OHCA subsequent to paramedic-identified STEMI, all analyses in this report excluded cardiac arrest that occurred in the presence of paramedics (paramedic-witnessed arrest). These patients have unique patient-related and system-related factors that markedly differ from other OHCA patients.

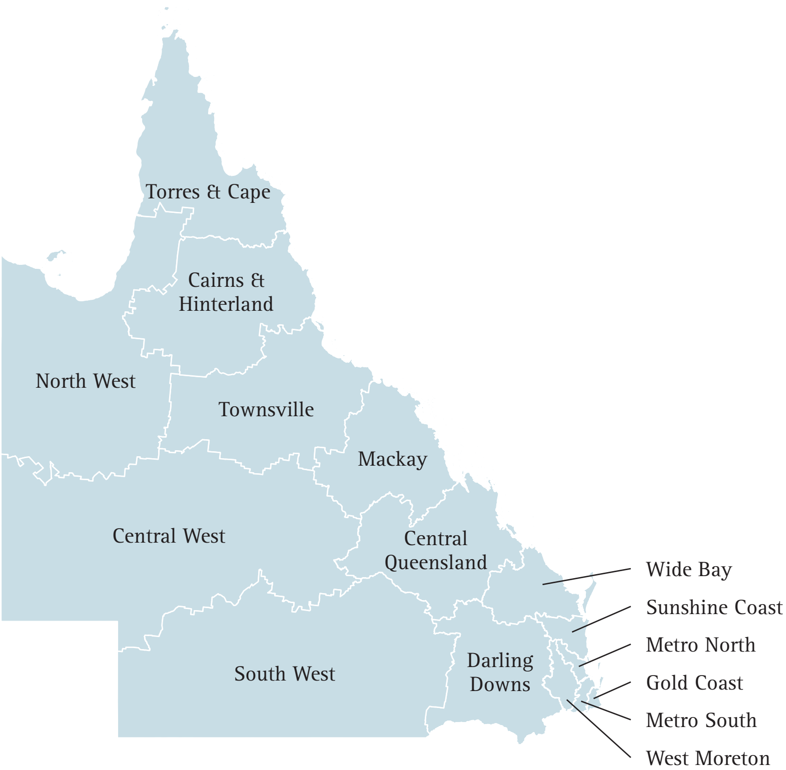
2 The Queensland Ambulance Service

The QAS provides care to an estimated five million Queensland residents who are geographically dispersed over 1.7 million square kilometres. Relative to other Australian states, Queensland has a high proportion of its population residing outside major cities, with 38% of Queenslanders living in regional or remote areas (compared to 23-27% in other states).[13] Given the size and terrain of the state, this wide population dispersion presents unique challenges for the QAS in the delivery of high quality ambulance services to all Queenslanders.

The state is divided into 15 geographical Local Ambulance Service Network (LASN) areas (Figure 1). There are 296 ambulance response locations across the state, including 229 permanent ambulance locations, 22 hospital-based ambulance locations, 10 airport locations, five field offices, 24 locations with QAS first responders, and six locations with honorary volunteers. In addition to road ambulances, aeromedical and helicopter retrieval services are available, coordinated by Retrieval Services Queensland (RSQ) under the governance of the Department of Health, Queensland Government.

The request for an emergency ambulance in Australia is made through a single national Triple Zero (000) telephone number. In Queensland, these calls are triaged from seven Operations Centres located throughout the state. Their role is to obtain the location of the incident, ensure clinical prioritisation, dispatch of an appropriate emergency ambulance response, and provide instructions to implement first aid where appropriate. Telephone triage in Queensland is performed using the Medical Priority Dispatch System, which is complemented by the Computer-Aided Dispatch (CAD) system, to facilitate rapid deployment of resources.

The QAS treatment protocols for OHCA follow the recommendations of the Australian Resuscitation Council. In circumstances where there are obvious signs of death, paramedics may appropriately withhold resuscitation. Discontinuation of resuscitation may occur if 20 minutes of continuous CPR is performed without a return of spontaneous circulation (ROSC), in the presence of a cardiac rhythm of asystole or pulseless electrical activity at a rate less than 10 per minute, and determination of life extinct criteria being met.



LASN	Geographic size (km²)	Population
Torres & Cape	130,238	26,889
North West	253,700	30,494
Central West	382,800	10,474
South West	319,800	24,365
Cairns & Hinterland	141,600	245,940
Townsville	149,500	246,718
Mackay	90,360	172,587
Central Queensland	111,200	210,665
Wide Bay	37,050	215,596
Sunshine Coast	10,020	416,828
Metro North	3969	999,148
Metro South	3856	1,142,808
Gold Coast	1846	606,291
West Moreton	9521	291,031
Darling Downs	88,650	299,910

Figure 1. Population and geographic size of the 15 LASN areas.

3 The OHCA data collection

The QAS Cardiac Outcomes Project was established in 1999. It comprises the OHCA program and the statewide prehospital reperfusion strategy for STEMI patients. The overall aim of the Cardiac Outcomes Project is to provide data-driven insights into patient outcomes and the quality of the prehospital cardiac services delivered by the QAS. This report analyses data from the OHCA data collection for the 2017 calendar year, with a focus on early interventions through bystander CPR and defibrillation for all OHCA patients, and on early reperfusion treatment for a subset of these patients who suffered cardiac arrest secondary to a paramedic-identified STEMI.

The OHCA data collection was commenced in 1999 and to date has more than 82,000 cases. It contains information obtained during the Triple Zero (000) call, from patient care records, and in-hospital care and survival information, to accurately describe the epidemiology, clinical management and outcomes of all OHCA patients attended by QAS paramedics. Primary data sources for the OHCA data collection include the digital Ambulance Report Form (dARF), CAD, the Death and Cardiac Arrest Report Form (DCARF), electrocardiogram (ECG) tracing strips from cardiac monitors, and linked data from the Queensland Hospital Admitted Patient Data Collection (QHAPDC), the Emergency Data Collection (EDC), and the Queensland Registry of Deaths (Figure 2).

The linked data provide information on the in-hospital management and survival of OHCA patients who are transported by QAS ambulance to public hospitals in Queensland. Key data elements such as ambulance response times, clinically-important times and survival outcomes can be derived from the OHCA data collection, and are used to undertake statistical analysis to measure service delivery and performance.

All OHCA patients attended by QAS paramedics are reviewed and processed for reporting. The veracity of the data collection is maintained through a rigorous ongoing process which ensures uniformity and consistency. The data are subject to a comprehensive cleaning process, where missing data are identified and recovered where possible, duplicate cases are checked and removed, and inconsistent or conflicting data elements are corrected. The OHCA data collection is periodically reconciled with the main QAS electronic data warehouse using a search script consisting of key words and phrases to identify possible OHCA cases that are not captured through the usual paper documentation submission method. These cases subsequently undergo the same manual data auditing process before being incorporated into the OHCA data collection.

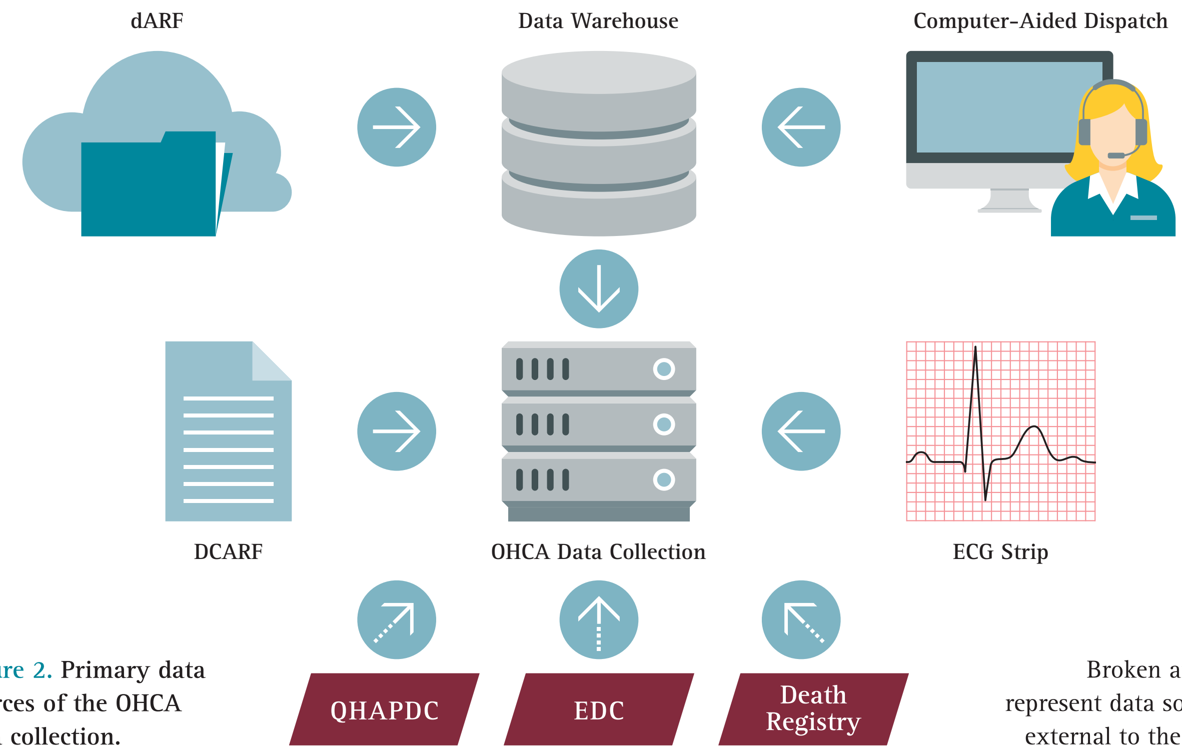


Figure 2. Primary data sources of the OHCA data collection.

Broken arrows represent data sources external to the QAS.

4 Demographics

In the calendar year 2017, the QAS attended a total of 5301 OHCA cases; 200 cases more than the previous year. This translates into an incidence rate of 108 cases per 100,000 population (compared to 102 cases per 100,000 population in 2016). Among the 5301 OHCA patients attended by paramedics, a resuscitation attempt was made by paramedics in 41% (2149/5301) of the cases. Of these 2149 cases, 1741 were not witnessed by paramedics and are the subject of this report.

The majority (96%) were adults (aged 16 years or older); of these, 67% were male. The median (interquartile range) age of adult patients was 66 (50-78) years (Figure 3). OHCA occurred most frequently in residential homes (75% of cases), followed by public places (12%) and aged care facility (5%).

Medical aetiology (presumed cardiac, other medical causes, or unknown cause) was the primary cause of OHCA, accounting for 81% of the cases (Figure 4). The aetiology of OHCA by age group in adults is shown in Figure 5. Medical aetiology was the predominant cause of OHCA in all adult age groups, except for the 16-35 years age group. There was an association between the increased prevalence of medical aetiology and advancing age. In the 16-35 years age group, asphyxia (primarily hanging) was the most common cause of OHCA, followed by medical cause. In children (<16 years of age), medical aetiology was the primary cause of OHCA (53% of all paediatric cases), followed by drowning (22%) and trauma (14%).

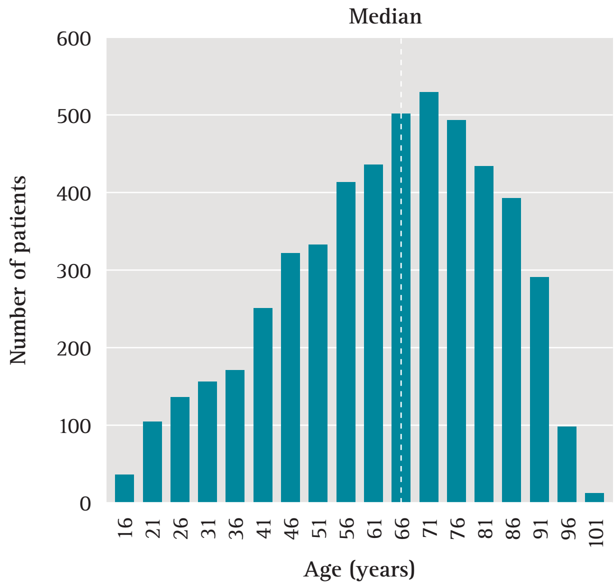


Figure 3. Age distribution in adults (16 years or older).

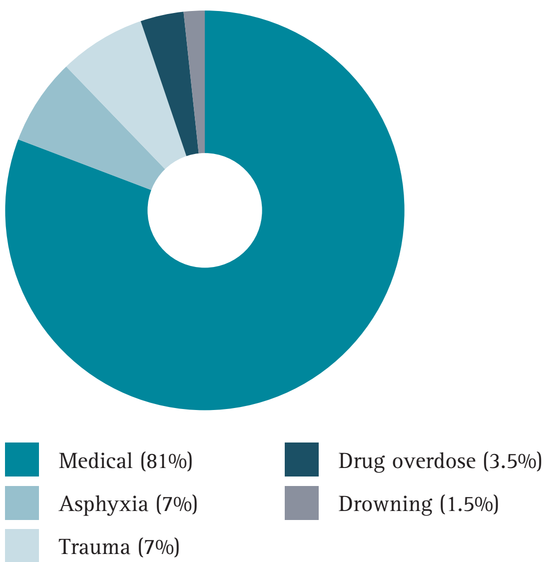


Figure 4. Aetiology of OHCA.

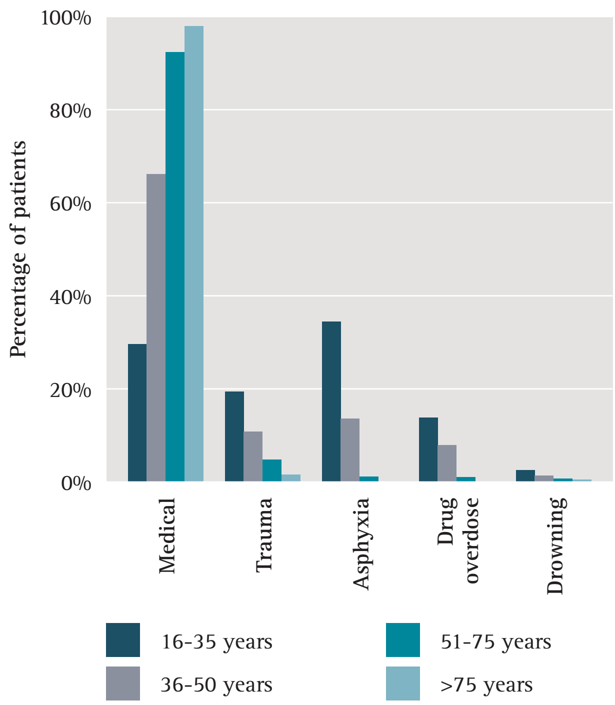


Figure 5. Aetiology of OHCA by adult age group.

5 Survival outcomes of the Utstein patient group

Substantial variation exists in the methods of calculating and reporting survival outcomes among emergency ambulance services across Australia and worldwide, dependent upon the different patient inclusion criteria used (e.g. Utstein template, government reporting criteria, targeted analysis). It is therefore important to have a consistent denominator for survival calculations to provide comparable measures of survival outcomes across different emergency ambulance services. The Utstein template is the most widely used criteria for uniform reporting of OHCA survival outcomes globally.[14] Accordingly, we are reporting this to enable comparison nationally and internationally of our results.

The following criteria define the Utstein patient group: all-cause, resuscitation attempted, initial shockable rhythm, and bystander-witnessed. In 2017, there were 303 cardiac arrests attended by QAS paramedics that met these criteria. For this patient group, the rates of event survival (ROSC on hospital arrival), survival to discharge, and 30-day survival were 49%, 32% and 32%, respectively (Figure 6). These figures compare favourably with other ambulance services in Australia and worldwide, which given the State's challenging geography is a notable achievement (Figure 7).

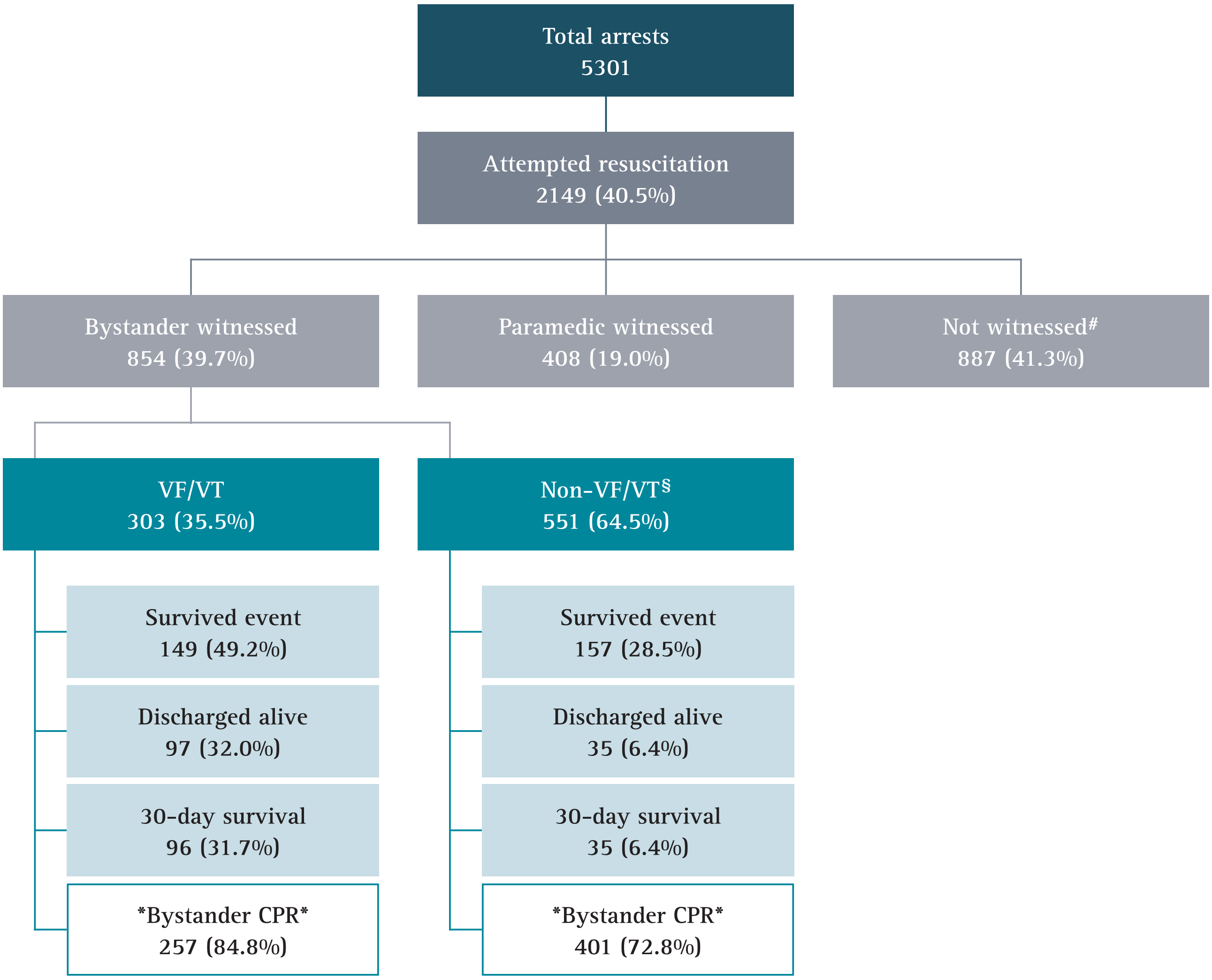


Figure 6. Breakdown of OHCA events in 2017 according to paramedic-attempted resuscitation, witness status and initial cardiac arrest rhythm. #Includes unknown witness status. §Includes unknown initial rhythm.

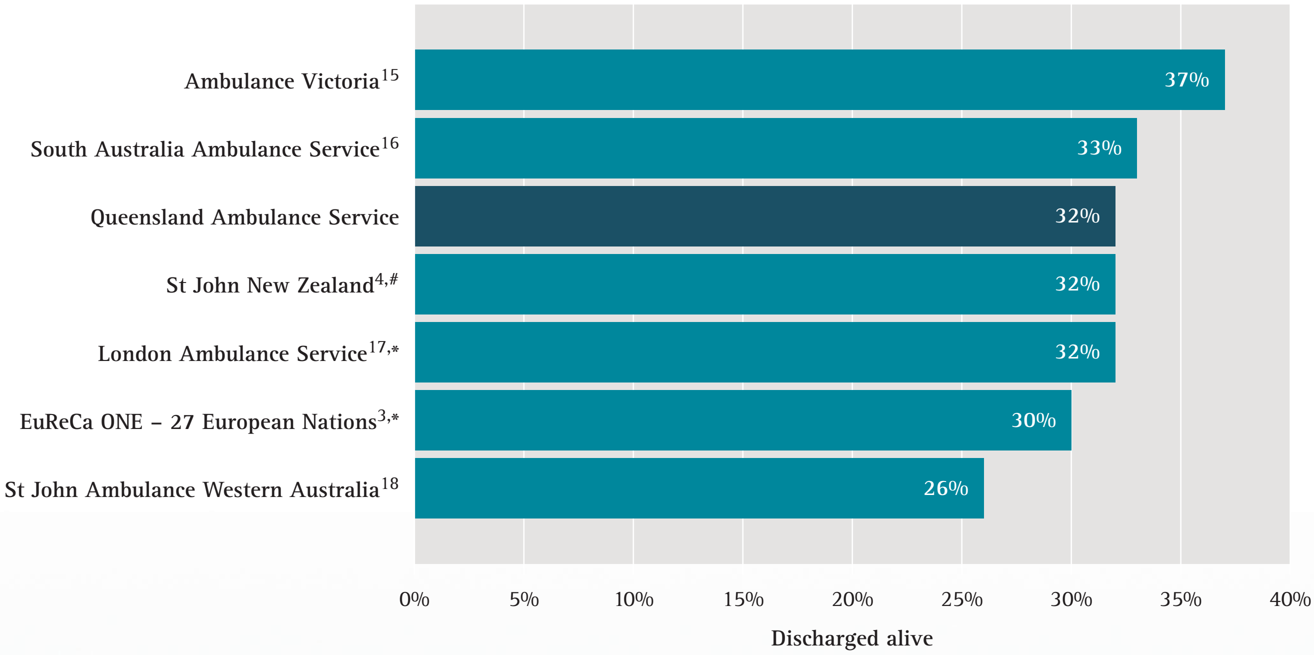


Figure 7. **Survival outcomes (discharged alive) of the Utstein patient group reported by various ambulance services.** All ambulance services reported data for the calendar year 2017 or financial year 2017/2018, except EuReCa ONE which reported 2014 data. #30-day survival. *Only included arrests of cardiac aetiology.

6 Early bystander-initiated interventions save lives

Early response to OHCA during the first moments after the patient collapses is critical for survival. Previous studies have shown that the likelihood of survival from OHCA reduces between 7% and 10% for every minute delay in performing CPR.[19] Even the highest performing emergency medical services will not be able to arrive at the patient and perform CPR more rapidly than bystanders. Therefore, early interventions initiated by bystanders prior to paramedic arrival are crucial, and any strategy to improve the outcomes of OHCA patients must seek to increase the rate of bystander CPR and defibrillation.

Over the past decade in Queensland, there has been a steady increase in bystander CPR rates. In 2017, of all non-paramedic witnessed OHCA patients who received resuscitation by paramedics, 74% received bystander CPR, compared to 61% in 2008 (a 21% relative increase, $p < 0.001$) (Figure 8). Such improvement in bystander CPR rates was attributable to a range of initiatives that have been implemented in Queensland throughout the past decade with the goal of educating lay people about OHCA.

As expected, bystander CPR rate was highest among those whose arrest was witnessed by a bystander; sustaining at over 70% for the past decade and reaching a high of 77% in 2017 (Figure 8). This figure compares favourably with other ambulance services in Australia and New Zealand, which report bystander CPR rates between 70% and 79% for bystander-witnessed arrest.[20] Bystander CPR was more common amongst arrests occurring in public places than in residential homes (88% versus 74% for bystander-witnessed arrest, $p < 0.001$).

Figure 9 shows that older age (> 75 years old), arrest occurring in residential homes, unwitnessed arrest, and arrest during night time (23:01 - 06:59 the next day) were associated with not receiving bystander CPR. Specifically, these factors increased the likelihood of not receiving bystander CPR by 123%, 84%, 43% and 36%, respectively (Figure 9). Understanding the factors that prevent bystanders from performing CPR is important so that those barriers can be mitigated. Previous research has shown that the close relationship between patients and their family members can cause the potential helper to experience significant psychological stress and consequently fail to initiate CPR.[21]

Despite the high rate of bystander CPR, the fact that 26% of the patients did not receive this critical early intervention presents an opportunity for further investment. Geospatial distribution of OHCA attendance can be used for local targeting of community awareness strategies (Figure 10).

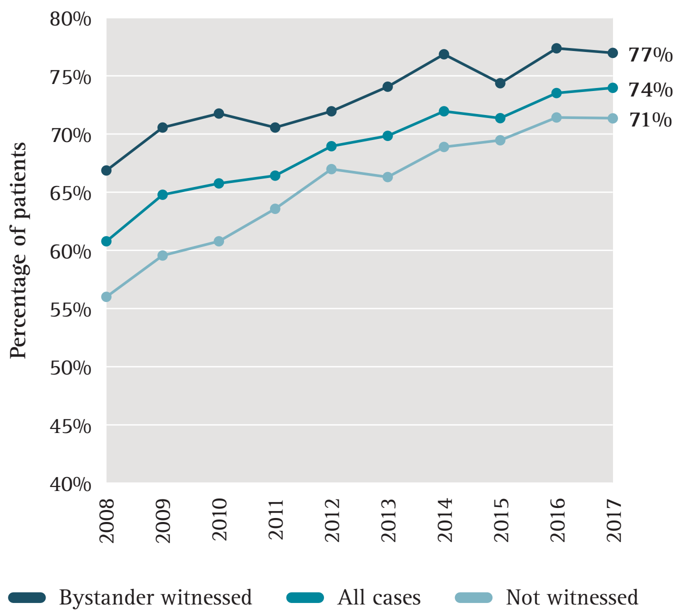


Figure 8. Bystander CPR rates by year.

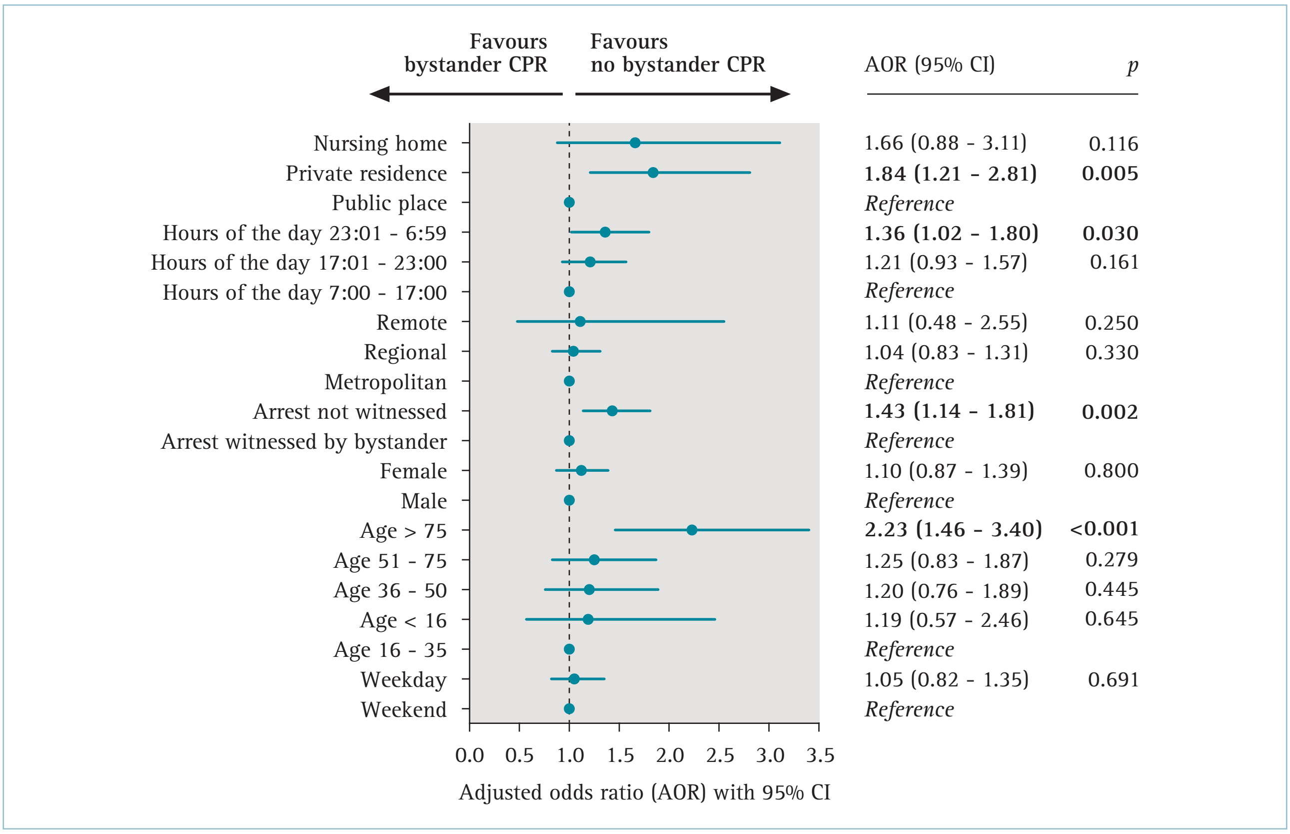
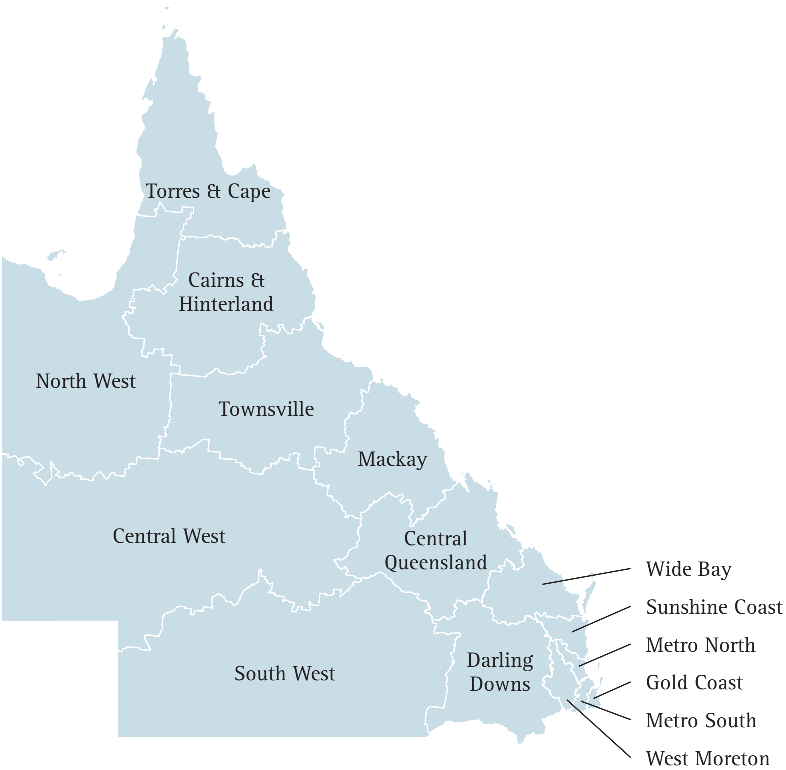


Figure 9. Factors associated with bystander CPR.



LASN	Total no. of cases (2017)	Bystander CPR n (%)
Torres & Cape*	8	5 (63%)
North West*	12	6 (50%)
Central West*	4	4 (100%)
South West*	13	11 (85%)
Cairns & Hinterland	115	87 (76%)
Townsville	105	73 (70%)
Mackay	47	37 (79%)
Central Queensland	94	65 (69%)
Wide Bay	82	60 (73%)
Sunshine Coast	150	116 (77%)
Metro North	333	247 (74%)
Metro South	335	245 (73%)
Gold Coast	216	156 (72%)
West Moreton	103	81 (79%)
Darling Downs	124	86 (69%)

Figure 10. Bystander CPR rate by LASN areas. *Given the small sample size, results should be interpreted with caution.

Figure 11 shows better survival outcomes in patients who received bystander CPR compared to those not receiving bystander CPR. Patients who received bystander CPR were also more likely to have resuscitation attempted by paramedics than those not receiving bystander CPR (76% versus 14%, $p < 0.001$). Improvement in survival was more substantial in the subset of patients whose arrest was witnessed by a bystander and had an initial shockable cardiac arrest rhythm (ventricular fibrillation or ventricular tachycardia, VF/VT) (Figure 12). More than half (51%) of these patients survived the event when they received bystander CPR, compared to 37% without bystander CPR ($p = 0.095$). Survival to discharge (34% versus 19%, $p = 0.042$) and 30-day survival (34% versus 19%, $p = 0.047$) was also higher for patients receiving bystander CPR than no bystander CPR (Figure 12).

Defibrillation, while the patient is in shockable rhythm, is another intervention that when performed early will maximise survival. It is considered to be the only intervention that can terminate VF/VT and restore normal cardiac rhythm and circulation. It has been shown that every minute delay in defibrillation will reduce the likelihood of survival by approximately 10%.[22] As such, it is critical to minimise the time interval from collapse to first rhythm analysis and defibrillation, while continuing CPR during this interval.

Automated external defibrillators (AEDs) have been widely promoted by health authorities globally in recent years as a practical and effective way of reducing the delay to defibrillation of OHCA patients. In 2017, the QAS attended 1741 cases where the arrest occurred before the arrival of paramedics and resuscitation was subsequently attempted by paramedics. Of these, only 21 (1.2%) were defibrillated by a bystander using an AED prior to paramedic arrival. This figure concurs with international literature, which reported bystander defibrillation rates of less than 2%.[23] Arrests occurring in public places were more likely than those in residential locations to receive bystander defibrillation (7% versus 0.2%, $p < 0.001$).

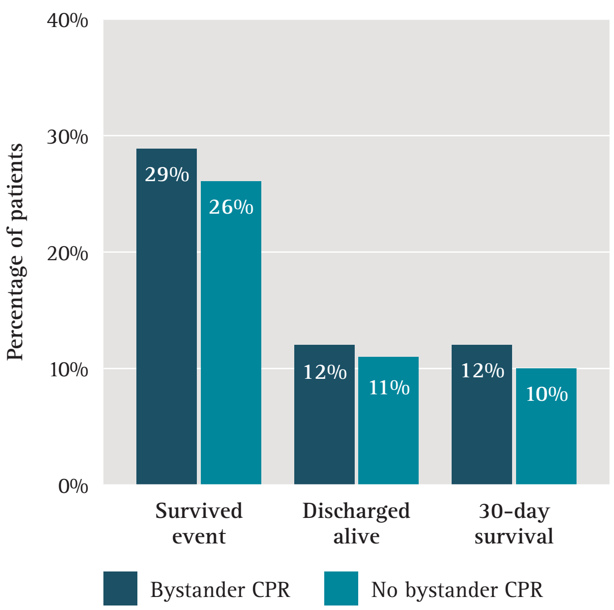


Figure 11. Survival outcomes, bystander CPR versus no bystander CPR.

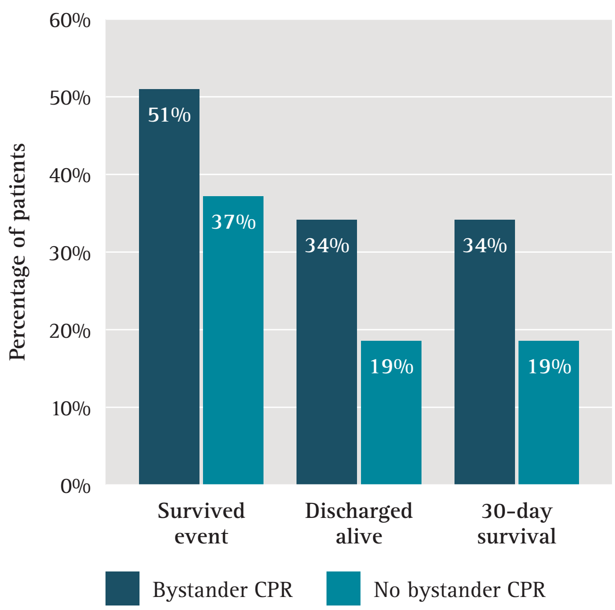


Figure 12. Survival outcomes, bystander CPR versus no bystander CPR. OHCA cases that were witnessed by bystanders, had resuscitation attempted by paramedics and had initial shockable rhythm were included.

Patients receiving bystander defibrillation had better survival outcomes than those who did not receive bystander defibrillation (Figure 13). It has been shown that the availability of a system that captures the locations of AEDs within a jurisdictional area and assists bystanders with the locating of AEDs improves the uptake of bystander defibrillation.[24] There is currently progress underway in Queensland in this area, as it presents an important opportunity for the QAS and other community agencies to invest additional effort in this important link in the chain-of-survival. It is important though to couple any such strategies with a strong foundation of bystander CPR, as AEDs only work when a patient is in shockable rhythm.

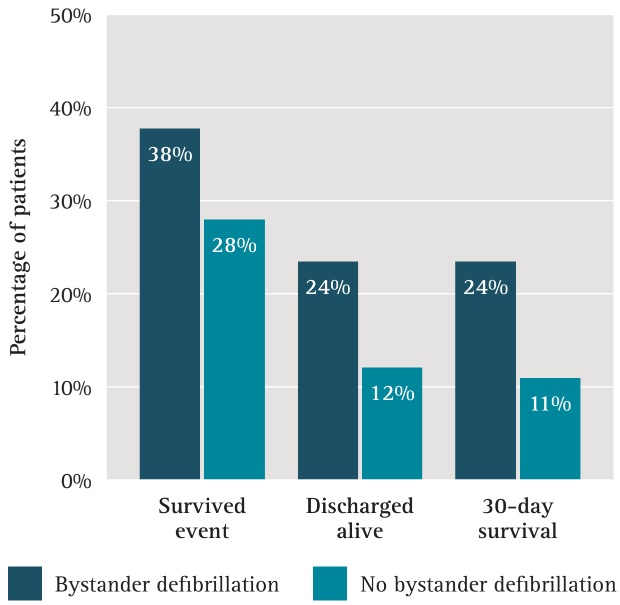


Figure 13. **Survival outcomes, bystander defibrillation versus no bystander defibrillation.**

7 OHCA in the context of STEMI

Patients experiencing OHCA in the context of STEMI represent a unique cohort who benefit from early interventions and targeted prehospital management. Adult patients who experienced OHCA of suspected cardiac aetiology following paramedic-identified STEMI, between January 2013 and December 2017 in Queensland, were included in this subgroup analysis. During the study period, paramedics identified and treated 287 STEMI patients who subsequently suffered OHCA while in the care of paramedics.

Excellent event survival was observed for these patients, with 77% surviving the event and 75% surviving to discharge. Important determinants of survival included initial shockable cardiac arrest rhythm, administration of reperfusion medications by paramedics, and the Triple Zero (000) phone call made inside business hours (09:00 - 17:00, Monday - Friday) (Figure 14). These findings support the important role of early recognition of the symptoms and the rapid activation of emergency medical services by bystanders, followed by rapid administration of reperfusion medications by paramedics.

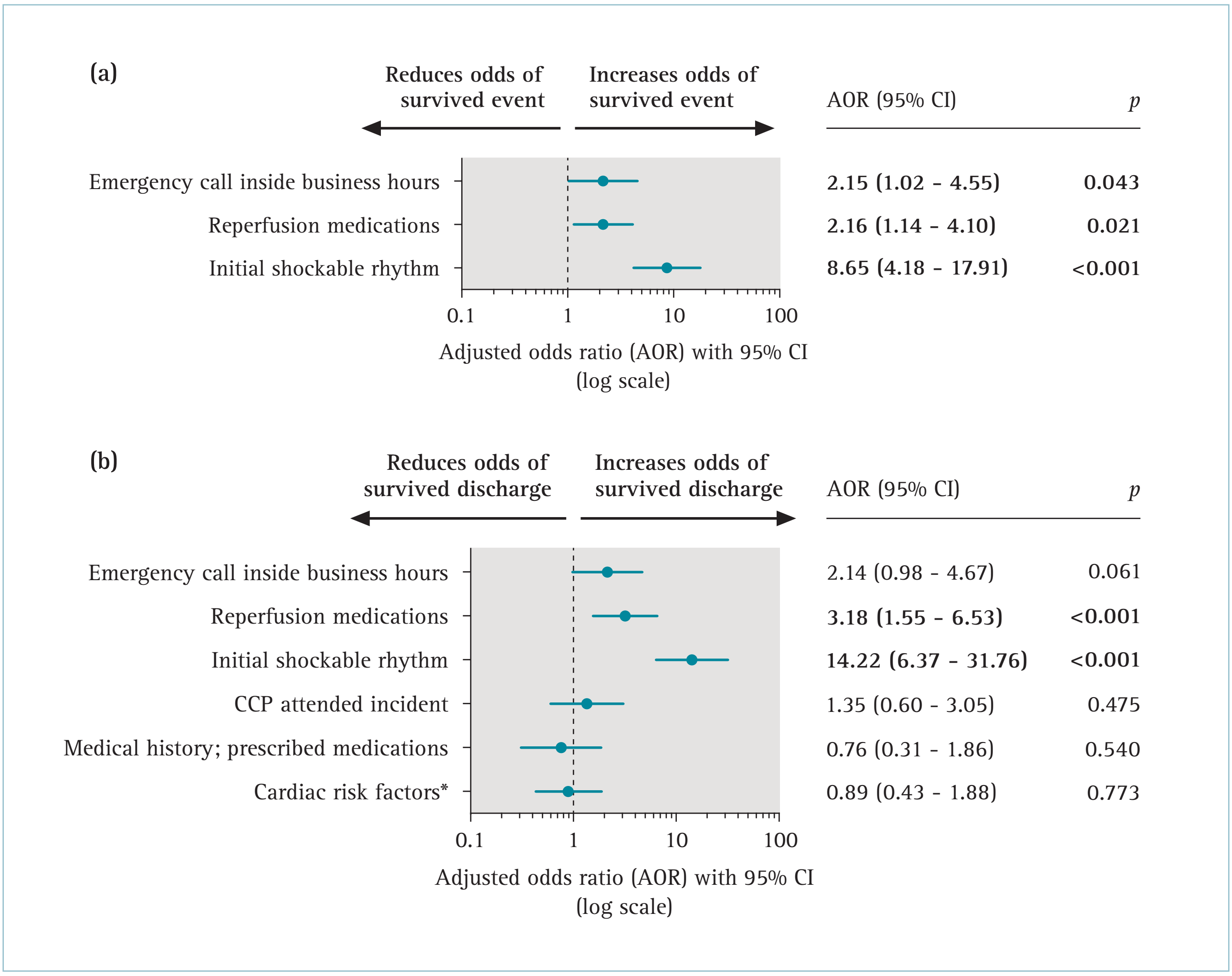


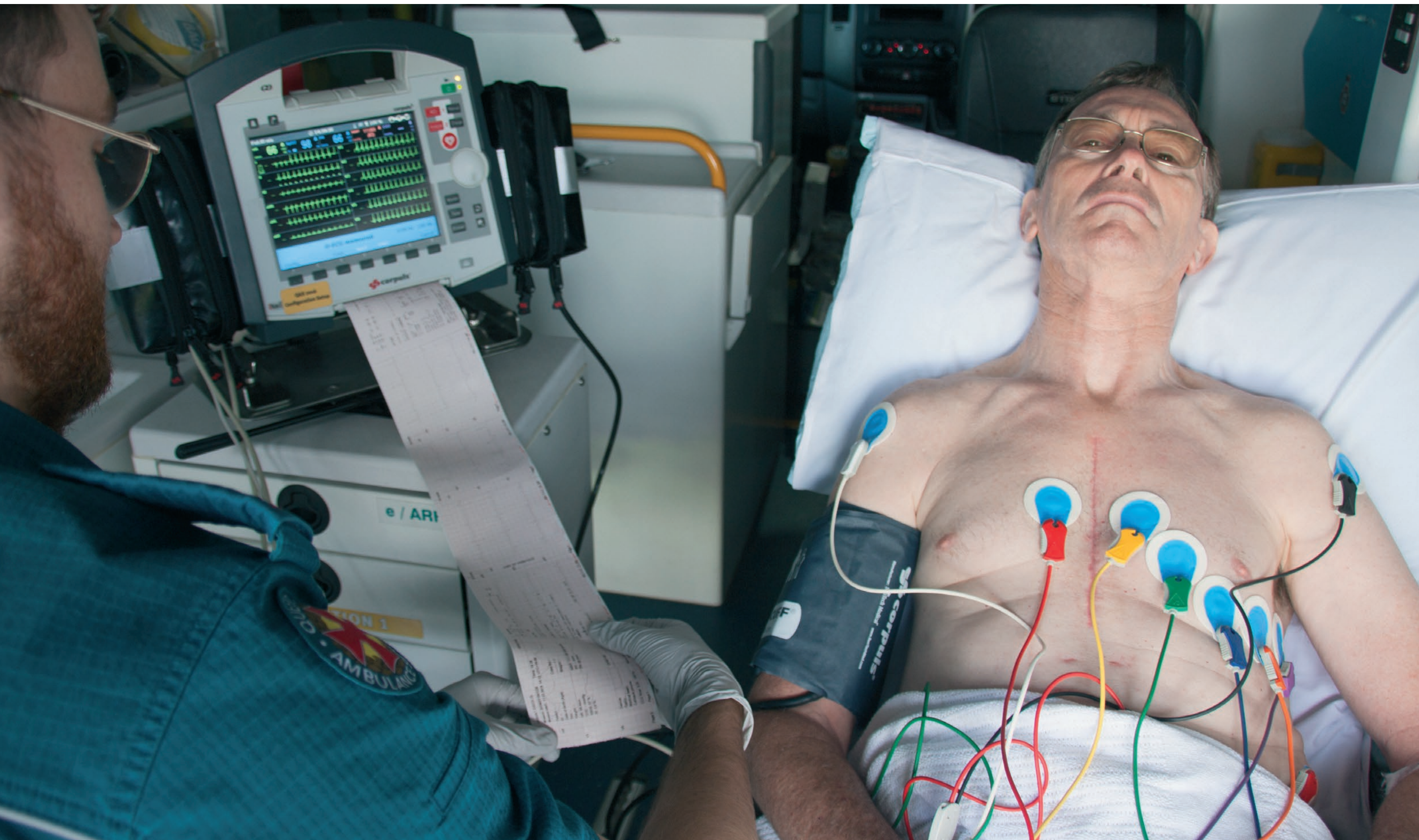
Figure 14. Factors associated with event survival (a) and survival to discharge (b) among patients who suffered OHCA following paramedic-identified STEMI. *Cardiac risk factors were defined as reported medical history of hypertension, hyperlipidaemia or type 2 diabetes.

8 Conclusions

This report highlights the importance of early interventions for OHCA through bystanders providing early CPR and defibrillation. We demonstrated that survival outcomes of patients receiving bystander CPR and defibrillation were superior to those not receiving these interventions. While the rates of bystander CPR and defibrillation compared favourably with Australian and international figures, there remains a need to improve strategies that assist bystanders to recognise and respond to OHCA, with the goal of increasing the rates of these critical bystander-initiated early interventions. Efforts should focus on improving bystander recognition of cardiac arrests, encouraging appropriate and early initiation of CPR in patients experiencing OHCA, and facilitating distribution of and access to AEDs.

This report provides a novel investigation of the survival outcomes and determinants of survival of patients who had paramedic-identified STEMI prior to deteriorating into OHCA. The patients included in this study were found to be highly salvageable and responsive to resuscitation measures, with three-quarters of patients surviving the initial OHCA event and subsequently surviving to hospital discharge.

Management of, and longer-term survival from, OHCA is dependent upon care across the healthcare continuum. Linked hospital data used in this report are vital to enable the analysis of both the prehospital and in-hospital components of care, so that a more complete picture of health service performance, patient journey and outcomes can be captured. It is also an important demonstration of the positive collaborations that exist between the QAS, as the prehospital clinical service provider, and the hospitals and broader health system. The findings of this report will form a basis to identify further opportunities for service improvement, with the focus on improving early interventions initiated by bystanders and ultimately optimising patient outcomes. Ongoing, systematic analysis of data about OHCA and bystander interventions is essential to the planning, implementation and evaluation of effective prehospital care.



9 Acknowledgements

This report was prepared by Dr Tan Doan, Mr Brendan Schultz and Associate Professor Emma Bosley with contributions from Professor Stephen Rashford and Ms Elizabeth Cardwell. We thank the Statistical Services Branch (Department of Health, Queensland Government) for the linked data relating to in-hospital processes and survival outcomes. We thank paramedic personnel for the care provided to these patients and submission of the clinical data, Emergency Medical Dispatchers for the rapid identification and dispatch of resources to these time critical patients, and Ms Louise Sims for coding and management of data which comprise this report.

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