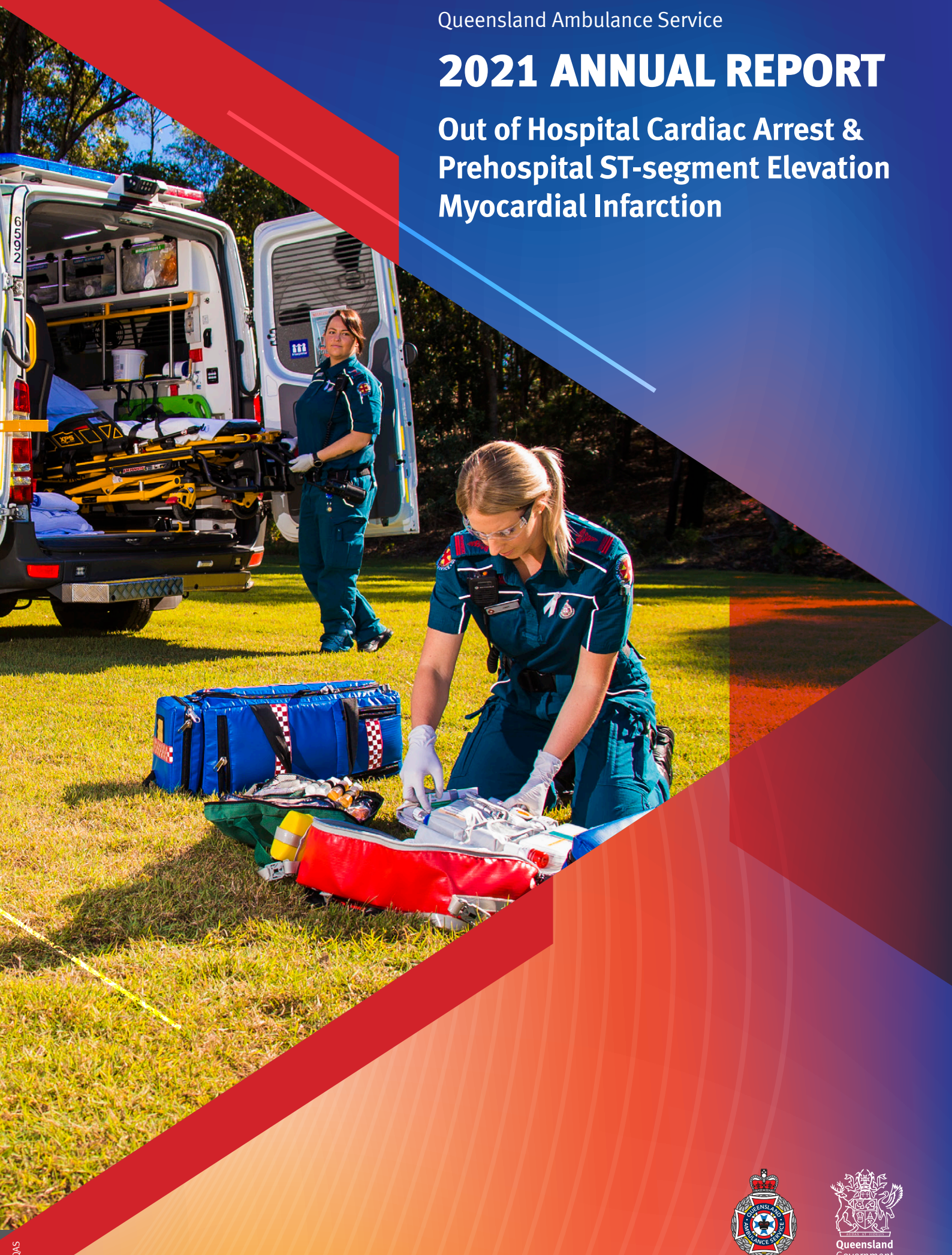
Queensland Ambulance Service

# 2021 ANNUAL REPORT

## Out of Hospital Cardiac Arrest & Prehospital ST-segment Elevation Myocardial Infarction



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# About this report

This report presents important information on the response, management, conveyance, and survival outcomes of two cardiac patient groups attended by Queensland Ambulance Service (QAS) paramedics in the 2021 calendar year:

1. Out-of-hospital cardiac arrest (OHCA), and
2. Prehospital ST-segment elevation myocardial infarction (STEMI).

Central to cardiac arrest management is the delivery of high-quality uninterrupted chest compressions, normally by hand (manual chest compressions). There are circumstances in which the ability to deliver high-quality manual chest compressions is compromised, such as during patient relocation and transport. Mechanical chest compression devices (MCCDs) can safely provide high-quality uninterrupted chest compressions in those situations. In July 2020, the QAS implemented MCCDs throughout South-East Queensland for selected Critical Care Paramedic (CCP) units in the catchment areas of the tertiary hospitals that provide percutaneous coronary intervention (PCI) and emergency extracorporeal membrane oxygenation (ECMO). This report describes the epidemiology and outcomes of OHCA patients who received mechanical chest compressions. Evaluation of the performance of this new technology is essential to guide operational adjustments and improvements.

This report extends to analyse a sub-group of cardiac arrests that were due to suicide. Suicide is the most common cause of death among young Australians.[1] While suicide-related OHCA is relatively infrequent compared to underlying medical illness, it is cause that affords clear opportunity for prevention. There is a paucity of evidence regarding the characteristics and outcomes of suicide-related OHCA in Australia and internationally. A more complete understanding of suicide methods, patient characteristics and outcomes, and temporal trends of those variables, is essential to inform prehospital management strategies and public health interventions.

STEMI is a special focus in this report, inclusive of a costing analysis of the acute treatment for prehospital STEMI patients who were identified and treated in the field by paramedics before rapid transport to hospital for definitive care. This analysis is the first to investigate the upfront treatment costs of paramedic-identified STEMI patients, incorporating both prehospital and hospital cost components.

# OUT-OF-HOSPITAL CARDIAC ARREST

# Key OHCA facts at a glance

Adults (≥ 16 years)

| | | |
|---|---|---|
| **5840** | **Cardiac arrests attended** | **112** |
| **2346 (40%)** | **Resuscitation attempted** | **81 (72%)** |

Children


## Median response time

Both metropolitan and rural

## 508 mechanical chest compression cases

(July 2020 –December 2021)

## Utstein patient group

- 49% survived event
- 28% discharged alive
- 28% survived to 30 days

## Suicide-related OHCA

Account for 11% of all paramedic-attended OHCA
Four times more common in males; however, rate increases faster in females over time

**Three most common suicide methods:**

Hanging
63%

Overdose
11%

Chemical asphyxia
9%

**Resuscitation attempted: 23%**

**Survival outcomes among resuscitation attempts**

- 29% survived event
- 9% discharged alive
- 8% survived to 30 days

# Incidence and demographics

In 2021, QAS paramedics attended a total of 5952 OHCA cases. The crude incidence rate was 114 cases per 100,000 population. Of all paramedic-attended cases, 5840 (98.1%) were adults (≥ 16 year old). Across all ages, 2427 (40.8%) paramedic-attended OHCA received a resuscitation attempt by paramedics. Key statistics for adults and children are displayed in Figure 1.

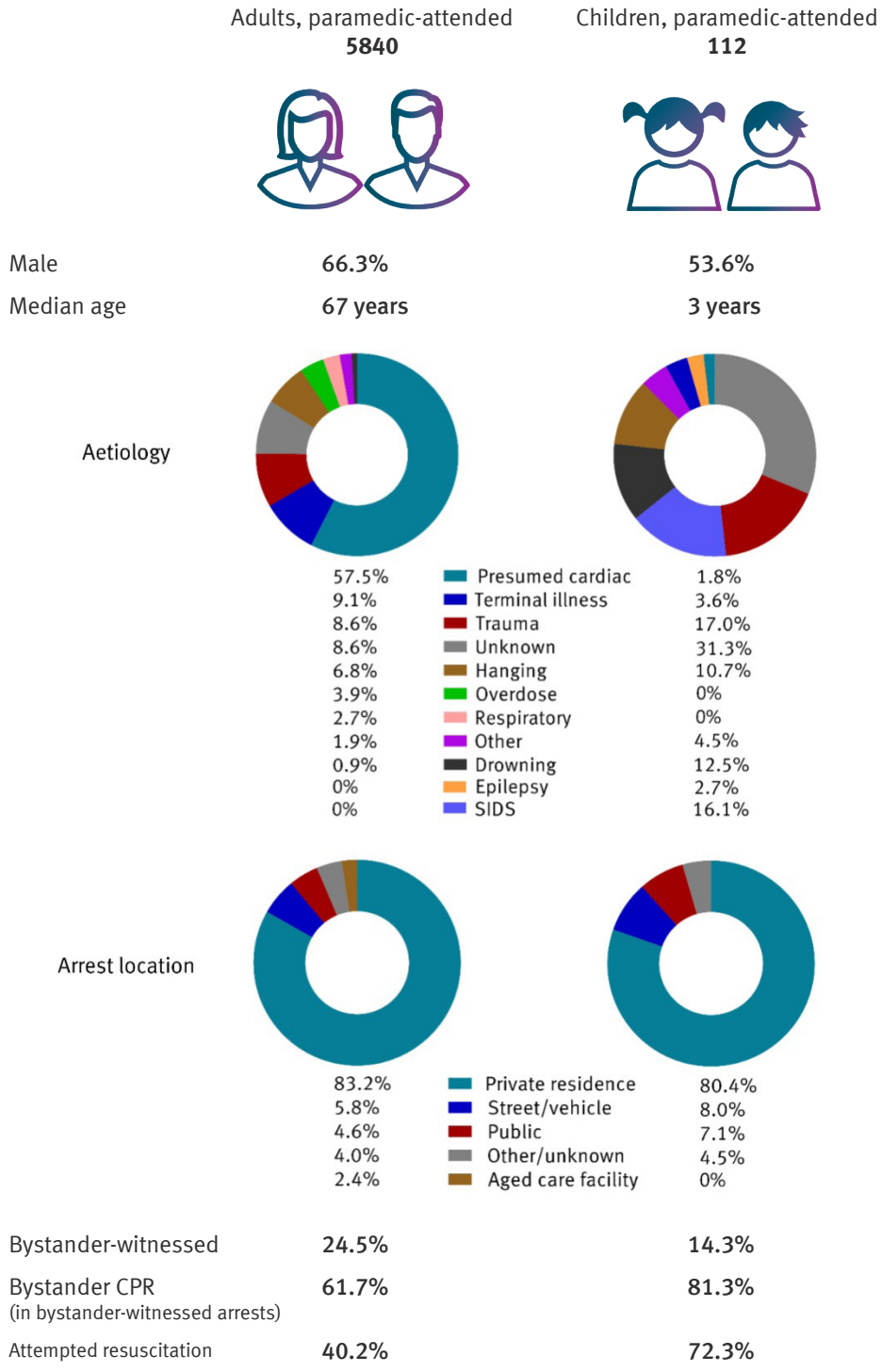



**Figure 1.** Key characteristics of OHCA patients, adults versus children.

# Ambulance response time

Among attempted-resuscitation patients, the median response time was 9 minutes (from receipt of Triple Zero call to first paramedic arriving at scene), for both metropolitan and rural areas (Figure 2). Statewide, response time was within the QAS 10 minutes benchmark in nearly three-quarters of the patients (Figure 2).

| | Statewide | Metropolitan | Rural |
|---|---|---|---|
| **Median response time** | 09 min | 09 min | 09 min |
| **Within 10 minutes** | 73% | 75% | 70% |

**Figure 2.** Ambulance response time among attempted-resuscitation patients.

# Survival outcomes

Survival outcomes of various patient groups are presented in Figure 3. For all patients who received an attempted resuscitation by paramedics, the rates of event survival (return of spontaneous circulation [ROSC] that is sustained to hospital arrival), survival to hospital discharge, and 30-day survival were 28.0%, 11.9%, and 11.7%, respectively. As expected, paramedic-witnessed arrests had the highest survival rates, with event survival, survival to discharge, and 30-day survival rates being 46.8%, 33.2%, and 32.2%, respectively (Figure 3).

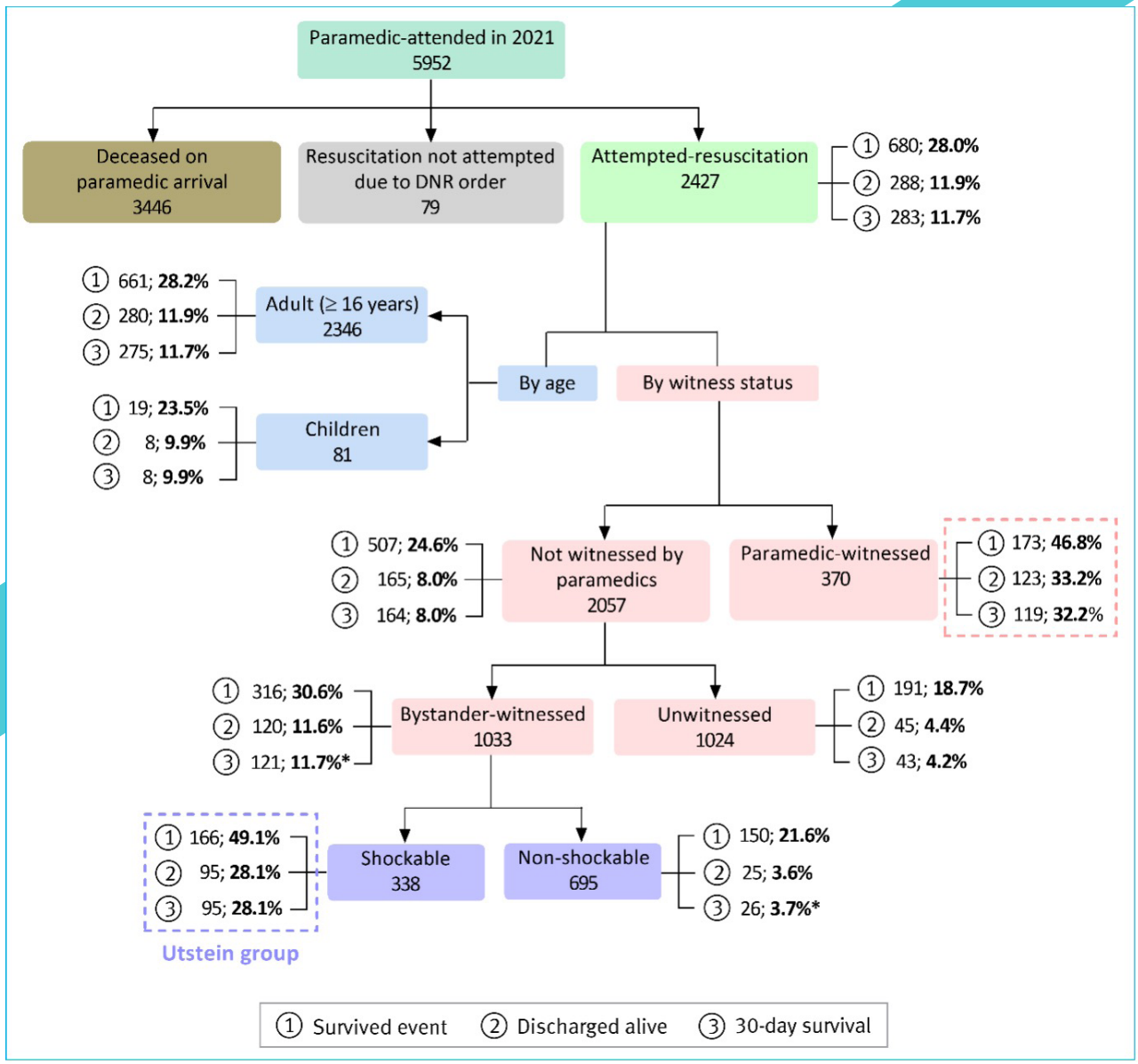



**Figure 3.** Survival rates of different patient groups. *30-day survival was higher than survival to discharge due to one patient staying in the hospital for more than 30 days and deceased on discharge.

In 2021, there were 338 paramedic-attended cardiac arrests that met the Utstein criteria (all-cause, attempted-resuscitation, initial shockable rhythm, bystander-witnessed). For this patient group, the rates of event survival, survival to discharge, and 30-day survival were 49.1%, 28.1%, and 28.1%, respectively (Figure 3). These figures compare favourably with other ambulance services in Australia and worldwide (Table 1), which given the state's challenging geography is a notable achievement.

**Table 1.** Survival rates for the Utstein patient group from other ambulance services

| Ambulance service | Time period | Definition | Survived event (%) | Discharged alive (%) | 30-day survival (%) |
|---|---|---|---|---|---|
| **Queensland Ambulance Service** | Calendar 2021 | All-age<br>All-cause<br>Attempted-resuscitation<br>Bystander-witnessed<br>Initial shockable rhythm | 49.1 | 28.1 | 28.1 |
| **New Zealand**[2] | 1 July 2020 – 30 June 2021 | ≥ 15 year old<br>All-cause<br>Attempted-resuscitation<br>Bystander-witnessed<br>Initial shockable rhythm | 49.0 | | 28.0 |
| **Ambulance Victoria**[3] | Calendar 2021 | All-age<br>All-cause<br>Attempted-resuscitation<br>Bystander-witnessed<br>Initial shockable rhythm | 62.0 | 35.0 | |
| **St John Western Australia**[4] | Calendar 2021 | All-age<br>All-cause<br>Attempted-resuscitation<br>Bystander-witnessed<br>Initial shockable rhythm | 48.0 | | 33.9 |
| **Seattle & King County (USA)**[5] | Calendar 2020 | All-age<br>Non-traumatic<br>Attempted-resuscitation<br>Bystander-witnessed<br>Initial shockable rhythm | | 39.0 | |
| **CARES (30 state-based registries in the USA)**[6] | Calendar 2021 | All-age<br>Non-traumatic<br>Attempted-resuscitation<br>Bystander-witnessed<br>Initial shockable rhythm | 48.4 | 29.0 | |
| **Irish OHCAR**[7] | Calendar 2020 | › 17 year old<br>Medical cause<br>Attempted-resuscitation<br>Bystander-witnessed<br>Initial shockable rhythm | 42.0 | 28.0 | |

# Mechanical chest compression devices

Jaime Estrella was witnessed to collapse while at work and was immediately assisted by his colleagues. Effective bystander cardiopulmonary resuscitation (CPR) was performed, and he presented in ventricular fibrillation on the arrival of the primary ambulance unit. Resuscitative measures were commenced, with him remaining refractory to standard advanced life support. Jaime was identified early as a potential candidate for ECMO, and the receiving hospital was notified. A MCCD was utilised to facilitate ongoing resuscitation during transport. So effective was the MCCD, Jaime required an anaesthetic to address the consciousness that occurred as a result of the device despite no cardiac activity. Upon arrival at hospital, Jaime was successfully placed on ECMO. He was found to have an occlusion of a coronary artery that required a stent insertion. The ECMO was weaned with Jaime surviving cognitively intact. The incident exemplifies high-quality, coordinated care with all systems of the chain of survival working ‘hand in glove’.

The management of cardiac arrest has evolved considerably over the past two decades. However, there is still scope for improvement, and the QAS is committed to continual service development to further improve the care and outcomes for our patients. Central to any resuscitative effort is the delivery of high-quality chest compressions with minimal interruptions. There are circumstances that present significant challenges to the delivery of high-quality manual chest compressions, such as during patient relocation or transport. MCCDs can provide high-quality uninterrupted chest compressions in those situations.

In July 2020, the QAS deployed 21 state-of-the-art Corpuls MCCDs in South-East Queensland on selected CCP units in the catchment areas of the tertiary hospitals that provide PCI and ECMO. Consideration for a wider deployment will depend upon the performance of the devices and an evaluation of outcomes. MCCDs provide a bridge for sophisticated in-hospital care, where that is available.

From their introduction in July 2020 through to 31 December 2021 (cut-off of this report), MCCDs were used on a total of 508 patients (Figure 4). Figure 5 shows the location of those cases, and Figure 6 shows patient characteristics. Median age was 59 years, being 4 years younger than that of all attempted-resuscitation patients. Asystole was the most common initial rhythm (44.9%), followed by ventricular fibrillation/ventricular tachycardia (28.0%). The most common cause of arrest was presumed cardiac (62.6%), and 82.1% of arrests occurred in private residences. The rates of transport, event survival, survival to discharge, and 30-day survival among MCCD patients were 41.9%, 26.0%, 6.1% and 6.1%, respectively.

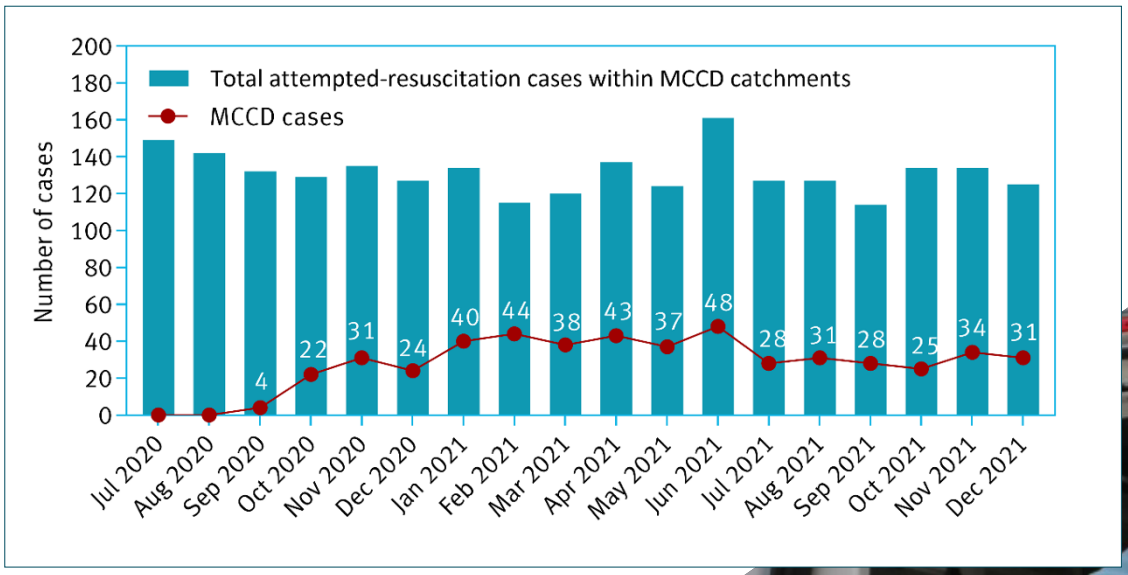



**Figure 4.** Monthly number of MCCD cases in relation to monthly total number of attempted-resuscitation cases within the MCCD catchment areas.

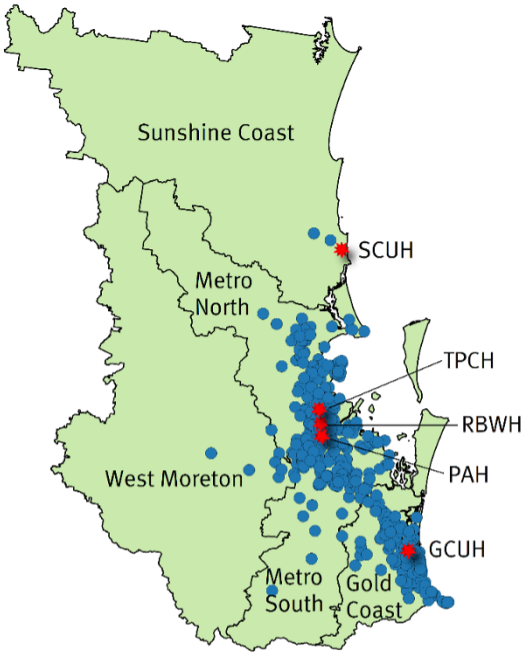



**Figure 5.** Location of the 508 MCCD cases (blue circles), and of the 5 tertiary PCI-capable hospitals in South-East Queensland (red stars). Each circle represents a case.

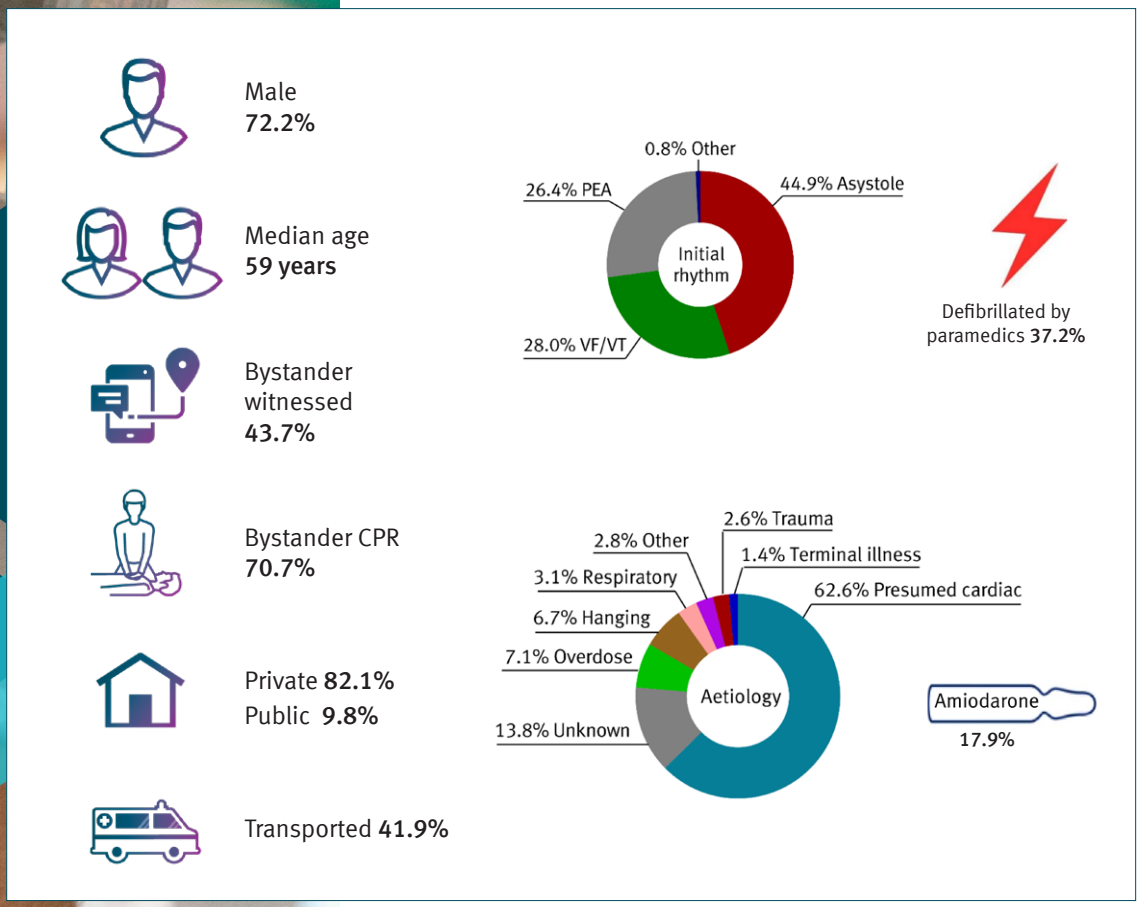



**Figure 6.** Characteristics of the 508 patients who received MCCD.

On average, manual compressions were performed for 11 minutes before the patient was switched to MCCD for another 20 minutes. The most common MCCD configurations were: continuous compressions at a rate of 110 per minute, and 5 cm depth.

Figure 7 below shows destinations of the transported patients. Gold Coast University Hospital, The Royal Brisbane and Women's Hospital, The Princess Alexandra Hospital and The Prince Charles Hospital accounted for the majority of transported MCCD cases.

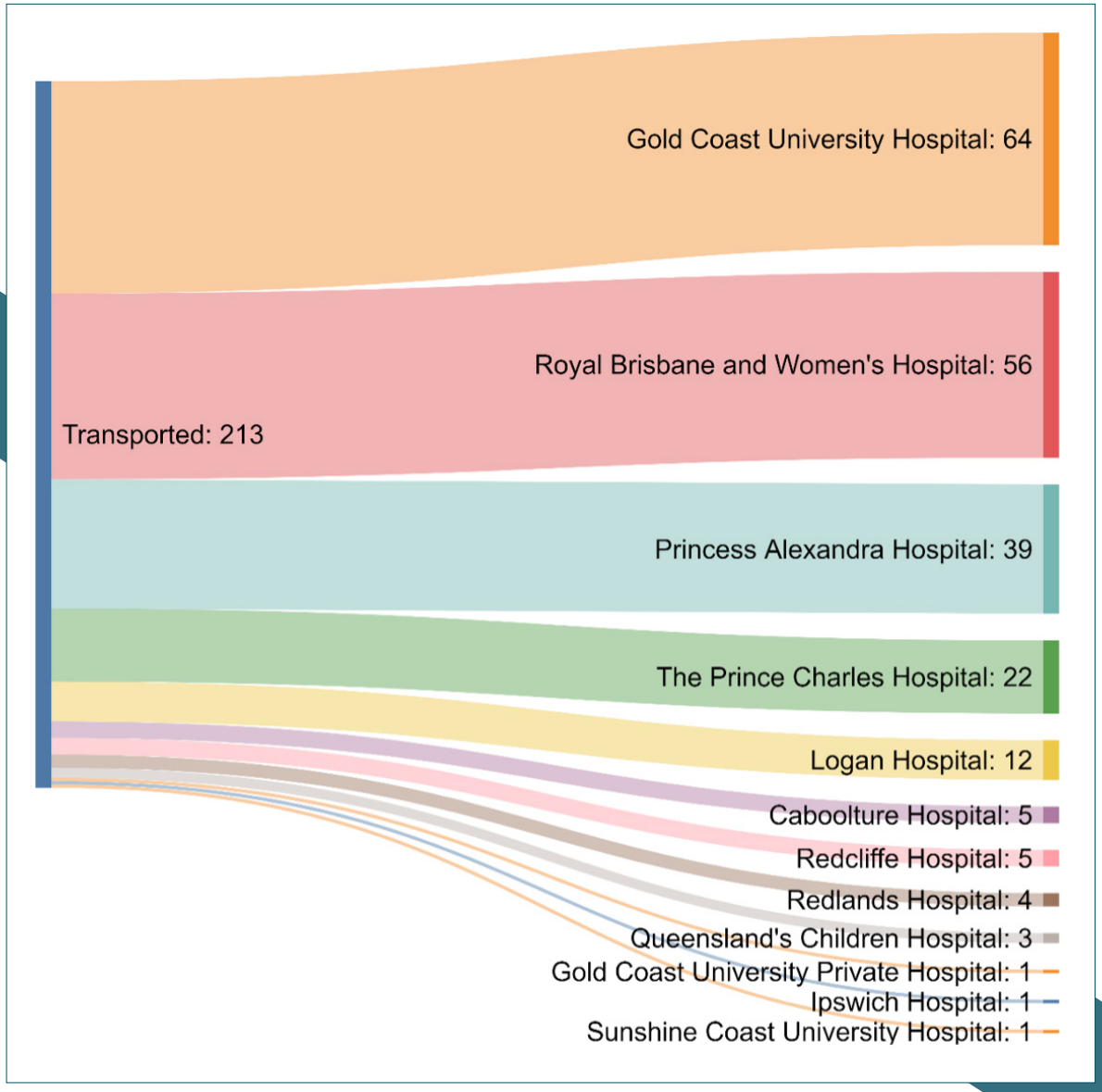



**Figure 7.** Hospital destinations of the transported MCCD cases.

# Suicide-related OHCA

## Background

Suicide is the most common cause of death among young Australians.[1] The rate of deaths by suicide in Australia has increased over the past 14 years, from 10.6 deaths per 100,000 population in 2006 to 12.1 in 2020.[1] While OHCA due to suicide is relatively infrequent compared to presentations relating to underlying medical illness, it is a cause of cardiac arrest affording clear opportunity for prevention.

There is a paucity of evidence regarding the characteristics and outcomes of suicide-related OHCA both in Australia and internationally. While studies by Alqahtani et al.[8] and Deasy et al.[9,10] were conducted in Australia, they were limited specifically to hanging-related OHCA. Lee et al.[11] in Korea is the only OHCA study that included all methods of suicide; however, this study only included patients who received a resuscitation attempt by paramedics and excluded those who were deceased prior to paramedic arrival. A more complete understanding of methods, patient characteristics and survival outcomes of suicide-related OHCA is essential to inform prehospital management strategies and public health interventions.

Our series includes all suicide-related OHCA that were attended by QAS paramedics between 1 January 2007 and 31 December 2020. Method of suicide was captured through manual review of electronic ambulance records. Suicide methods were categorised into the following groups: hanging, physical asphyxia excluding hanging, chemical asphyxia (cardiac arrest induced by exposure to a suspected asphyxiating agent), overdose/poisoning, self-inflicted gunshot wound (GSW), jumping from height, self-harm by sharp object, drowning, traffic collision, electrocution, and other traumas.

## Findings

A total of 7356 suicide-related OHCA cases were included. The overall incidence rates increased from 9.0 cases per 100,000 population in 2007 to 12.4 in 2020 (Figure 8). The incidence rates for males were approximately 4 times those for females (Figure 8); however, incidence rate for males has increased to slower degree than for females (average percent increase per year 2.8% versus 3.7%).

Overall, hanging was the most common suicide method (63.0%), followed by overdose/poisoning (10.7%) and chemical asphyxia (9.1%) (Figure 9). Hanging, overdose/poisoning and jumping from height display an upward trend; whereas chemical asphyxia and self-inflicted GSW appears to be stable over time (Figure 9).

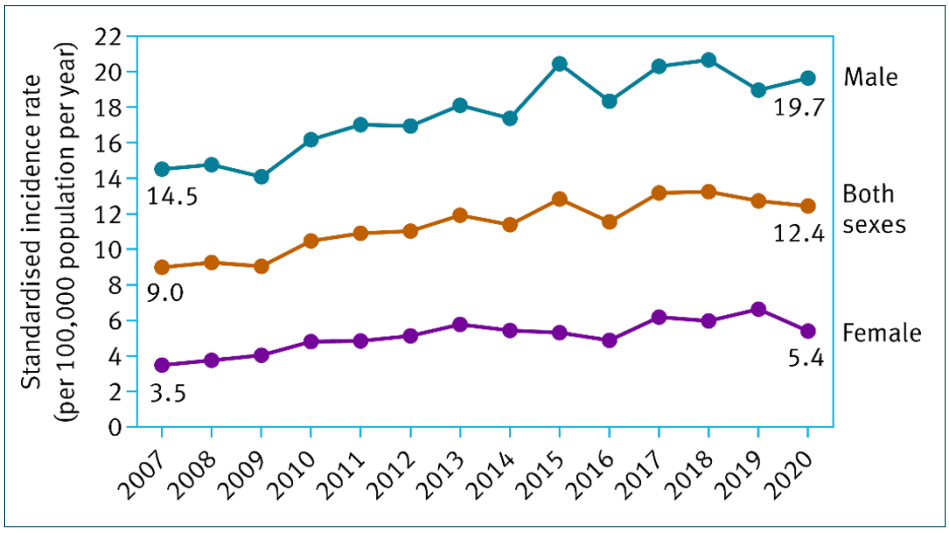



**Figure 8.** Standardised incidence rates of suicided-related OHCA.

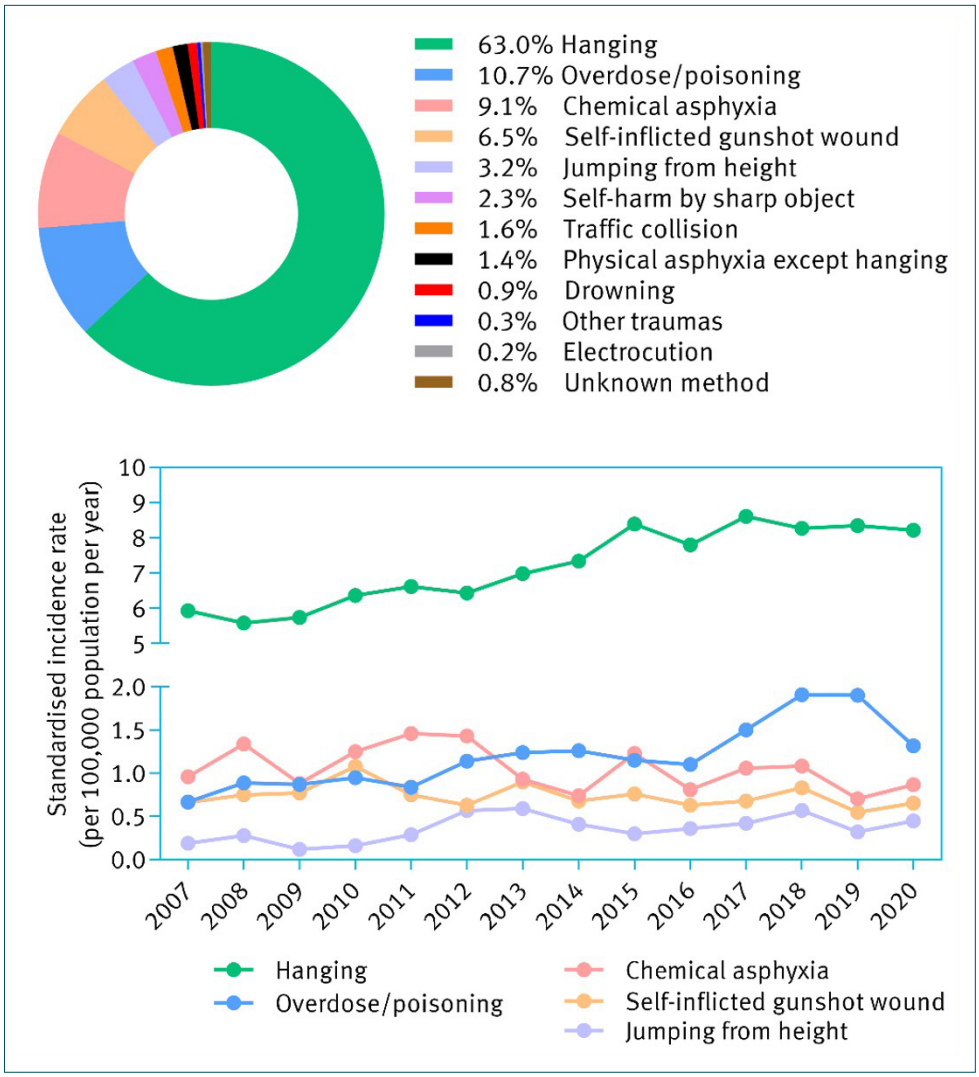



**Figure 9.** Suicide methods (top), and temporal trends of the incidence rates of the five most common methods (bottom).

Figure 10 shows suicide methods by sex and age group. Hanging was the most common method of suicide in both sexes and across all age groups, with notable predominance in the ≤ 17 years age group. The only exception was ≥ 65 year females, with overdose/poisoning being the most common suicide method in this group. Self-inflicted GSW was seen most commonly in ≥ 65 year males compared to other groups.

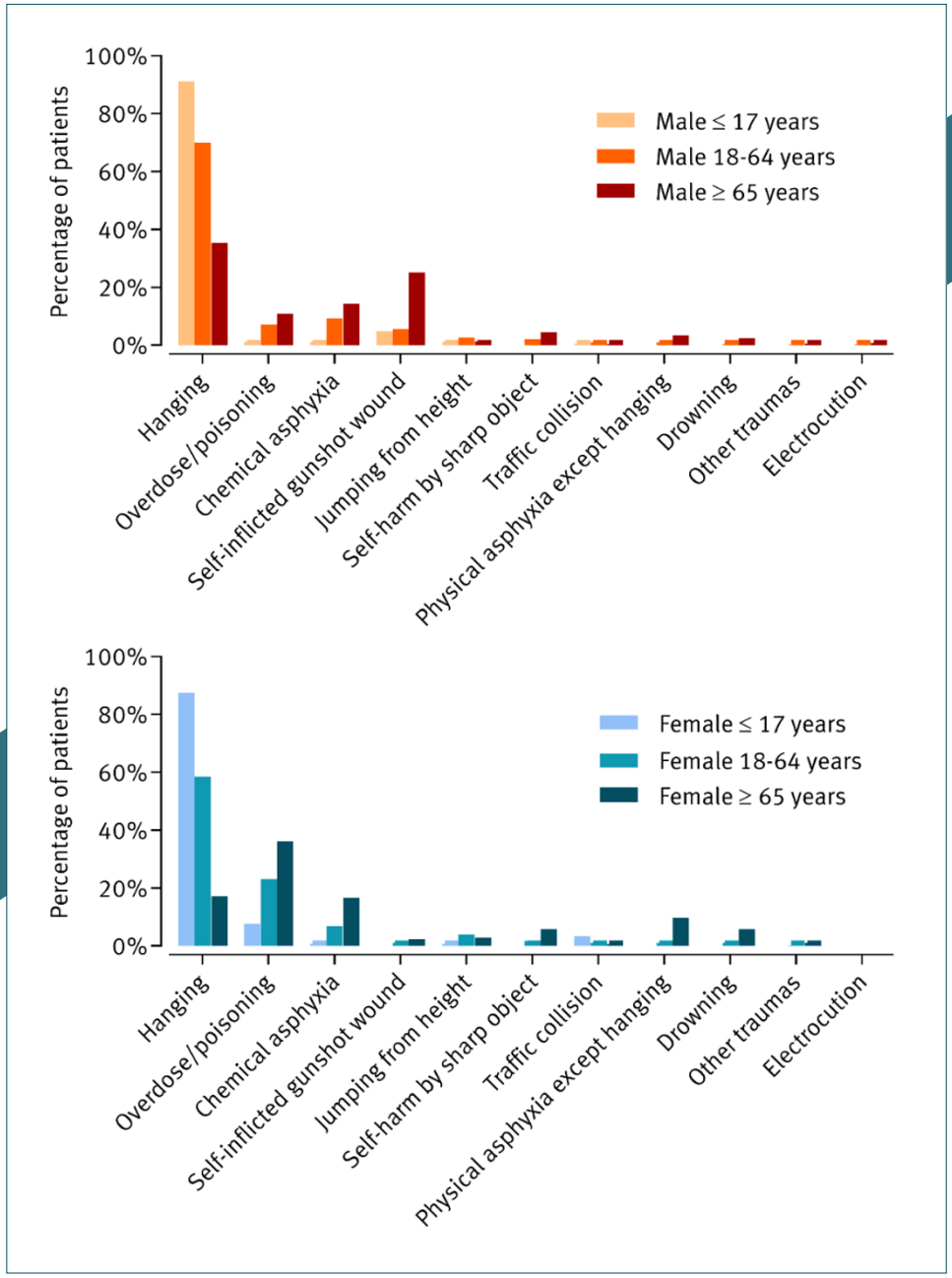
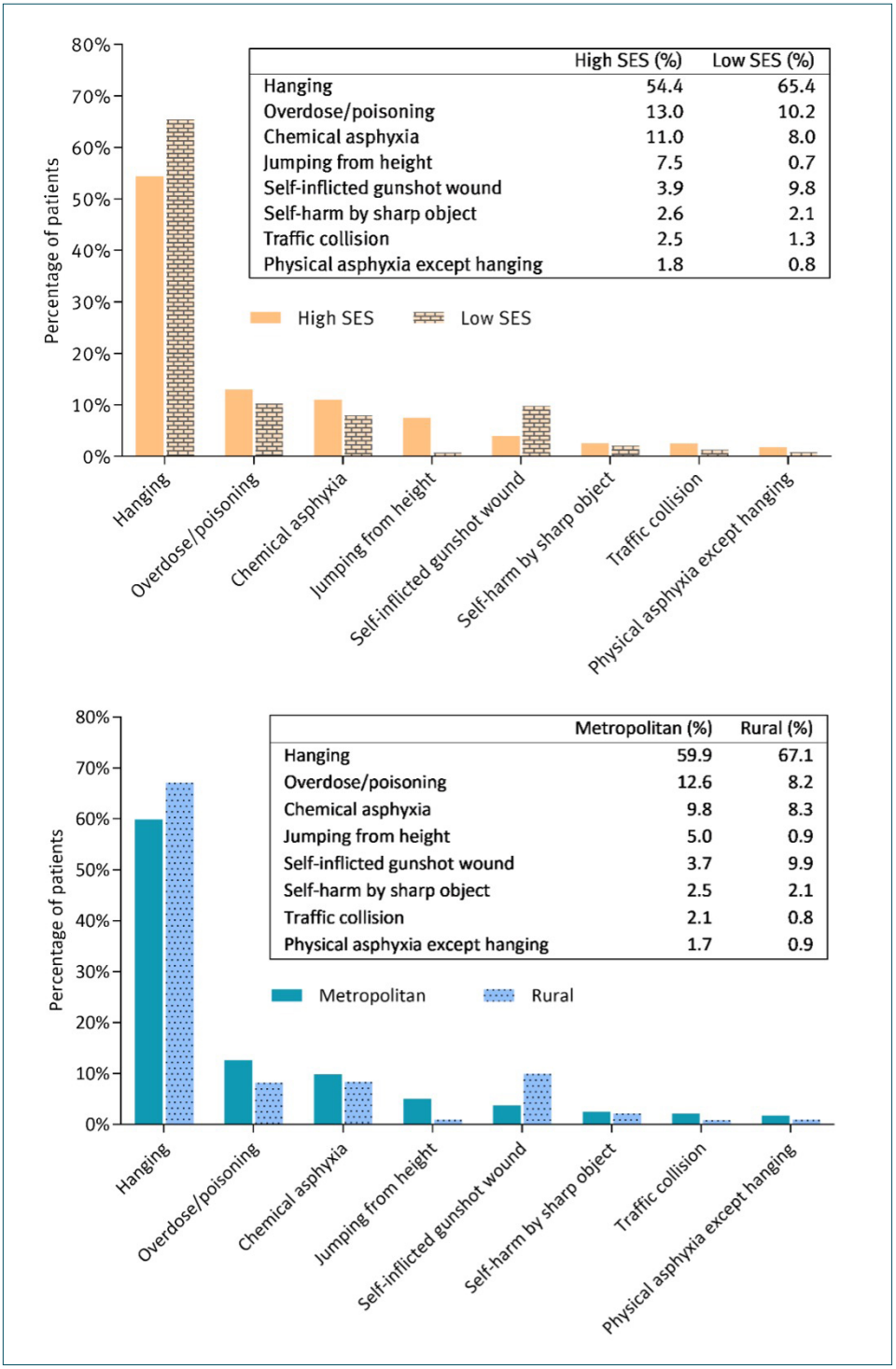



**Figure 10.** Suicide methods by sex and age group.

By socioeconomic status (SES), overdose/poisoning, chemical asphyxia and jumping from height were more common in high SES than low SES areas (Figure 11). Similarly, these suicide methods were more prevalent in metropolitan compared to rural areas (Figure 11). In contrast, hanging was more common in low SES and rural areas (Figure 11). Self-inflicted GSW was most common among ≥ 65 year males in rural areas; whereas overdose/poisoning was most prevalent in ≥ 65 year females in metropolitan (Figure 12).




| | High SES (%) | Low SES (%) |
|---|---|---|
| Hanging | 54.4 | 65.4 |
| Overdose/poisoning | 13.0 | 10.2 |
| Chemical asphyxia | 11.0 | 8.0 |
| Jumping from height | 7.5 | 0.7 |
| Self-inflicted gunshot wound | 3.9 | 9.8 |
| Self-harm by sharp object | 2.6 | 2.1 |
| Traffic collision | 2.5 | 1.3 |
| Physical asphyxia except hanging | 1.8 | 0.8 |

| | Metropolitan (%) | Rural (%) |
|---|---|---|
| Hanging | 59.9 | 67.1 |
| Overdose/poisoning | 12.6 | 8.2 |
| Chemical asphyxia | 9.8 | 8.3 |
| Jumping from height | 5.0 | 0.9 |
| Self-inflicted gunshot wound | 3.7 | 9.9 |
| Self-harm by sharp object | 2.5 | 2.1 |
| Traffic collision | 2.1 | 0.8 |
| Physical asphyxia except hanging | 1.7 | 0.9 |

**Figure 11.** Suicide methods by socioeconomic status and remoteness.

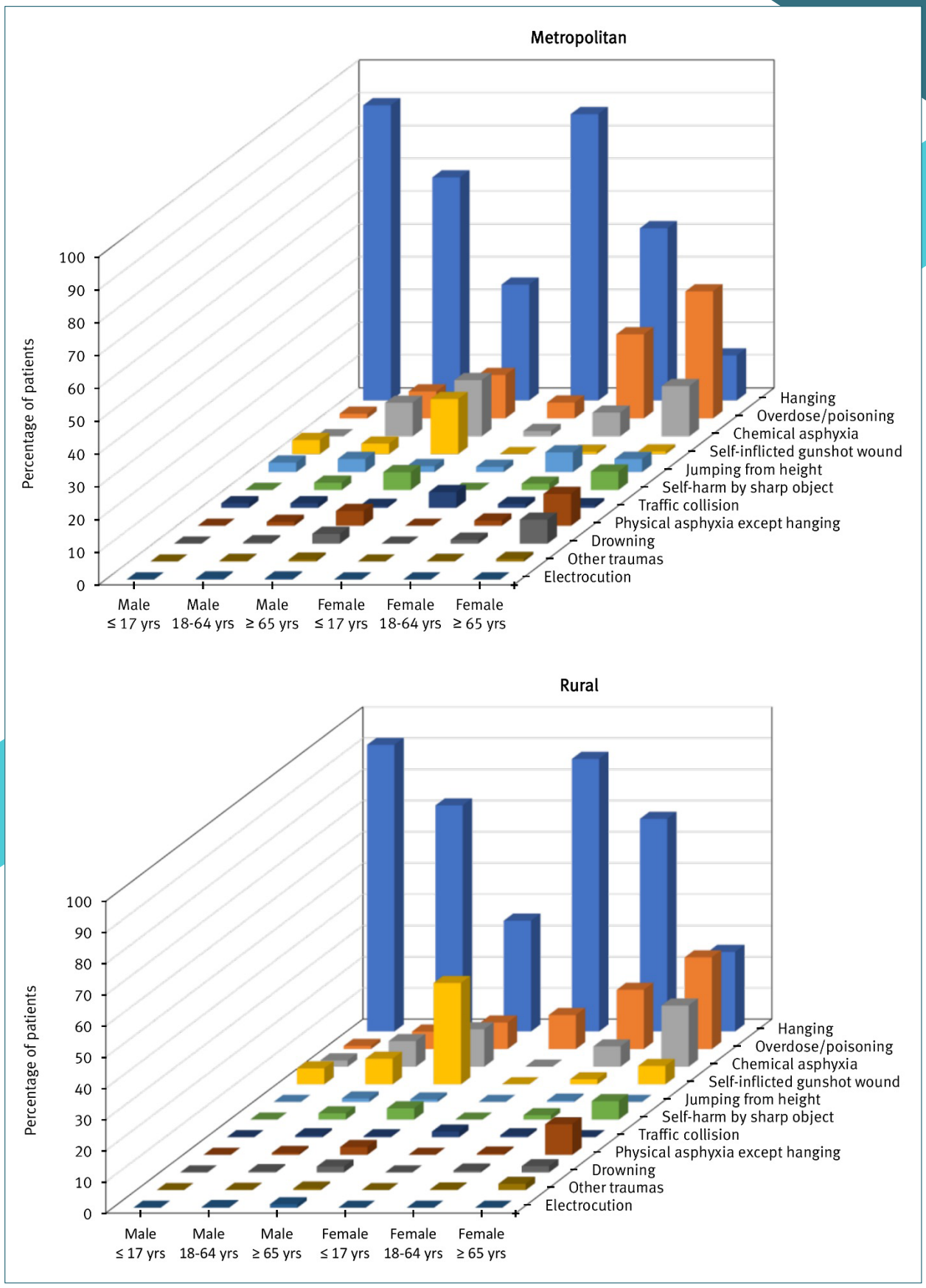



**Figure 12.** Suicide methods by sex, age group and remoteness.

Compared to cardiac arrests of medical aetiologies, suicide-related arrests were younger (median age 41 versus 70 years), more likely to be male (77.1 versus 64.3%), and less likely to receive bystander CPR (21.9 versus 31.8%), have an initial shockable rhythm (0.7 versus 14.0%) or be witnessed (4.2 versus 32.9%) (Figure 13). Suicide-related OHCA was less likely to receive a resuscitation attempt by paramedics than medical OHCA (22.9 versus 45.5%) (Figure 13).

| | Suicide-related | Medical cause |
|---|---|---|
| Male | 77.1% | 64.3% |
| Median age | 41 years | 70 years |
| Initial shockable rhythm | 0.7% | 14.0% |
| Private<br>Public | 78.5%<br>8.3% | 82.9%<br>5.2% |
| Witnessed arrest | 4.2% | 32.9% |
| Bystander CPR | 21.9% | 31.8% |
| Attempted resuscitation | 22.9% | 45.5% |

**Figure 13.** Comparison of characteristics between suicide-related arrest and medical arrest.

Among suicide-related OHCA patients who received a resuscitation attempt by paramedics, the overall rates of event survival, survival to hospital discharge and to 30 days were 28.6%, 8.5% and 8.0%, respectively. Our rate of survival to hospital discharge (8.5%) is higher than that reported by Alqahtani et al.[8] (2.9%) for Victoria and Lee et al.[11] (3.4%) for South Korea.

Over time, the overall rates of survival to hospital increased from 21.6% in 2007 to 29.3% in 2020 (Figure 14). Such increase in event survival did not translate into improved survival to discharge, which remained fairly stable during the study period (Figure 14).

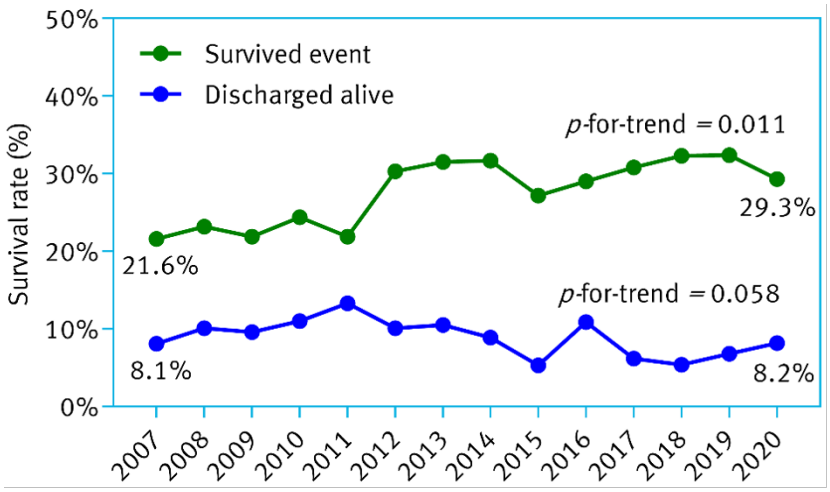



**Figure 14.** Temporal trends of survival outcomes among suicide-related OHCA patients who received a resuscitation attempt from paramedics. The 30-day survival curve almost overlaps with the curve for survival to discharge, and therefore is not shown.

## Implications for prevention strategies

The relatively poor prognosis of suicide once cardiac arrest has occurred highlights the importance of primary prevention efforts. Similar to other developed countries, suicide prevention is a national priority in Australia. Compared to cardiac arrest of medical aetiologies, suicide-related OHCA disproportionately affects the young and working-age adults. As such, social and economic impact of suicide is profound. It is estimated that suicide costs the Australian economy 5.9 billion Australian dollars a year, including loss of productivity, decreased participation in the workforce, increased need for provision of treatment and support services, premature death and disability.[12] As such, suicide prevention strategies would have a positive impact on the patient, their family, and society as a whole.

Most suicide prevention initiatives in Australia have focused on limiting access to means of suicide. Examples include the gun buyback scheme (1996),[13] mandatory installation of catalytic converters in new vehicles (1986),[14] replacing tricyclic antidepressants with less toxic serotonin re-uptake inhibitors for depression treatment (1988),[15,16] reducing paracetamol pack size (2013),[17] real-time prescription monitoring system (2020), restricting access to hazardous chemical products to authorised persons only,[18] and safety measures at common jumping sites.[19,20]

“Means restriction” strategies can reduce suicide from methods such as chemical asphyxia, overdose/poisoning, self-inflicted GSW, and jumping from common sites. However, these methods combined account for only 30% of suicide-related OHCA in Queensland. Hanging is the most common suicide method and is increasing, especially among young people. It poses a challenge to “means restriction” prevention strategies, due to the ubiquity of ligatures and ligation points. This suggests that strategies to prevent suicide need a stronger focus on early identification, continuing support and treatment of individuals at high risk of suicide, such as those at risk of or suffering from acute mental illness.

Given the over-representation of the young in suicide by hanging, there is an urgent need for more prevention programs that are specifically tailored to young people. Social and cultural obstacles to healthy psychological maturation of the young, especially in rural and low SES areas, need to be better understood. Increasing awareness strategies should also be another focus of any suicide prevention program. A randomised control trial from ten European countries showed that a school-based mental health awareness program reduced the incidence of suicide attempts by 55% at 12-month follow-up.[21]

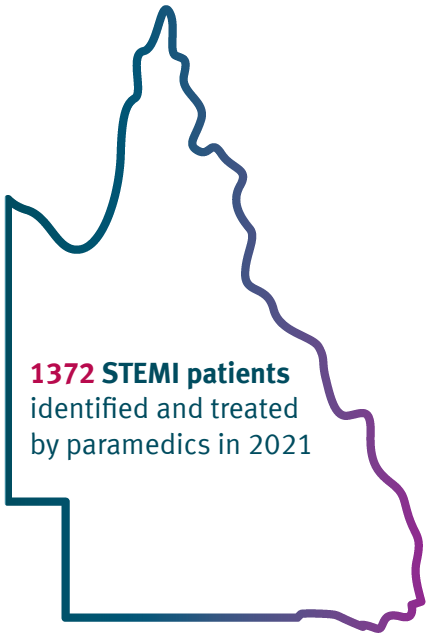
Education programs for primary care that aim to improve the early recognition of mental health issues and risk of suicide can reduce suicide rates.[22] Strengthening mental health services through improved staffing and better availability of outpatient mental health care is another effective measure.[23] In addition to improving the availability of mental health services, barriers to seeking help need to be investigated and addressed.

QAS paramedics respond annually to approximately 60,000 people in the community who experience a mental health crisis.[24] As an ongoing effort to ensure people experiencing a mental health crisis in the community receive the most appropriate and timely access to assessment, treatment and care, the QAS implemented the Mental Health Response Program. The program includes the Mental Health Liaison Service (MHLS) and the Mental Health Co-responder Program (MH CORE). The MHLS involves a senior mental health clinician working in the Brisbane Operations centre to provide information, advice and assistance to call takers and paramedics statewide. This is to support the timely and appropriate dispatch of resources to people in a mental health crisis, in addition to assisting the attending paramedics' clinical decision-making on-scene. The MHLS also provides direct clinical support to patients experiencing a mental health crisis via telemedicine. The MH CORE pairs a senior mental health clinician with a paramedic to respond to emergency calls. The MH CORE provides timely and thorough physical health, mental state, and risk assessment for patients in their own home to identify the most appropriate treatment plans for the patient. The program also facilitates access to appropriate follow-up and referrals.

While the majority of suicide-related OHCA in our study were males, incidence rates were increasing at a faster rate among females, consistent with previous reports.[25,26] Differential increases over time in risk factors for suicide among females compared to males may in part explain this trend.[25] For example, a survey in the United States revealed a significant increase in the number of female youth who experienced persistent feelings of sadness between 2007 and 2017, with no significant changes in male youth.[27] Our findings, including the increased rates of firearm related suicides in older males and overdose/poisoning related suicides in older females, underscore the importance of prevention efforts that focus on both sexes.

# PREHOSPITAL ST-SEGMENT ELEVATION MYOCARDIAL INFARCTION (STEMI)

# Key STEMI facts at a glance



**1372 STEMI patients**
identified and treated
by paramedics in 2021


Median time from scene arrival to first 12-lead ECG, for both metropolitan and rural areas


Patients had first 12-lead ECG performed within 10 minutes of scene arrival

**97.4%**
30-day survival rate in patients receiving prehospital fibrinolysis

**97.4%**
30-day survival rate in direct PCI referral patients

**Prehospital cost** accounts for **3%** of total cost of acute treatment for STEMI

Compared to no prehospital reperfusion therapy:
› Direct PCI referral is cheaper and has better outcomes
› Prehospital fibrinolysis has similar cost and better outcomes

# Epidemiology and survival outcomes

In 2021, paramedics identified and treated 1372 STEMI cases. The majority of patients were males (71.4%), being on average 8 years younger than females (Figure 15).

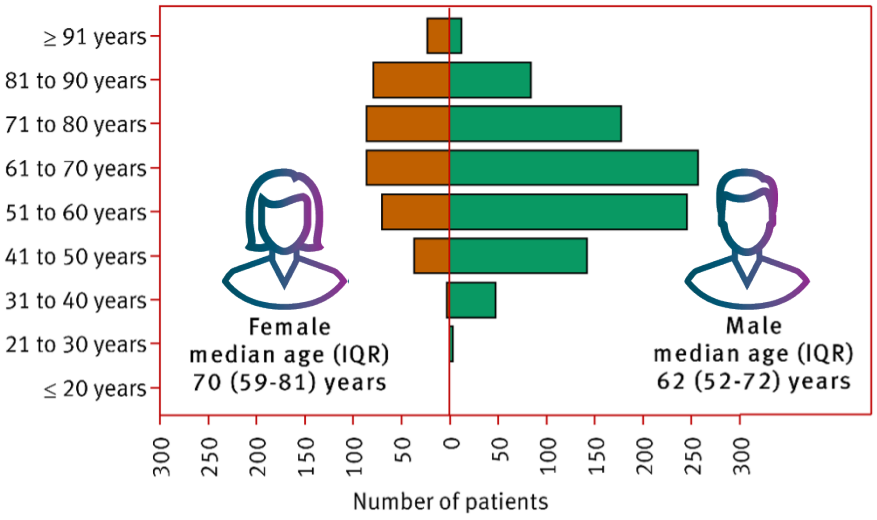



**Figure 15.** Age distribution of STEMI patients, males versus females.

The median time from first medical contact, defined as first paramedic arrival at scene, to performance of first 12-lead electrocardiogram (ECG) was 6 minutes for both metropolitan and rural areas (Figure 16). The percentages of patients in metropolitan and rural areas who had their first 12-lead ECGs performed within 10 minutes of first medical contact were 80% and 79%, respectively (Figure 16).

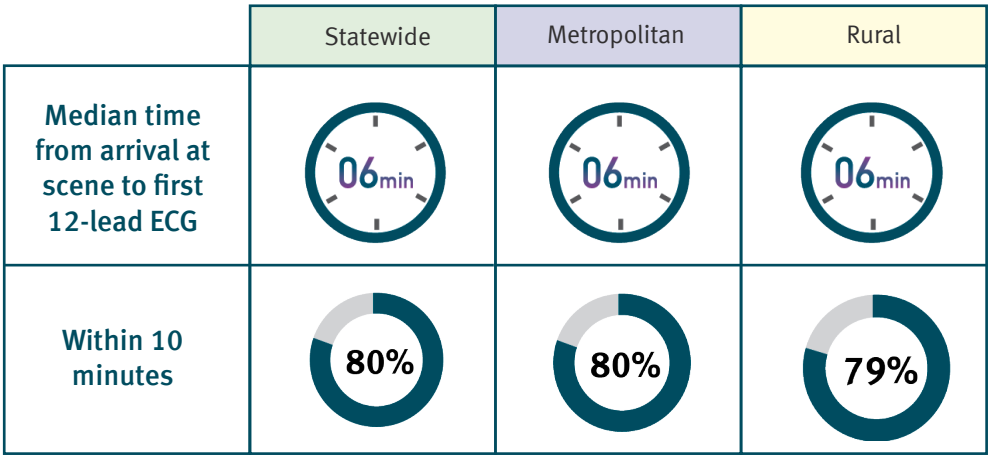



**Figure 16.** Time from first paramedic arrival at scene to first 12-lead ECG.

Statewide, 52.9% of patients received direct PCI referral, 11.2% prehospital fibrinolysis, with 35.9% not receiving either reperfusion pathway (Figure 17). The proportion of patients who received direct PCI referral in metropolitan areas has remained fairly stable over the last few years (Figure 17). In contrast, the proportion of direct PCI patients in rural areas increased markedly, from 24.6% in 2018 to 34.5% in 2021 (Figure 17).

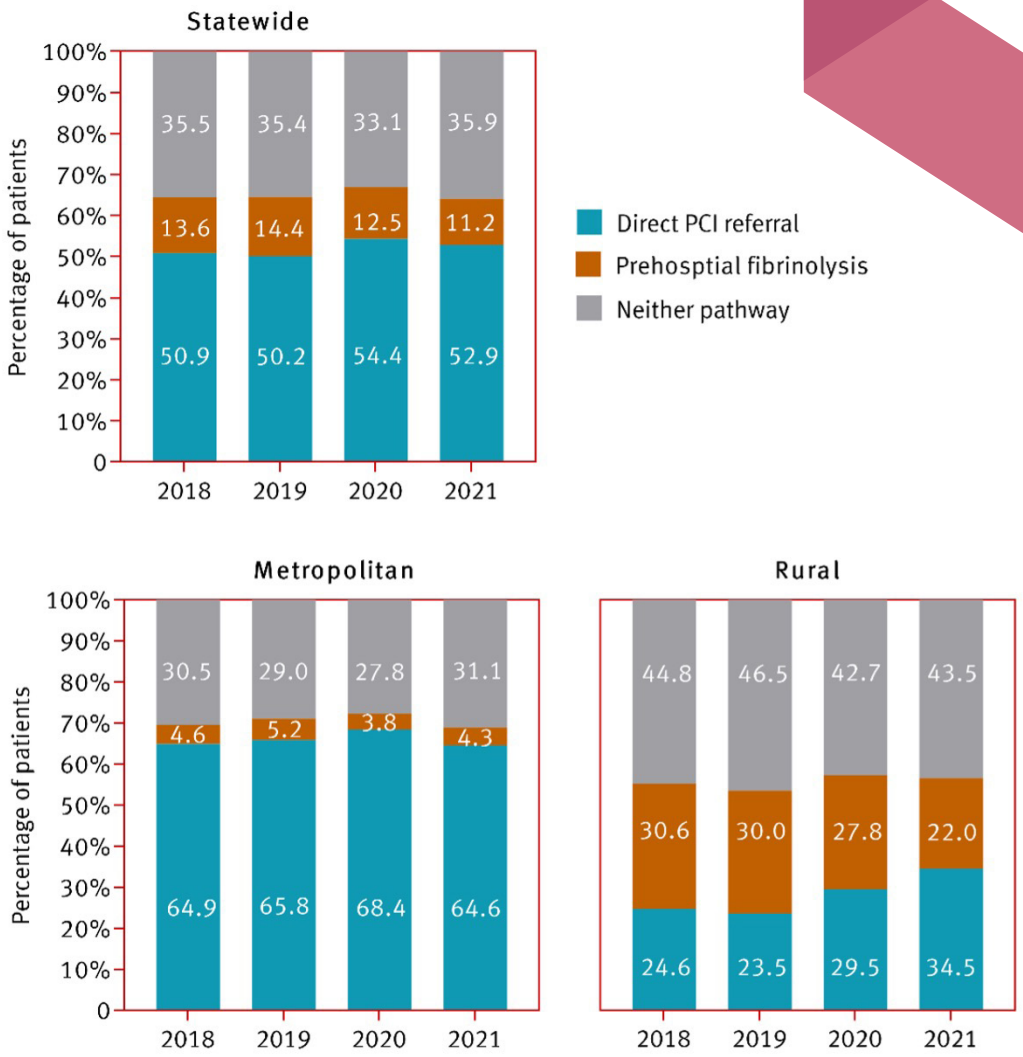



**Figure 17.** Prehospital reperfusion pathways.

Patients not receiving either reperfusion pathway predominantly occurs due to medical contraindications within the QAS reperfusion guidelines precluding paramedic initiated treatment or the patient being in close proximity to the hospital. These patients were still identified for prenotification to the receiving facility to ensure rapid assessment and treatment upon arrival. For both metropolitan and rural areas the most common contraindication to prehospital reperfusion therapy was the patient being either pain free or experiencing atypical chest pain (19.2% of the recorded contraindications for metropolitan, and 15.3% for rural areas) (Figure 18). An altered level of consciousness (Glasgow Coma Scale ‹ 15) was the second most common contraindication in patients in metropolitan areas (14.9% of the recorded contraindications); whereas patient age being older than 75 years was the second most common contraindication in rural areas (12.3% of the recorded contraindications) (Figure 18). Close proximity to a healthcare facility as a reason for not initiating a prehospital reperfusion pathway was more common in rural than metropolitan areas (Figure 18).

The 30-day all-cause mortality rate for the entire cohort was 8.0%. Direct PCI referral patients and prehospital fibrinolysis patients had the same 30-day mortality rate (2.6% for each group). The corresponding figure for patients who did not receive either reperfusion pathway was 17.7%.

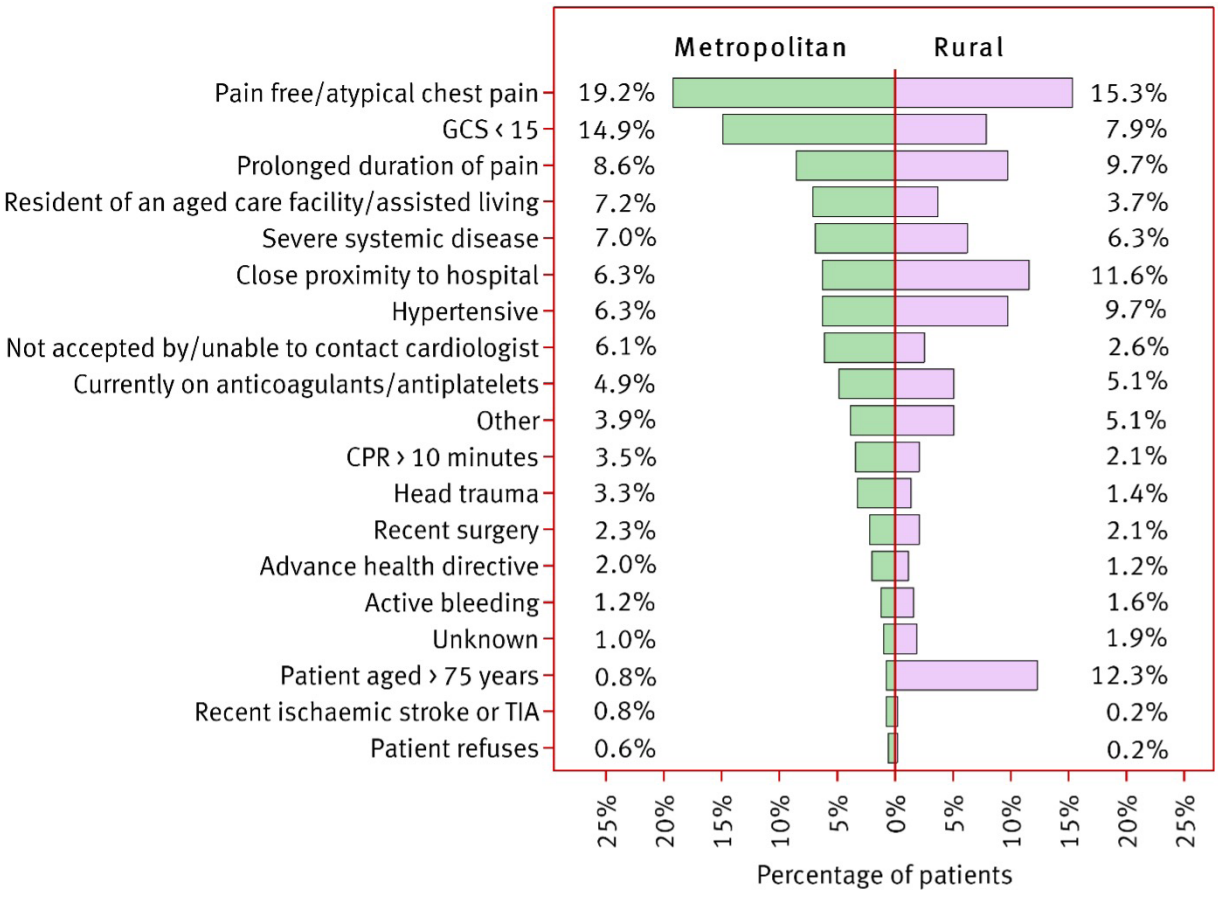



**Figure 18.** Contraindications to prehospital reperfusion therapy within the QAS reperfusion guidelines. A patient could have more than one contraindication.


# Prehospital activation of STEMI aeromedical retrieval

Having a vast landmass and decentralised population, Queensland is faced with unique challenges in the management of prehospital STEMI. The state's large rural population usually means reduced access to specialist cardiac services and increased delays for retrieval services. The management of prehospital STEMI in non-urban settings within Queensland is a challenging area of practice requiring an efficient system-wide approach to health service delivery.

Within the QAS reperfusion guidelines, prehospital STEMI patients located more than 60 minutes transport time from STEMI identification to a PCI-capable hospital will be administered prehospital fibrinolysis with tenecteplase, when clinically appropriate. The National Heart Foundation of Australia and Cardiac Society of Australia and New Zealand,[28] and the Queensland Statewide Cardiac Clinical Network[29] recommend that prehospital STEMI patients who have received fibrinolysis in the field should be transferred emergently to a PCI-capable hospital. Under the QAS prehospital fibrinolysis pathway, prehospital administration of tenecteplase is followed by rapid transport to a PCI-capable hospital within road-based traveling distance, otherwise to the closest community hospital with subsequent transfer to a PCI-capable hospital, if clinically necessary. For inter-hospital transfer, an aircraft (rotary wing or fixed wing) is normally used, weather permitting. When weather conditions are not suitable for flying, or when an aircraft is not available, an ambulance is used to transfer patients by road.

To minimise delays in inter-hospital transfer of prehospital STEMI patients to a PCI-capable hospital, the QAS implemented the Pre-Hospital Activation of STEMI for Retrieval (PHASTER) protocol in 2019, incorporating the direct notification of Retrieval Services Queensland (RSQ) about STEMI patients after fibrinolysis has been administered by paramedics. Historically, notification of RSQ was performed by the initial receiving hospital. Under the PHASTER protocol, RSQ receives early notification of paramedic-identified STEMI patients by the QAS Clinical Consultation and Advice Line senior clinician before patient arrival at the initial receiving hospital. Figure 19 shows flow and communication for prehospital fibrinolysis patients under the PHASTER protocol.

Prehospital STEMI identified by paramedics ▶

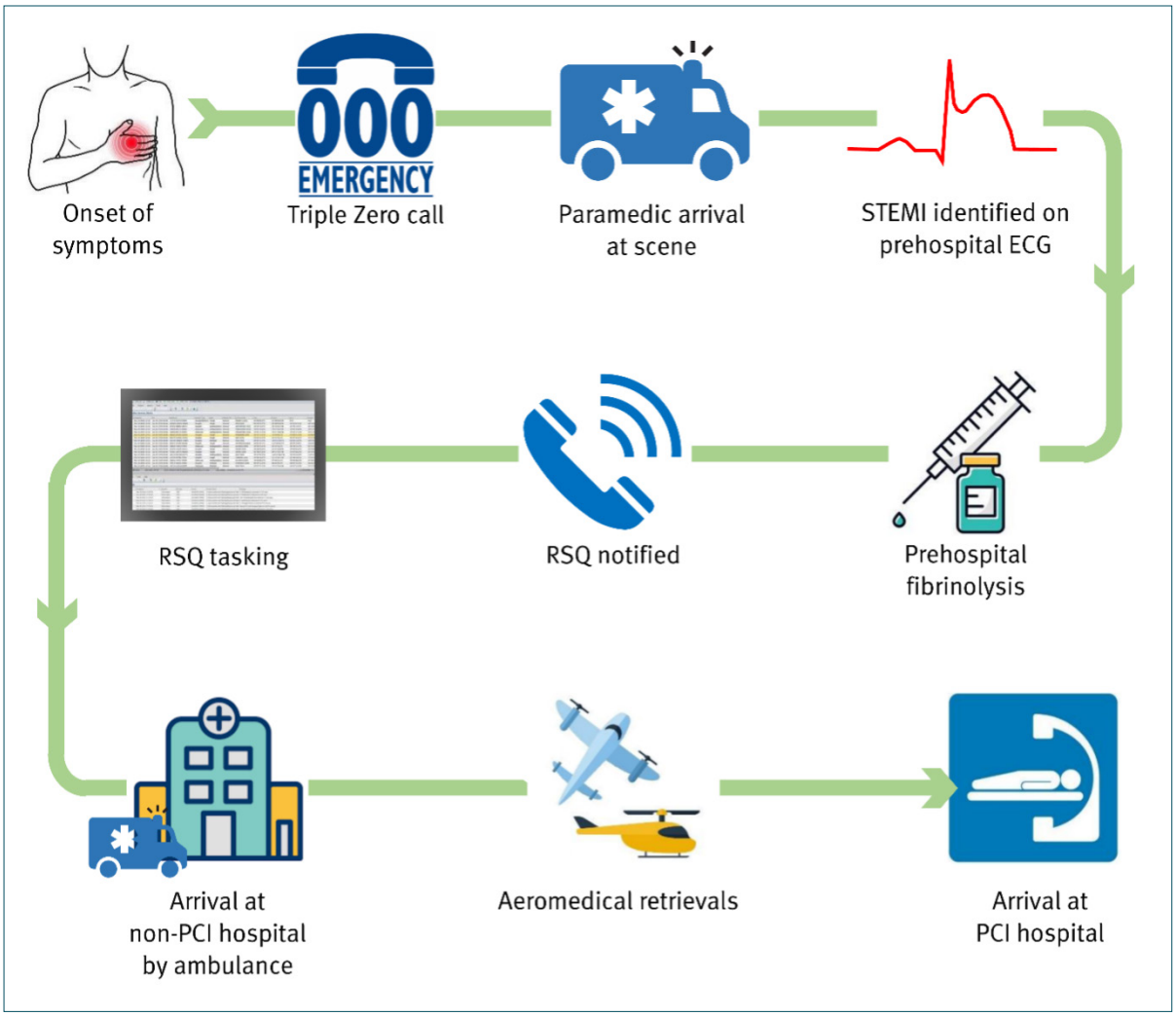



**Figure 19.** Flow and communication for prehospital fibrinolysis STEMI patients under the PHASTER protocol.

In 2021, QAS paramedics administered prehospital fibrinolysis to 154 patients. Of those, 80 (51.9%) were transported directly to a PCI-capable hospital immediately following tenecteplase administration in the field (Figure 20). The remainder (74/154) were transported to a regional non-PCI hospital with subsequent transfer to a PCI-hospital, with one exception where the patient was not transferred (Figure 20). Aeromedical retrieval was the primary mode of inter-hospital transfer (57/73, 78.0%) (Figure 20). Figure 21 shows the incident locations of the prehospital fibrinolysis STEMI cases who were initially transported to a regional hospital with subsequent transfer to a public PCI-capable hospital.

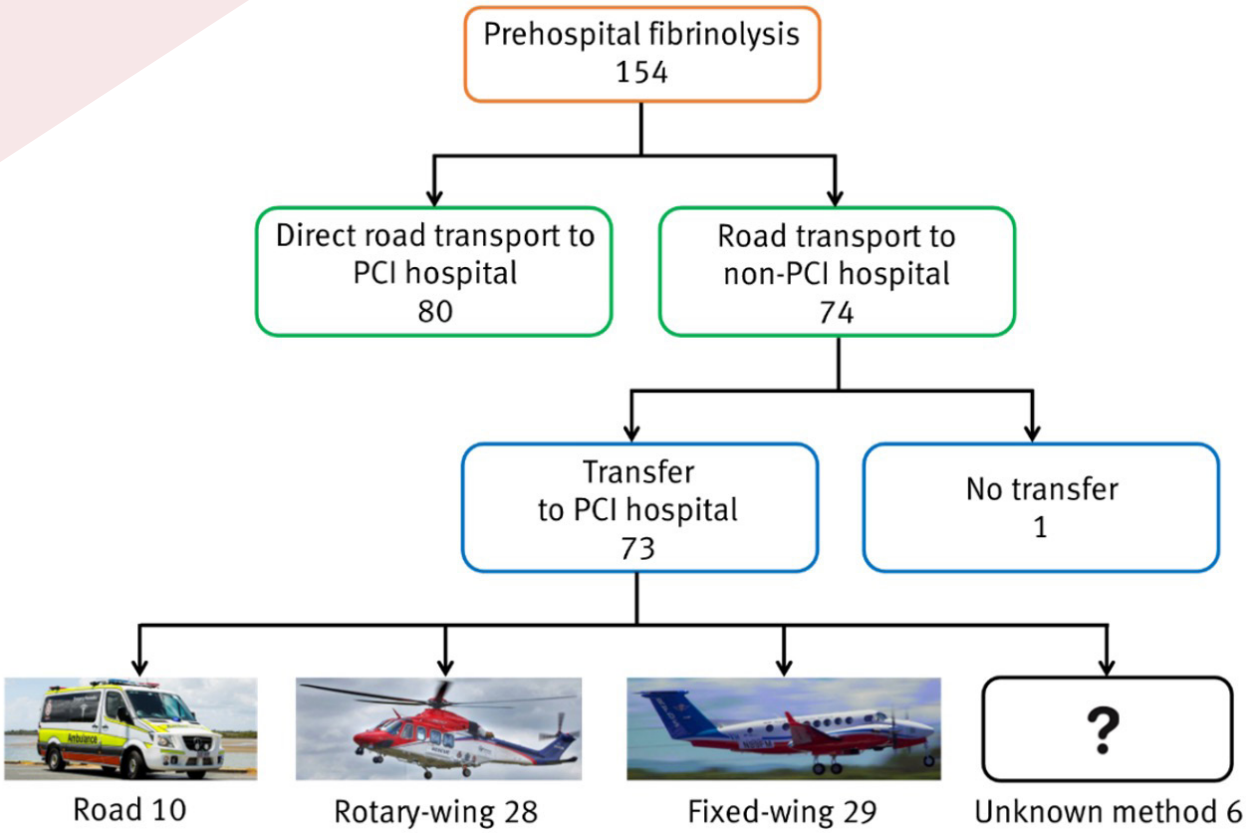



**Figure 20.** Methods of transport and inter-hospital transfer of prehospital fibrinolysis patients.

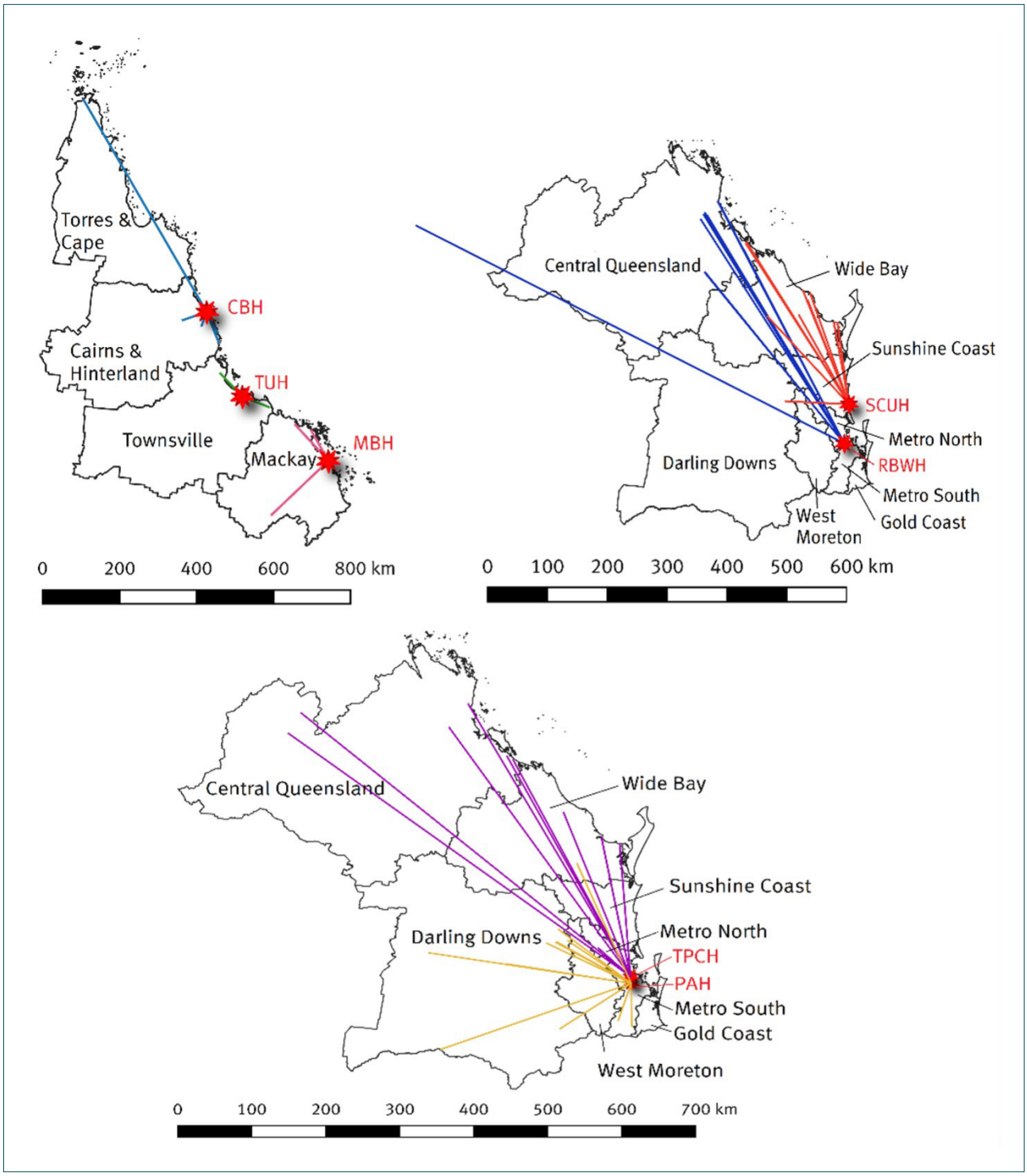



**Figure 21.** Incident locations of the prehospital fibrinolysis STEMI cases who were initially transported to a regional hospital with subsequent transfer to a public PCI-capable hospital.

# Prehospital fibrinolysis in elderly STEMI patients

People aged 75 years or above (hereafter referred to as elderly) generally experience a rapid rise in cardiovascular morbidity and mortality.[30] Elderly patients constitute an increasing percentage of STEMI patients. In fact, the percentage of elderly STEMI patients that QAS paramedics treated has increased from 18.8% in 2010 to 25.1% in 2021 (Figure 22). Elderly STEMI patients tend to present later and with atypical symptoms, generally have more comorbidities and a higher angiographic risk profile compared to younger patients.[31] These factors complicate STEMI treatment in the elderly.

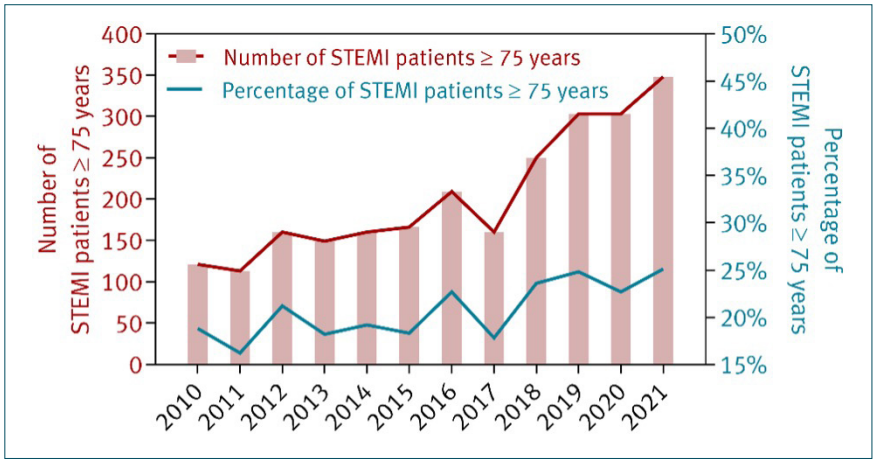



**Figure 22.** Number and percentage of paramedic-identified STEMI patients aged ≥ 75 years.

Current STEMI guidelines recommend primary PCI as the preferred reperfusion method irrespective of age, provided that it can be performed in a timely fashion.[32,33] Fibrinolytic therapy is a life-saving alternative when timely PCI is not feasible.[32,33] Despite decades of research and experience, fibrinolytic therapy in the elderly remains a contentious issue. Limited evidence from observational studies and underpowered trials suggests that the mortality benefit associated with fibrinolytic therapy is preserved in the elderly.[30,34,35] Furthermore, there is no mechanistic reason why fibrinolysis is not effective in older patients.[30] Nevertheless, the benefit of fibrinolysis needs to be balanced against the higher risk of stroke and intracerebral haemorrhage (ICH), as well as non-ICH bleeding complications associated with fibrinolysis use in the elderly. Dose reduction of fibrinolytic agents is likely necessary in elderly patients. Reduced cardiovascular reserve and pharmacokinetic/pharmacodynamic alterations due to advanced age provide the rationale for dose reduction of fibrinolytic agents. The landmark STREAM trial has found that half-dose tenecteplase reduces the likelihood of ICH without compromising reperfusion efficacy, albeit small sample size.[35]

Within the QAS reperfusion guidelines, prehospital fibrinolysis with tenecteplase is contraindicated for autonomous administration to patients aged ≥ 75 years. For those patients who appear to be relatively healthy without significant comorbidities, the attending paramedics are required to contact the QAS Clinical Consultation and Advice Line for approval of tenecteplase administration by a QAS senior medical officer. The below analysis describes the characteristics and outcomes of STEMI patients aged ≥ 75 years who were administered prehospital fibrinolysis by QAS paramedics between 1 January 2010 to 31 December 2021. Comparisons were made with ≥ 75 year patients who did not receive prehospital fibrinolysis due to age being the sole reason as recorded in ambulance medical records during the same time period. Table 2 shows that age is the only characteristic that has a statistically significant difference between the two groups, with fibrinolysis patients being younger than those who did not receive the therapy (median 77 versus 81 years). A higher percentage of fibrinolysis patients were transported directly to a PCI-capable hospital (47.6 versus 20.9%). Fibrinolysis patients had numerically lower 30-day mortality than those without prehospital fibrinolysis; however, the difference was not statistically significant (Table 2).

**Table 2.** Characteristics and outcomes of elderly STEMI patients who received prehospital fibrinolysis versus who did not solely due to age

| Variable | With prehospital fibrinolysis | Without prehospital fibrinolysis solely due to age | *p* |
|---|---|---|---|
| Number of patients | 63 | 67 | |
| Age, median (IQR) years | 77 (75-79) | 81 (78-86) | **< 0.001** |
| Male | 40 (63.5%) | 41 (61.2%) | 0.857 |
| Tenecteplase dosage, mean (SD) mg | 33 (10) | | |
| Distance to nearest public PCI-capable hospital, median (IQR) km | 133 (35 - 290) | 128 (24 - 296) | 0.880 |
| Rural | 48 (78.7%) | 56 (83.6%) | 0.505 |
| Time from Symptom onset to STEMI identification, median (IQR) minutes | 56.5 (37-84) | 69.5 (35-116) | 0.331 |
| Direct transport to a PCI-capable hospital | 30 (47.6%) | 14 (20.9%) | **0.002** |
| LOS for acute treatment, median (IQR) days | 5.5 (3.2 - 10.1) | 4.5 (2.8 - 10.7) | 0.390 |
| 30-day mortality | 6 (9.5%) | 9 (13.4%) | 0.587 |


Queensland Ambulance Service

# Costs of acute treatment for prehospital STEMI

## Background

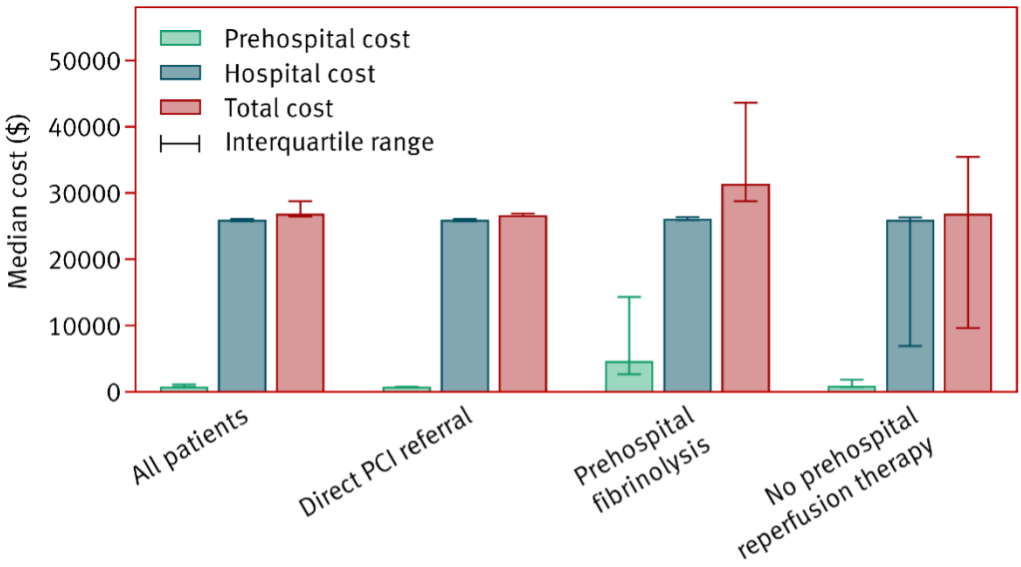
STEMI poses a substantial economic burden to the patient and society as a whole. While a limited number of studies have investigated the economic burden of STEMI, those studies included only hospital-diagnosed STEMI treated with primary PCI.[36-38] To date, data on the prehospital costs of STEMI treatment are lacking, as are studies that include all STEMI patients regardless of reperfusion method.

This analysis examined the prehospital and hospital costs of acute treatment for adult STEMI patients (≥ 18 years of age), who were identified and treated in the field by paramedics before rapid transport to hospital for definitive care, between 1 January 2016 and 31 December 2019. Costs of ambulance, aeromedical retrievals, emergency department, and acute hospitalisation were estimated. Costs were calculated from an Australian public health perspective, and expressed in Australian dollars ($), 2020 value.

Ambulance costs were obtained from the QAS Product Costing Model which provides region-specific cost of delivering ambulance service per emergency incident including STEMI. Total aeromedical retrieval costs for each patient were derived based on aircraft engine hours and engine hourly rates provided by RSQ. These costs already include cost of pilot, flight nurse, flight medical officer and flight paramedic, where applicable. Emergency department costs and hospitalisation costs were calculated using patient's Urgency Related Groups (URG) code (for emergency department) and Australian Refined Diagnosis Related Groups (AR-DRG) code (for hospitalisation) and the corresponding unit cost for each URG and AR-DRG code obtained from Queensland Health Funding Policy and Principles (QHFPP). In broad terms, QHFPP determines the price at which Queensland Government purchases services from hospitals. It specifies a price (unit cost) for each URG and AR-DRG code. These unit costs reflect full hospital costs, including labour, drug, overhead and capital costs.

## Findings

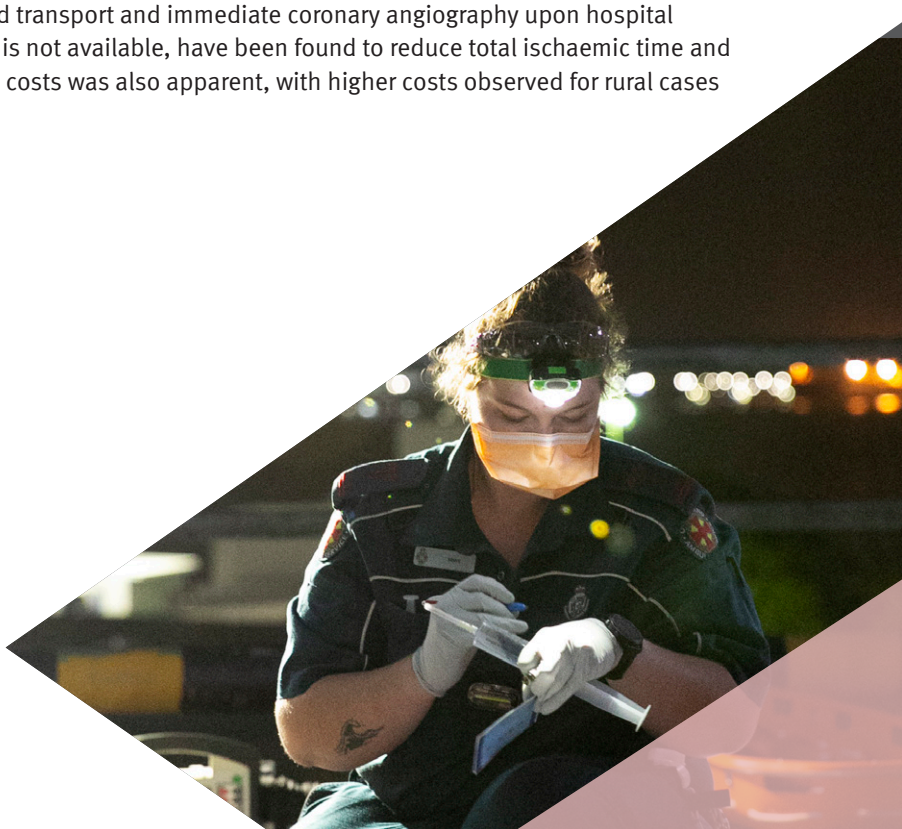
Figure 23 presents the breakdown of treatment costs for the total cohort and by prehospital reperfusion pathway. For the entire cohort, total median costs amounted to $26,837. Hospital costs (median $25,915, including emergency department and hospitalisation costs) accounted for 96.6% of total costs; whereas prehospital costs (ambulance and aeromedical retrieval, where applicable) were a median $785. Direct PCI referral patients incurred the lowest total costs (median $26,675), prehospital fibrinolysis patients the highest (median $31,341), and patients who did not receive a form of prehospital reperfusion therapy had a median total cost of $26,836. Relative to no prehospital reperfusion therapy, direct PCI referral was cheaper and had better survival outcomes; whereas prehospital fibrinolysis had marginally higher cost and better outcomes at $26,257 per life year gained.




| | Prehospital cost | Hospital cost | Total cost |
|---|---|---|---|
| All patients | 785 | 25915 | 26837 |
| Direct PCI referral | 775 | 25915 | 26675 |
| Prehospital fibrinolysis | 4675 | 26117 | 31341 |
| No prehospital reperfusion therapy | 896 | 25915 | 26836 |

**Figure 23.** Comparison of median costs by prehospital reperfusion pathway.

Patient characteristics that were associated with costs included age, incident location (metropolitan or rural), body mass index, in-hospital complications (cardiogenic shock, acute kidney disease), intensive care unit (ICU) treatment, length of stay (LOS), number of stents used, discharge status, and cardiac history (Figure 24). Of these, ICU treatment had the highest additional cost ($116,566 compared to no ICU treatment). Compared to patients who stayed in hospital for 2 days or shorter, those who required 3-4 inpatient days incurred an additional cost of $23,888. Given that hospital costs are the greatest contributor to the acute treatment of STEMI, and ICU treatment is resource-intensive, strategies that focus on early identification and treatment of STEMI to reduce myocardium damage, and consequently reduce the need for ICU and extended hospital admissions, are advocated. Timely identification and treatment of STEMI by paramedics in the field, followed by rapid transport and immediate coronary angiography upon hospital arrival, or prehospital fibrinolysis where direct PCI is not available, have been found to reduce total ischaemic time and improve survival outcomes.[39] Regional variation in costs was also apparent, with higher costs observed for rural cases (additional $14,097 relative to metropolitan).



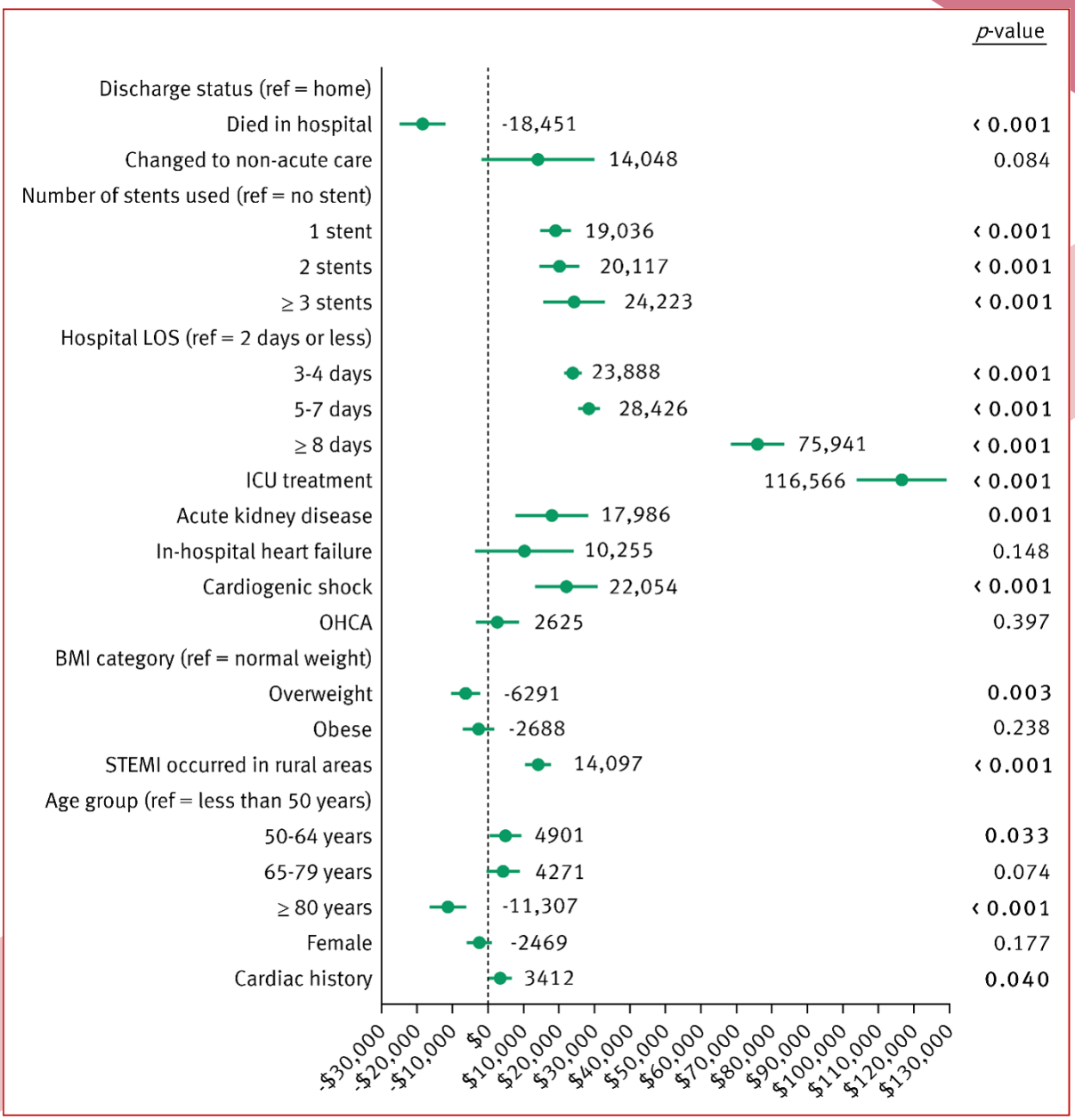



**Figure 24.** Effect of patient characteristics on cost. Positive/negative values mean more/less cost relative to the reference group. Bold *p* values indicate statistically significant ($p < 0.05$).

# Conclusions

This report demonstrates the outstanding quality of prehospital care that QAS paramedics deliver to OHCA patients across a vast and diverse geographic region. Our survival rates are among the best in Australia and internationally. The implementation of innovative technology, such as MCCD, is yet another example of the QAS commitment to continuous improvement in patient care. This report addresses a gap in knowledge about the epidemiology and outcomes of suicide-related OHCA. Such evidence-based information is essential to inform prehospital management strategies and public health interventions. The relatively poor prognosis of suicide once cardiac arrest has occurred highlights the importance of primary prevention efforts. Strategies to prevent suicide need a stronger focus on early identification, continuing support and treatment of individuals at high risk of suicide, such as those at risk of or suffering from acute mental illness.

Highly skilled QAS paramedics continue to provide high standard prehospital treatment to STEMI patients. Mortality in STEMI patients treated by QAS paramedics is very low, demonstrating the effectiveness of our system-wide approach to clinical management that integrates prehospital care into the STEMI treatment cascade. Timely transfer of STEMI in rural areas to specialist cardiac services is another example of the importance of our system-wide approach. Implementation of the PHASTER protocol for early prehospital notification to RSQ about STEMI patients immediately following prehospital fibrinolysis will help minimise delays in inter-hospital transfer and improve outcomes. This is another demonstration of the system working together to provide excellent, coordinated care to the benefit of our patients. This report is the first to investigate the upfront treatment costs of paramedic-identified STEMI patients, incorporating both prehospital and hospital cost components. It establishes that operation of an advanced prehospital reperfusion strategy comes at low cost (compared to hospital costs), whilst delivering high quality patient outcomes.

The case of Jaime Estrella described in this report is a demonstration of what the service achieves on a daily basis in delivering the complex but high-quality care, positively impacting the health and lives of patients, their families and the community.


# Glossary

| | |
|---|---|
| AR-DRG | Australian Refined Diagnosis Related Groups |
| BMI | Body Mass Index |
| CARES | Cardiac Arrest Registry to Enhance Survival |
| CBH | Cairns Base Hospital |
| CCP | Critical Care Paramedic |
| CPR | Cardiopulmonary Resuscitation |
| DNR | Do Not Resuscitate |
| ECG | Electrocardiogram |
| ECMO | Extracorporeal Membrane Oxygenation |
| GCS | Glasgow Coma Scale |
| GCUH | Gold Coast University Hospital |
| GSW | Gunshot wound |
| ICH | Intracerebral Haemorrhage |
| ICU | Intensive Care Unit |
| IQR | Interquartile Range |
| LOS | Length of Stay |
| MBH | Mackay Base Hospital |
| MCCD | Mechanical Chest Compression Device |
| MH CORE | Mental Health Co-responder Program |
| MHLS | Mental Health Liaison Service |
| OHCA | Out-of-Hospital Cardiac Arrest |
| OHCAR | Irish Out-of-Hospital Cardiac Arrest Register |
| PAH | Princess Alexandra Hospital |
| PCI | Percutaneous Coronary Intervention |
| PEA | Pulseless Electrical Activity |
| PHASTER | Pre-Hospital Activation of STEMI for Retrieval |
| QAS | Queensland Ambulance Service |
| QHFPP | Queensland Health Funding Policy and Principles |
| RBWH | Royal Brisbane and Women's Hospital |
| Ref | Reference |
| ROSC | Return of Spontaneous Circulation |
| RSQ | Retrieval Services Queensland |
| SCUH | Sunshine Coast University Hospital |
| SD | Standard Deviation |
| SES | Socioeconomic Status |
| SIDS | Sudden Infant Death Syndrome |
| STEMI | ST-segment Elevation Myocardial Infarction |
| TIA | Transient Ischaemic Attack |
| TPCH | The Prince Charles Hospital |
| TUH | Townsville University Hospital |
| URG | Urgency Related Groups |
| USA | United States of America |
| VF | Ventricular Fibrillation |
| VT | Ventricular Tachycardia |

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| | |
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