Department of Health

The management of STEMI patients identified by the Queensland Ambulance Service:

11 year findings (2008-2018)

Queensland Government

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Abbreviations

ACP	Advanced Care Paramedic
BP	Blood Pressure
CAD	Computer-Aided Dispatch
CCL	Cardiac Catheterisation Laboratory
CCP	Critical Care Paramedic
CI	Confidence Interval
CPR	Cardiopulmonary Resuscitation
dARF	Digital Ambulance Report Form
ECG	Electrocardiogram
GCS	Glasgow Coma Scale
GCUH	Gold Coast University Hospital
IQR	Interquartile Range
LASN	Local Ambulance Service Network
OHCA	Out-of-Hospital Cardiac Arrest
PAH	Princess Alexandra Hospital
PCI	Percutaneous Coronary Intervention
pPCI	Primary Percutaneous Coronary Intervention
QAS	Queensland Ambulance Service
QCOR	Queensland Cardiac Outcomes Registry
RBWH	Royal Brisbane and Women's Hospital
RSQ	Retrieval Services Queensland
SCUH	Sunshine Coast University Hospital
STEMI	ST-segment Elevation Myocardial Infarction
TPCH	The Prince Charles Hospital

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Executive summary

Demographics

- Over the last decade (2008-2018), QAS paramedics identified and treated 7869 STEMI patients. The rate of paramedic-identified STEMI has doubled, increasing from 9 (2008) to 18 (2013 onwards) cases per 100,000 population per year. This equals an increase from 400 cases in 2008 to more than 900 cases each year from 2013 onwards.

- Males accounted for 75% of all identified STEMI cases, being on average eight years younger than females (median age 60 versus 68 years).

Increased reperfusion treatment rate

- **There has been a marked increase in the proportion of patients receiving prehospital reperfusion treatment** (prehospital fibrinolysis or direct referral to a hospital for primary percutaneous coronary intervention [direct pPCI referral]). This is due to the implementation of the decision-supported prehospital reperfusion program for Advanced Care Paramedics (ACPs), which was implemented statewide in early 2016. Around 68% of identified STEMI patients received prehospital reperfusion treatment between 2016 and 2018, compared to 48% between 2008 and 2015. Improvement was observed in both metropolitan and regional areas, with the greatest increase observed in the latter. Patients not receiving reperfusion treatment were normally found to be medically contraindicated; however, they were still identified for prenotification to the receiving facility to ensure rapid assessment and treatment upon arrival.

Rapid response and improved time metrics

- **The time interval from arrival at scene to performance of first 12-lead electrocardiogram (ECG) has remained consistently short at six minutes in recent years, which is well within the QAS 10-minute performance target.**

- **For direct pPCI referral patients, all-site median time from first STEMI 12-lead ECG to reperfusion treatment was 83 minutes. Nearly 60% of the patients received the treatment within 90 minutes from first STEMI 12-lead ECG.** This compares favourably with international data. Nevertheless, further refinements to STEMI program are planned so that even more patients can receive early reperfusion treatment.

- **For prehospital fibrinolysis cases, the median time from first STEMI 12-lead ECG to prehospital fibrinolysis administration was 20 minutes (interquartile range 11-32).**

Low mortality rate

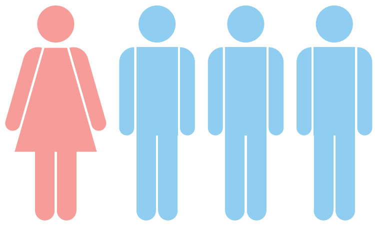
- **30-day all-cause mortality was very low**, with a statewide rate of 2.4% in the prehospital fibrinolysis group and 1.8% in the pPCI group. Early prehospital notification and timely reperfusion are critical for survival, as the likelihood of 30-day mortality increases substantially for every 10 minutes delay.

STEMI by the numbers

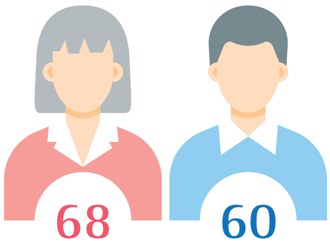
7869 STEMI patients

identified by paramedics between February 2008 and June 2018 in Queensland

75% Male

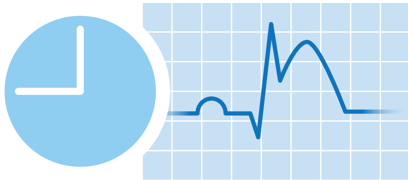


Median Age (years)



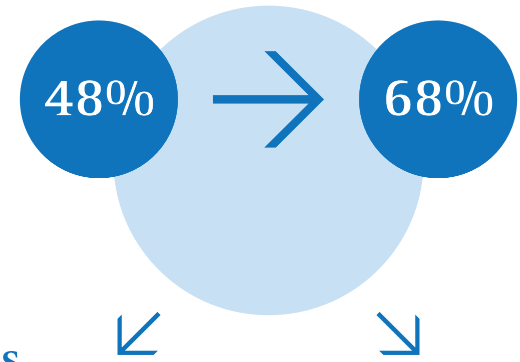
6 Minutes

median time from arrival at scene to first 12-lead ECG



Reperfusion treatment rate

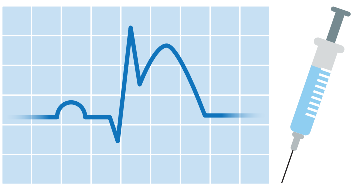
2008-2015



2016-2018

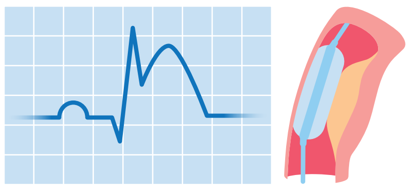
20 Minutes

median time from first STEMI 12-lead ECG to prehospital fibrinolysis administration



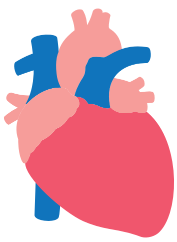
83 Minutes

median time from first STEMI 12-lead ECG to pPCI



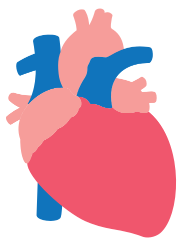
97.6%

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



98.2%

30-day survival rate in patients referred for **pPCI**



1 Introduction

ST-segment elevation myocardial infarction (STEMI) is a leading cause of morbidity and mortality in Australia and worldwide.[1,2] In Queensland, prehospital STEMI cases identified by paramedics are treated in the field before being promptly transported by an ambulance to a hospital for definitive care. Timely administration of prehospital reperfusion therapies by paramedics is critical for myocardial salvage and improving the outcomes of STEMI patients.[3] In February 2008, the Queensland Ambulance Service (QAS) implemented a prehospital reperfusion program for STEMI patients, which incorporates prospective STEMI data collection. The objective of the data collection is to gain an understanding of the epidemiology of prehospital STEMI in Queensland, and to evaluate prehospital components of the system of care and patient outcomes. Proactive utilisation of the STEMI data collection helps identify important factors influencing timely reperfusion and patient outcomes so that service delivery and care can be reviewed, monitored and improved where necessary. The findings are used to assess policies and clinical practices regarding the delivery of care across the state, and to identify areas of opportunity for quality improvement.

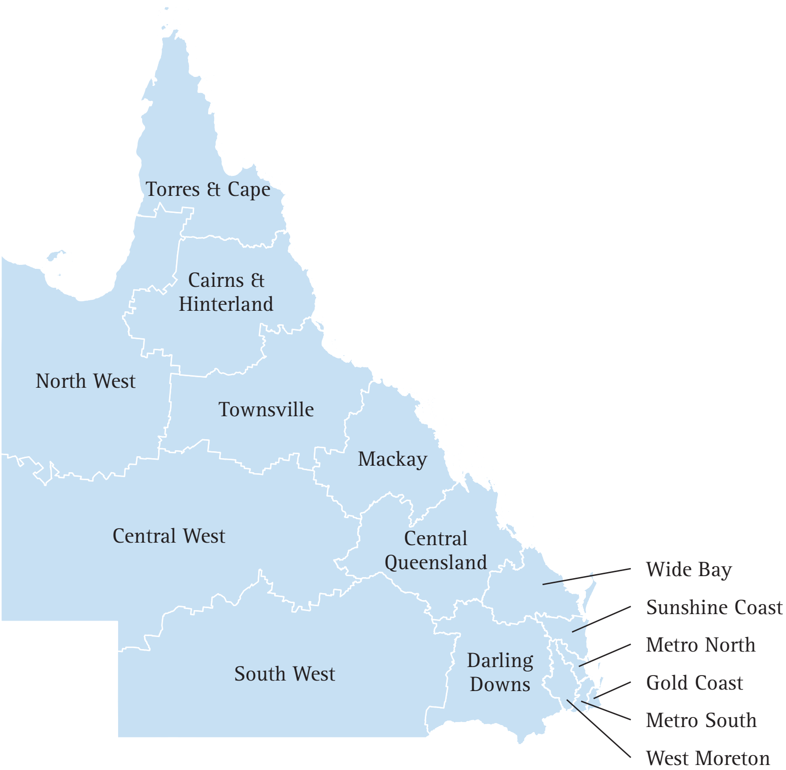
Between February 2008 and June 2018, QAS paramedics identified 7869 STEMI patients on the basis of a prehospital 12-lead electrocardiogram (ECG). When treating STEMI patients in the prehospital setting, QAS clinicians undertake a range of assessments and interventions as necessary for the patient's clinical condition. Of these, six key elements form a specific prehospital STEMI care bundle, including (i) administration of aspirin, (ii) administration of glyceryl tri-nitrate, (iii) pain management, (iv) appropriate prehospital reperfusion treatment when indicated, (v) early defibrillation for patients who suffer cardiac arrest, and (vi) rapid transport to an appropriate hospital with early notification. This report presents information on the response, clinical care, conveyance for and outcomes of the 7869 STEMI patients attended by QAS paramedics over the period between February 2008 and June 2018.

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).[4] 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. A typical response to a STEMI patient involves the concurrent deployment of Advanced Care Paramedics (ACPs) and Critical Care Paramedics (CCPs), where available. ACPs are trained in reperfusion skills such as 12-lead ECG acquisition and interpretation, decision-supported direct referral for primary percutaneous coronary intervention (direct pPCI referral), and decision-supported administration of prehospital fibrinolysis. CCPs are authorised to perform direct pPCI referral and prehospital fibrinolysis autonomously. CCPs represent around 8% of operational paramedics.



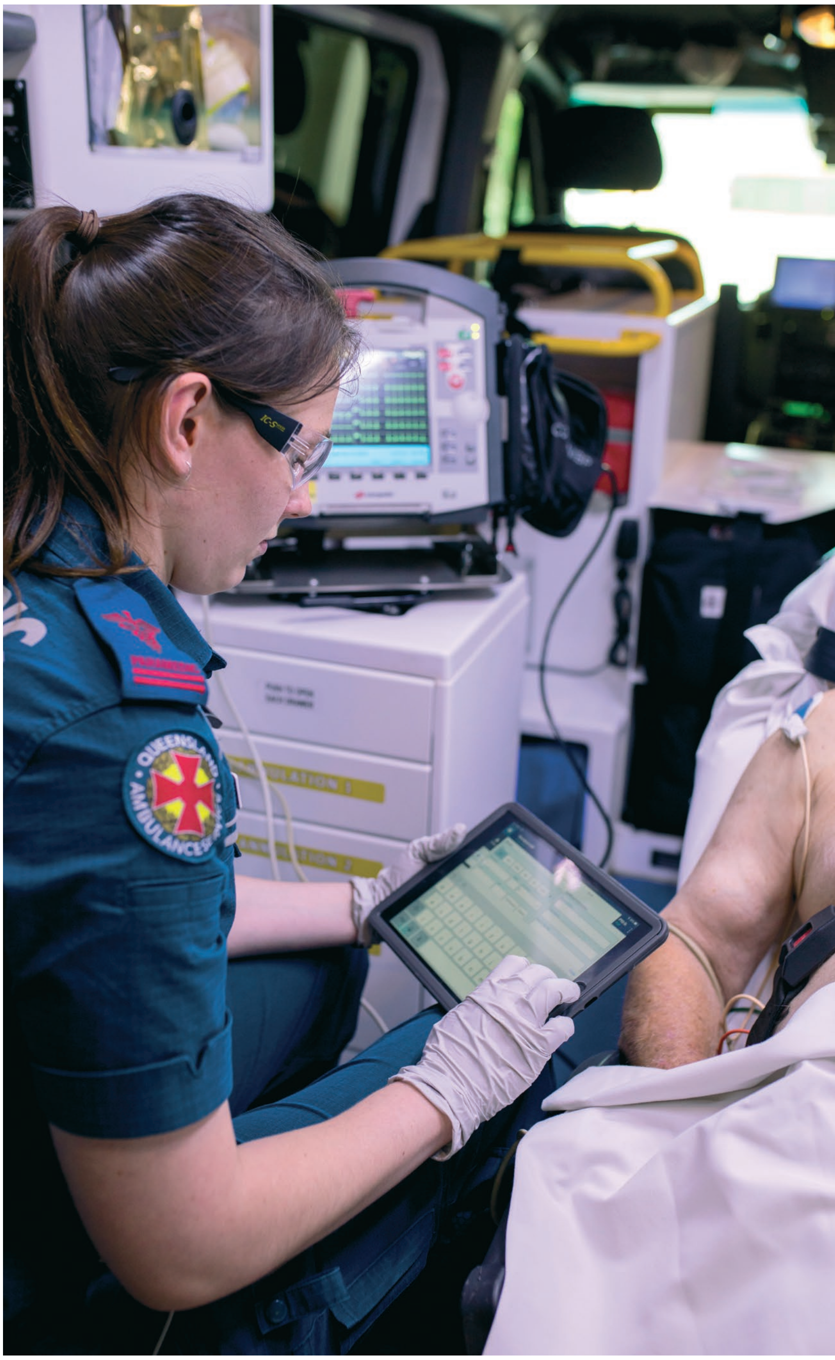
LASN	Geographic size (km²)	Population
Torres & Cape	130,238	26,889
North West	253,700	30,494
Central West	382,800	10,474
South West	319,800	24,365
Cairns & Hinterland	141,600	245,940
Townsville	149,500	246,718
Mackay	90,360	172,587
Central Queensland	111,200	210,665
Wide Bay	37,050	215,596
Sunshine Coast	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 QAS LASN areas.

3 QAS Cardiac Outcomes Project

The QAS Cardiac Outcomes Project was established in 1999. It comprises the Out-of-Hospital Cardiac Arrest (OHCA) program and the Statewide Prehospital Reperfusion program 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. The OHCA data collection to date has more than 82,000 cases. The inaugural OHCA report[5] was published in December 2018 with subsequent publications to follow.

From February 2008, the QAS implemented a prehospital reperfusion program for CCPs attending STEMI patients. The STEMI program has evolved over time, including the implementation of statewide Clinical Practice Procedures, the introduction of enoxaparin as an alternative to heparin (2011), ticagrelor as an alternative to clopidogrel (2015), and the implementation of decision-supported direct pPCI referral and decision-supported prehospital fibrinolysis for ACPs (2015). As part of the program, the STEMI data collection was developed to prospectively collect data on the prehospital clinical management for STEMI patients attended by paramedics. This report analyses the STEMI data collection over the period between February 2008 and June 2018.



4 STEMI data collection and reporting

The STEMI data collection contains information obtained during the Triple Zero (000) call, from patient care records, and more recently, in-hospital care and survival information. The collection accurately describes the epidemiology, clinical management and outcomes of all STEMI patients identified by QAS paramedics. Primary data sources of the STEMI data collection include the digital Ambulance Report Form (dARF), CAD, STEMI data collection form (completed by attending paramedics), 12-lead ECG tracing strips from cardiac monitors and, from January 2016, information from the Queensland Cardiac Outcomes Registry (QCOR) (Figure 2). QCOR provides data on the in-hospital management and survival of patients with STEMI admitted to public pPCI-capable hospitals in Queensland, many of whom are initially treated and transported by QAS paramedics. Key data elements, such as ambulance response times, clinically important times and survival outcomes can be derived from the STEMI data collection. These data are used to undertake statistical analysis to measure service delivery and performance.

All STEMI patients identified by 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 STEMI 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 STEMI 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 STEMI data collection.

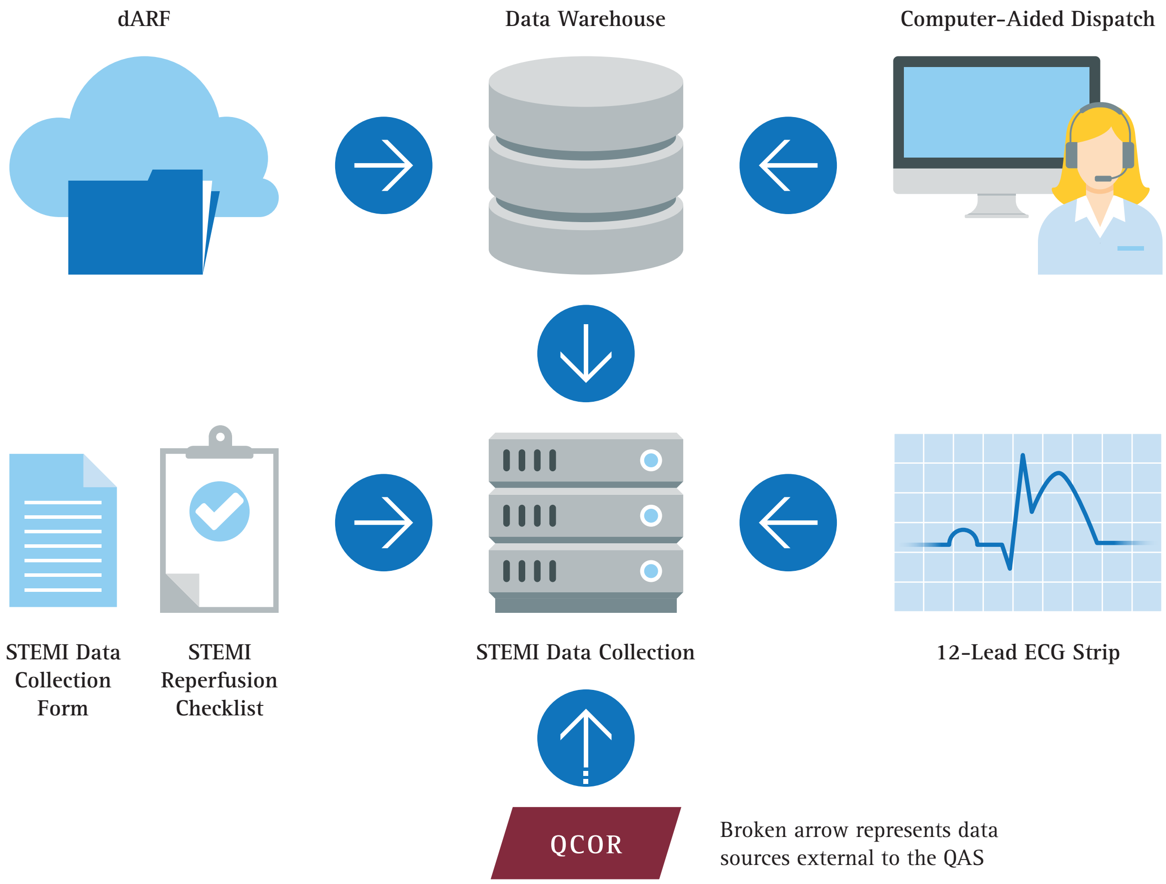


Figure 2. Primary data sources of the STEMI data collection.

5 QAS Clinical Practice Guidelines for STEMI management

In the prehospital setting, primary elements of STEMI management include (i) recognition of symptoms, prompt seeking of medical attention and initiating a Triple Zero (000) call; (ii) rapid deployment of an emergency ambulance response; (iii) expeditious acquisition of a 12-lead ECG, clinical assessment and implementation of reperfusion treatment by paramedics; and (iv) timely transport of the patient to a hospital (Figure 3).

Rapid recognition of STEMI followed by prompt restoration of coronary artery perfusion is key to myocardial salvage and favourable outcomes.[6] For all patients with symptoms suggestive of acute myocardial infarction, QAS paramedics record a 12-lead ECG. The following ECG criteria are indicative of STEMI:

- persistent ST-segment elevation of ≥ 1 mm in at least two contiguous limb leads; and/or ST-segment elevation of ≥ 2 mm in at least two contiguous chest leads (V1-V6); and
- normal QRS width (< 0.12 seconds); or right bundle branch block identified on 12-lead ECG.

The QAS has a well-established process for the management of prehospital STEMI (Figure 4). Upon recognition of STEMI, and when clinically indicated, paramedics aim to fast-track STEMI treatment either by directly referring the patient to a pPCI-capable hospital for pPCI, or by administering prehospital fibrinolysis.

If the patient meets criteria for direct pPCI referral, a dedicated telephone line is utilised to make direct contact with the on-call interventional cardiologist at the receiving pPCI-capable hospital to refer the patient. If the interventional cardiologist accepts the patient for pPCI, a prehospital treatment plan is agreed upon and the cardiac catheterisation laboratory (CCL) is activated. In Queensland, there are 20 pPCI-capable hospitals with a QAS paramedic referral pathway; of these, eight are public hospitals and 12 are private (Figure 5). If prehospital fibrinolysis is indicated for reperfusion, the fibrinolytic drug tenecteplase and adjunct therapies are administered by paramedics in the field. This is followed by rapid transport to a PCI-capable hospital within road-based travelling distance, otherwise to the closest community hospital with subsequent transfer to a PCI-capable hospital. Patients being transferred to rural hospitals are referred by the QAS before they arrive, so as to ensure early activation of the medical retrieval team. CCPs are authorised to perform direct pPCI referral and prehospital fibrinolysis autonomously, whereas ACPs are required to contact the QAS Clinical Consultation and Advice Line for decision support before administering reperfusion therapies (Figure 4).

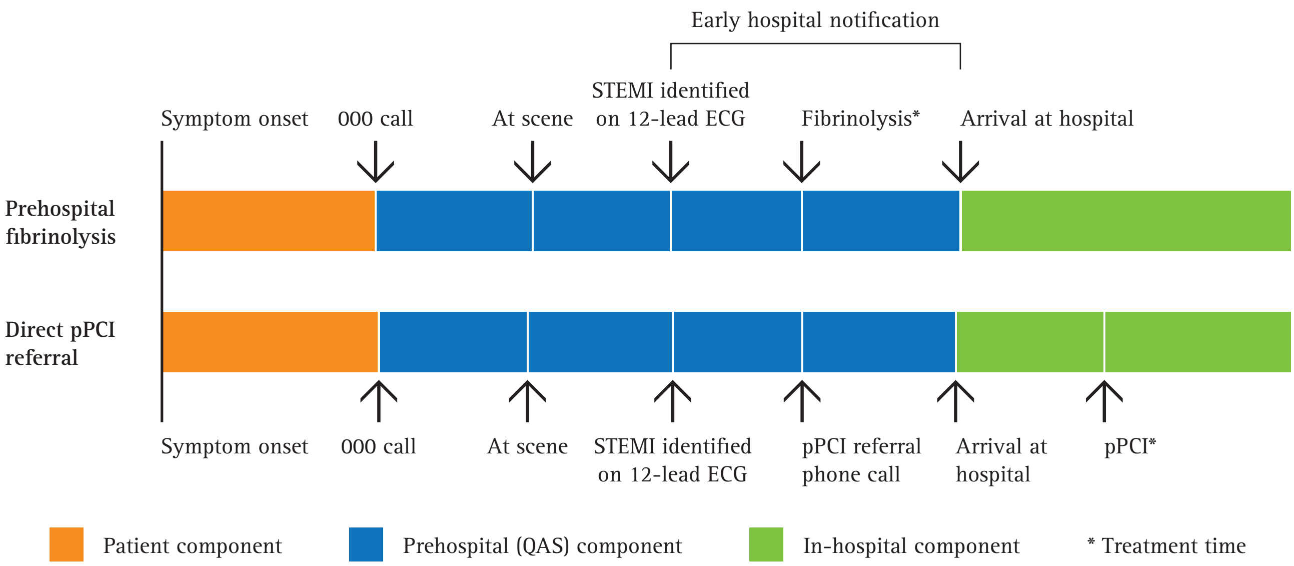


Figure 3. Time components from symptom onset to reperfusion treatment in STEMI.

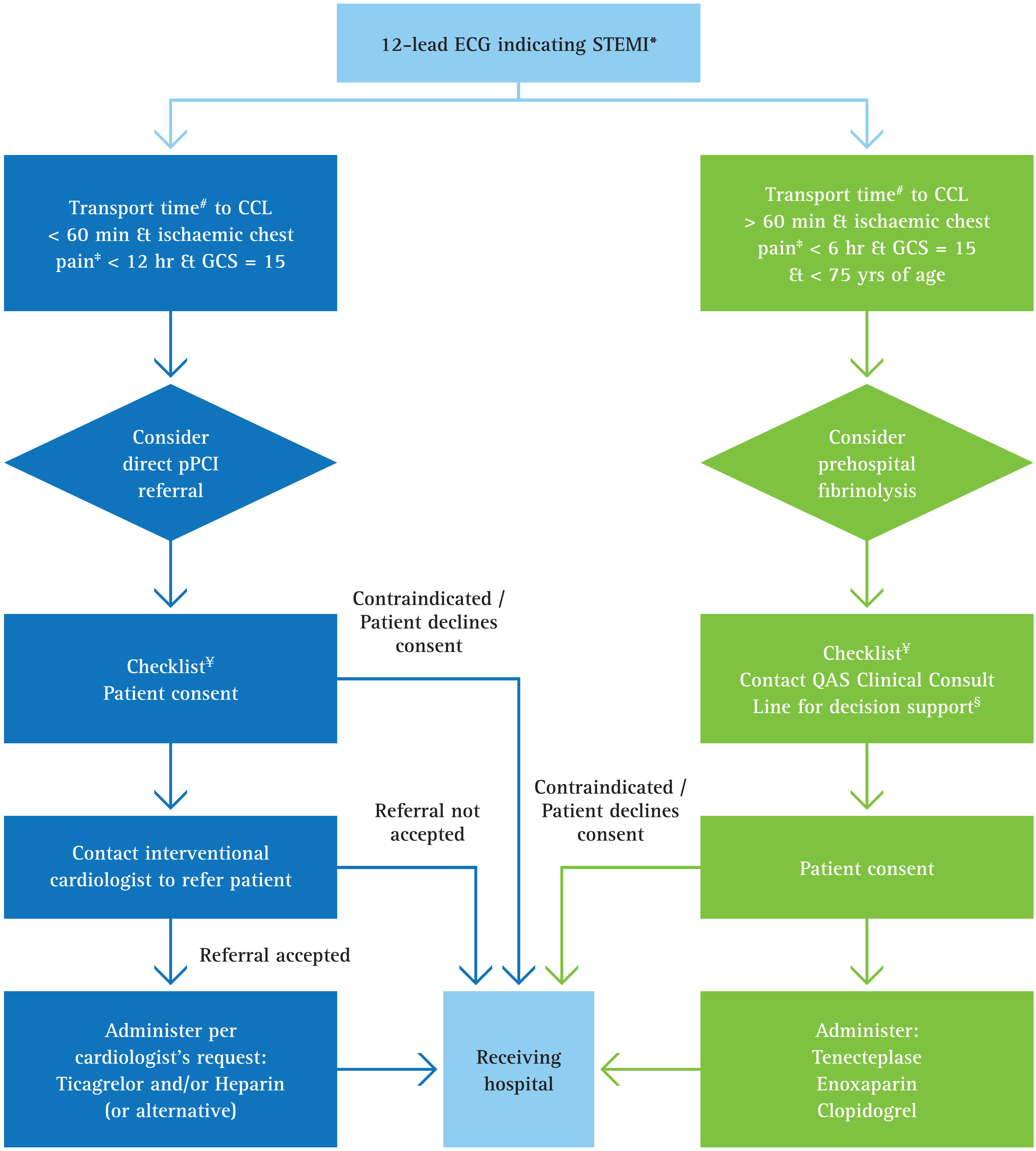


Figure 4. QAS procedures for prehospital management of STEMI.

* For ACPs, the ECG monitor must indicate "acute myocardial infarction".

‡ Patients who experienced ischaemic chest pain > 12 hours (for direct pPCI referral) or > 6 hours (for prehospital fibrinolysis) were excluded from this flowchart.

Transport time calculated from time of first STEMI 12-lead ECG to time of arrival at pPCI-capable hospital.

¥ For prehospital fibrinolysis, CCPs use the "Autonomous fibrinolysis administration checklist" and ACPs use the "Decision supported fibrinolysis administration checklist"; for direct pPCI referral, CCPs use the "Autonomous pPCI referral checklist" and ACPs use the "Decision supported pPCI referral checklist".

§ Required for only ACPs.

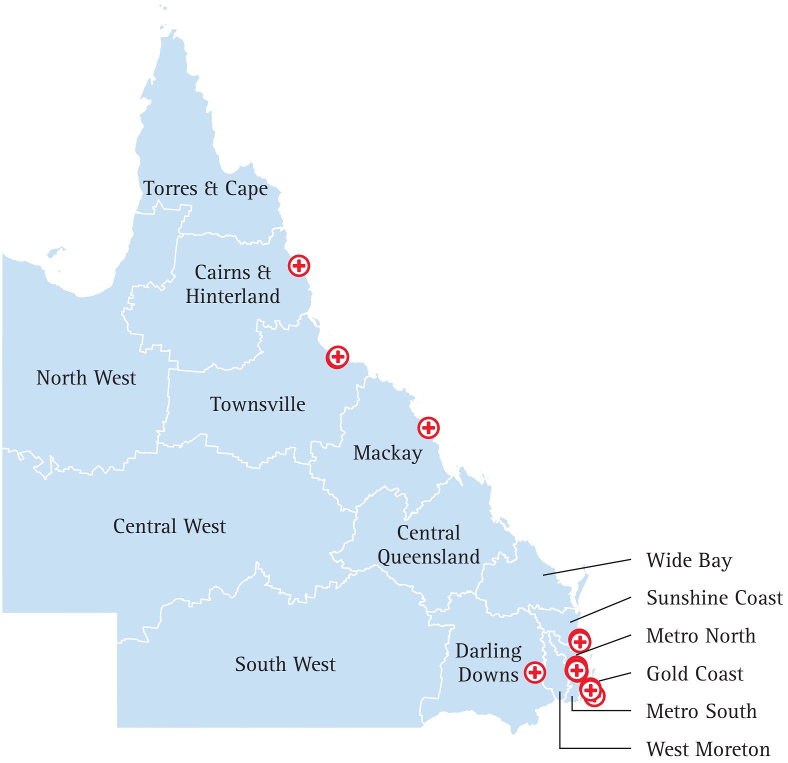


Figure 5. **pPCI-capable hospitals with a QAS paramedic referral pathway.**

LASN	PCI-capable hospital
Cairns & Hinterland	Cairns Hospital*
Townsville	Townsville Hospital* Mater Private Hospital Pimlico
Mackay	Mackay Base Hospital*
Sunshine Coast	Sunshine Coast University Hospital* Sunshine Coast University Private Hospital Buderim Private Hospital
Metro North	RBWH* TPCH* St Vincent's Private Hospital Northside St Andrew's War Memorial Hospital Wesley Hospital
Metro South	PAH* Greenslopes Private Hospital Mater Private Hospital Brisbane
Gold Coast	Gold Coast University Hospital* Gold Coast Private Hospital John Flynn Private Hospital Pindara Private Hospital
Darling Downs	St Andrew's Hospital

* Public hospitals

6 Patient demographics

Between February 2008 and June 2018, the STEMI data collection captured a total of 7869 STEMI cases; three-quarters (75%) of the patients were male. The median age of STEMI patients was 62 (range 18-102) years, with male patients being eight years younger than female patients (median age 60 versus 68 years, $p < 0.001$) (Figure 6). There was no noticeable fluctuation in patients' median age over the study period. Patients who received prehospital fibrinolysis were four years younger than direct pPCI referral patients (median age 57 versus 61 years, $p < 0.001$).

There has been a steady increase in the number of STEMI cases identified by paramedics over the years, both in absolute numbers of cases and in incidence rates per 100,000 population per year (Table 1, Figure 7). The incidence rates in 2017 were double compared to 2008 (18 versus 9 cases per 100,000 population per year).

The observed increase in STEMI cases may in part be attributable to continual improvement in record collection and submission of STEMI data collection forms over the years, and the increase in STEMI identification statewide due to expansion of the reperfusion program from only CCPs to ACPs. Sixty-four percent of cases occurred outside business hours (weekends and 16:01-07:59 weekdays), mandating the need to maintain a high level of staffing and emergency preparedness outside business hours.

Across the period between February 2008 and June 2018, metropolitan areas accounted for the majority (68%) of cases, followed by regional areas (30%); whereas only 2% of the STEMI cases occurred in remote parts of the state (Table 1, Figures 7-8). It should be noted that these figures are proportional to the population densities in these areas.

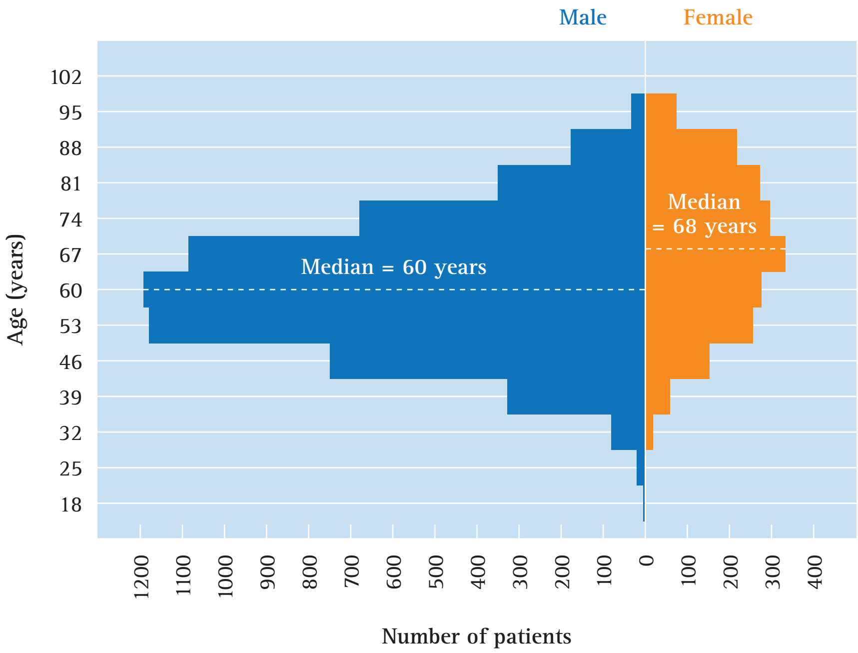


Figure 6. Age distribution by gender.

Table 1. Number of STEMI cases and incidence rates by year and remoteness (N = 7869).

Year	Statewide N (incidence*)	Metropolitan N (incidence*)	Regional N (incidence*)	Remote N (incidence*)
2008	400 (9)	258 (11)	136 (8)	6 (5)
2009	436 (10)	298 (12)	129 (7)	9 (7)
2010	645 (15)	447 (18)	191 (11)	7 (5)
2011	698 (16)	501 (20)	184 (10)	13 (10)
2012	759 (17)	559 (22)	193 (11)	7 (5)
2013	819 (18)	560 (21)	245 (13)	14 (11)
2014	835 (18)	569 (21)	252 (14)	14 (11)
2015	907 (19)	550 (20)	334 (18)	23 (18)
2016	922 (19)	600 (21)	309 (16)	13 (10)
2017	902 (18)	576 (20)	311 (16)	15 (12)
2018 (Q1-Q2)	546 (n/a)	349 (n/a)	188 (n/a)	9 (n/a)

* Incidence rate per 100,000 population per year. Number of STEMI cases for the full calendar year of 2018 were not available to allow for calculation of incidence rates for this year. For each remoteness category, incidence rates were calculated relative to the population size of that remoteness category.

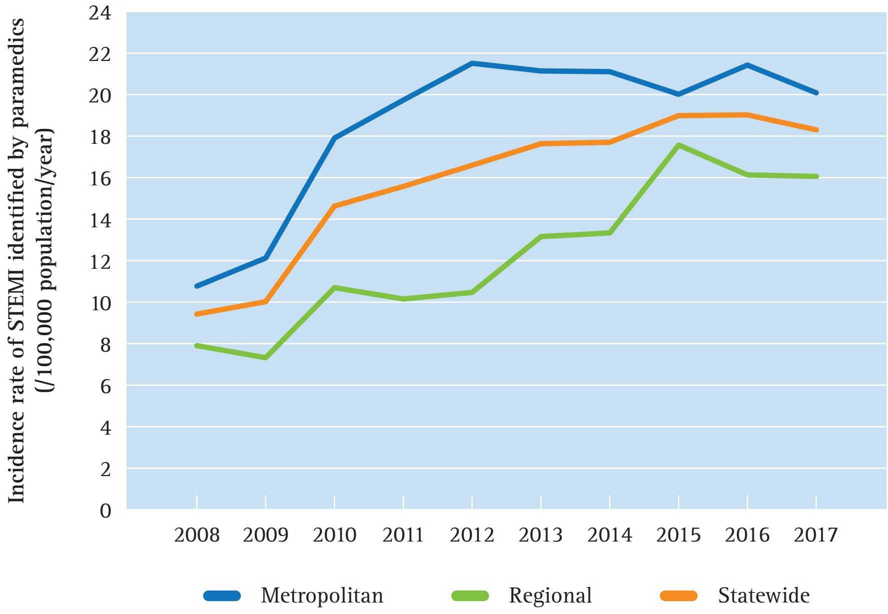


Figure 7. Incidence rates (per 100,000 population per year) of STEMI identified by paramedics. Incidence rates of remote areas are not shown due to small number of cases. For each remoteness category, incidence rates were calculated relative to the population size of that remoteness category. Remoteness was categorised according to the Australian Statistical Geography Standard (volume 5, July 2011).

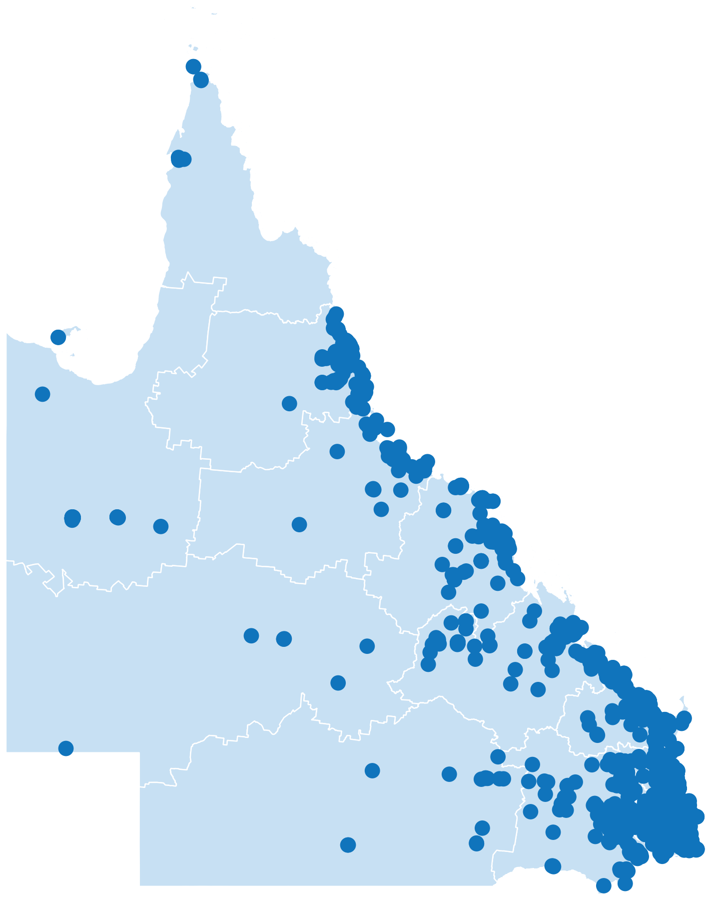


Figure 8. Spatial distribution of STEMI cases showing high concentration in metropolitan areas. Each dot represents one case.

7 Reperfusion pathways

Prehospital cardiac reperfusion pathways for STEMI patients were implemented by the QAS for CCPs in February 2008. To further expand access to prehospital fibrinolysis, and to reduce time delays for direct pPCI referral, decision support processes were developed in 2015 to provide real-time clinical advice and guidance to ACPs. A focussed education and training program for these paramedics was completed in early 2016, with 98% of ACPs working in regional and remote locations now trained to provide prehospital fibrinolysis for STEMI.

Over the years, there has been a significant improvement in the proportion of patients treated with any form of reperfusion therapy (direct pPCI referral or prehospital fibrinolysis), paralleling a significant reduction in the proportion of patients who did not receive reperfusion therapy (p for trend < 0.001) (Table 2, Figure 9). Across the study period, direct pPCI referral was the main form of reperfusion therapy, implemented for 40% of all STEMI cases; whereas 14% of STEMI cases were administered prehospital fibrinolysis. Spatial distribution of STEMI cases according to reperfusion pathway is shown in Figures 10 and 11. The overall proportion of patients who received any form of reperfusion therapy increased from 34% in 2008 to 76% in 2017.

Table 2. Number of patients who received direct pPCI referral, prehospital fibrinolysis or neither reperfusion pathway.

Year	Total no. of patients	Direct pPCI referral	Prehospital fibrinolysis	Neither reperfusion pathway
2008	400	47	90	263
2009	436	49	70	317
2010	645	110	87	448
2011	698	211	105	382
2012	759	297	104	358
2013	819	362	112	345
2014	835	370	93	372
2015	907	425	85	397
2016	922	461	91	370
2017	902	536	149	217
2018 (Q1-Q2)	546	275	84	187
All years	**7869**	**3143**	**1070**	**3656**

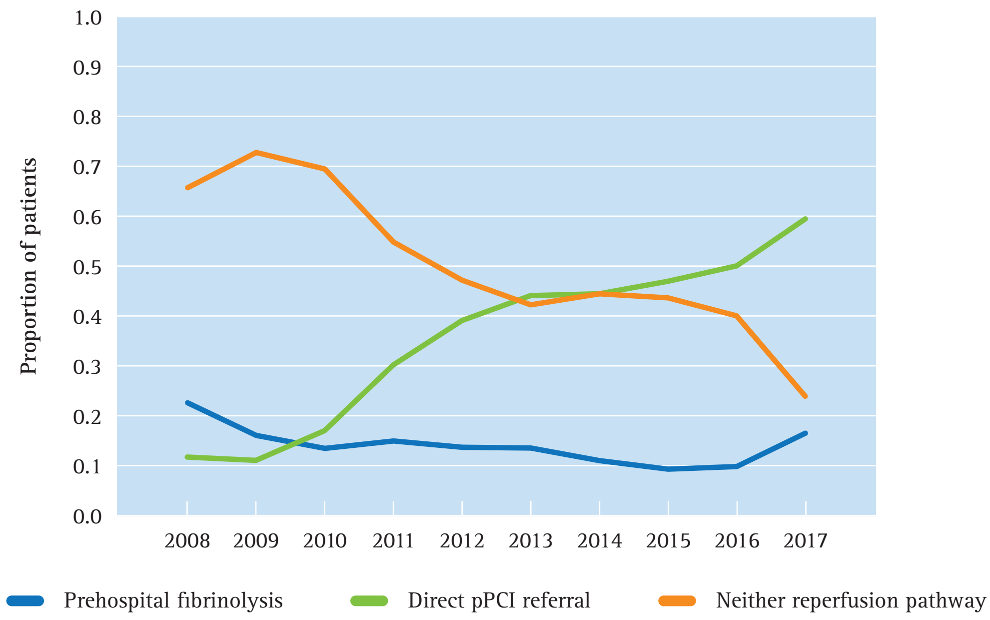


Figure 9. **Reperfusion pathways.** All proportions are relative to the total number of STEMI patients in the respective calendar year.

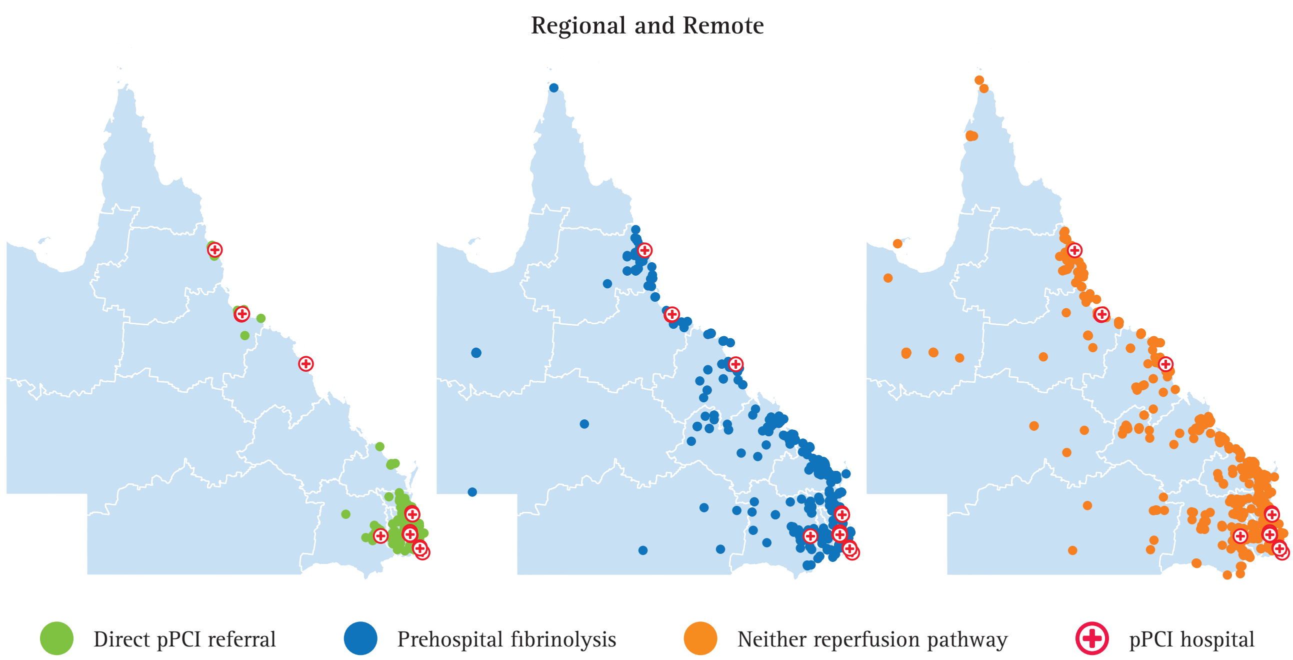


Figure 10. **Spatial distribution by reperfusion pathway of STEMI cases in regional and remote areas.**

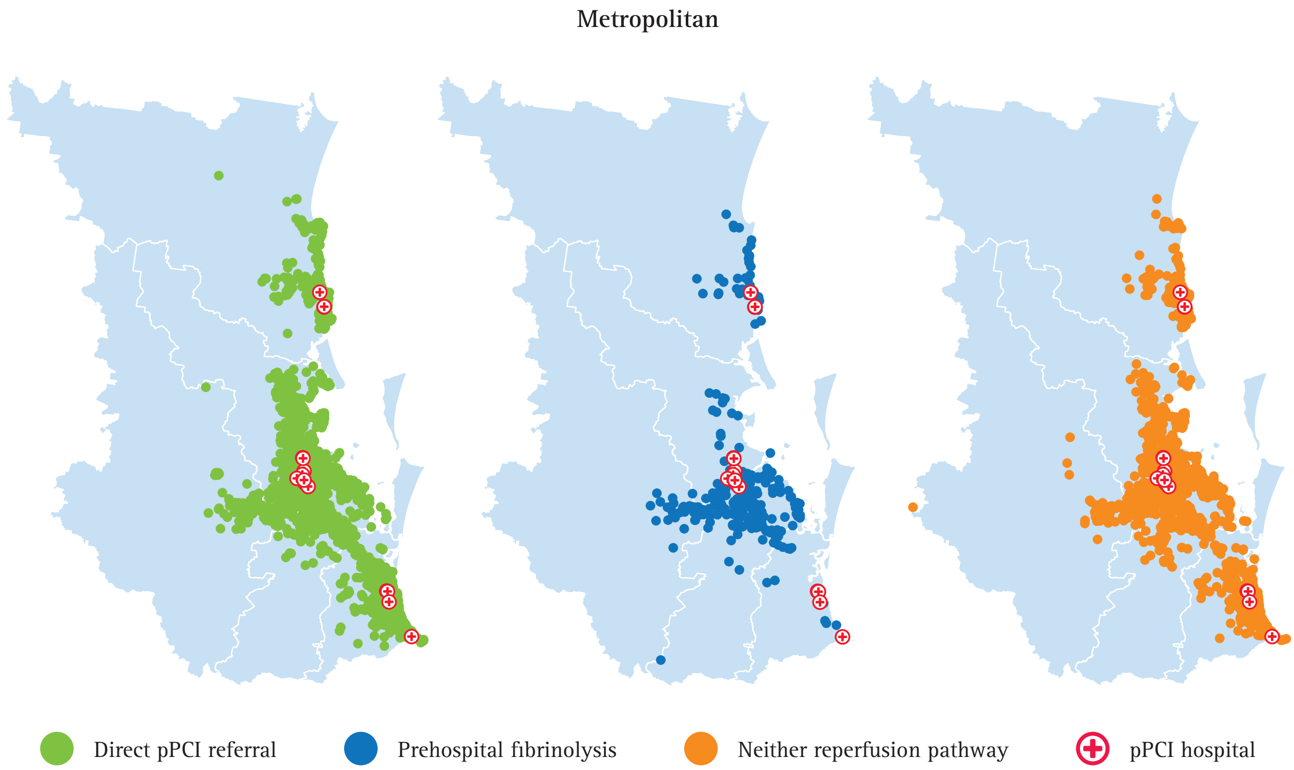


Figure 11. Spatial distribution by reperfusion pathway of STEMI cases in metropolitan areas.

The implementation of decision-supported prehospital reperfusion management for ACPs in 2015 has resulted in a marked increase in the proportion of STEMI patients who received prehospital reperfusion treatment. Specifically, 68% of patients received prehospital reperfusion treatment (prehospital fibrinolysis or direct pPCI referral) between 2016 and 2018, compared to 48% between 2008 and 2015. Direct pPCI referral increased from 34% (out of all STEMI cases) in the period between 2008 and 2015 to 54% in the period between 2016 and 2018 (a 59% relative increase) ($p < 0.001$) (Figure 12). Such an increase was observed in both metropolitan and regional areas, with the greatest increase observed in the latter (Figure 12).

While there has been a significant improvement in the rate of reperfusion treatment in regional areas, the fact that 45% of patients in these areas did not receive any form of reperfusion therapy presents a priority for further investigation.

Some patients did not receive reperfusion treatment due to being medically contraindicated. The most common contraindication to reperfusion therapy was pain duration and patient age (each accounted for 15% of the recorded contraindications), followed by borderline ST elevation (13%), and close proximity to hospital (9%) (Figure 13). These patients were still identified for prenotification to the receiving facility to ensure rapid assessment and treatment upon arrival.

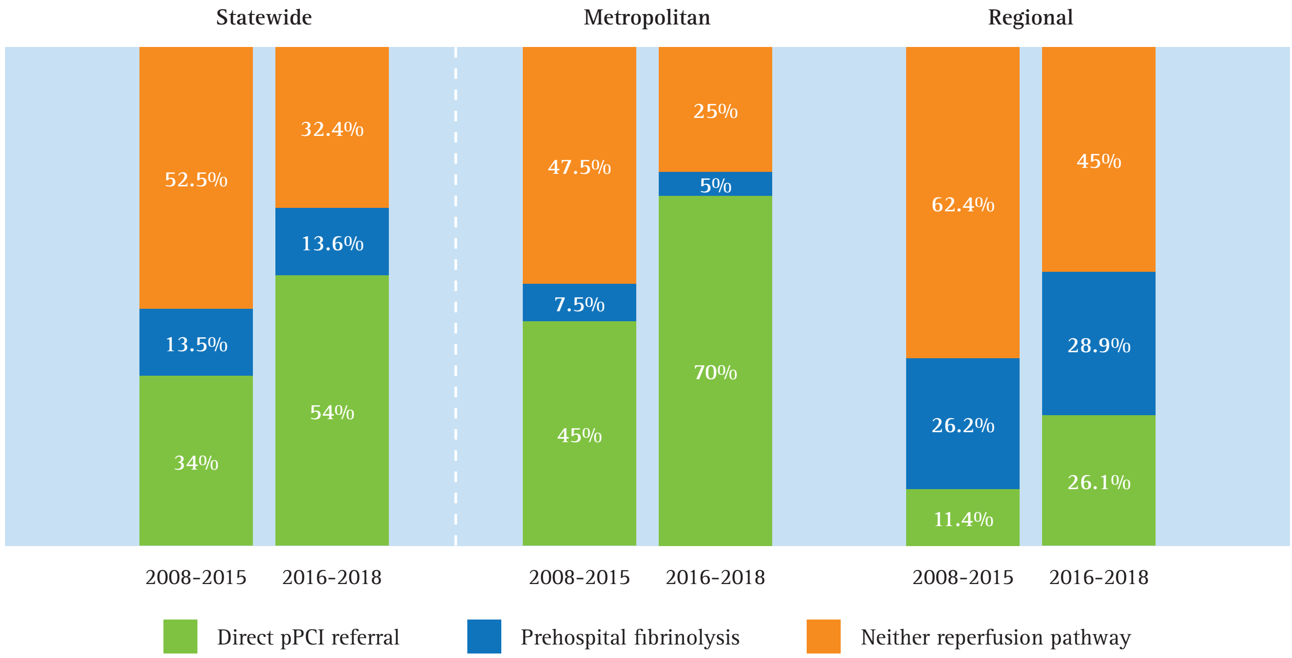


Figure 12. **Reperfusion pathways by remoteness between two periods (2008–2015 versus 2016–2018).** For each remoteness category, the proportions are relative to the total number of STEMI cases of the respective remoteness category. Remote areas are not shown due to small number of patients.

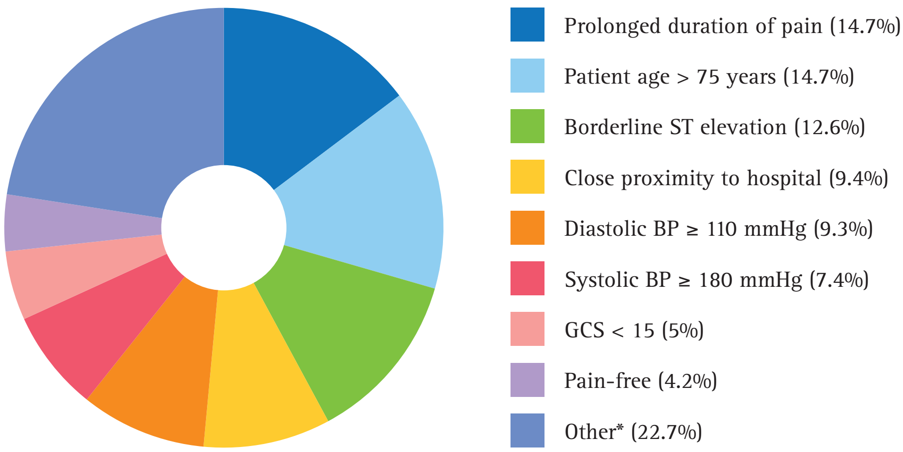
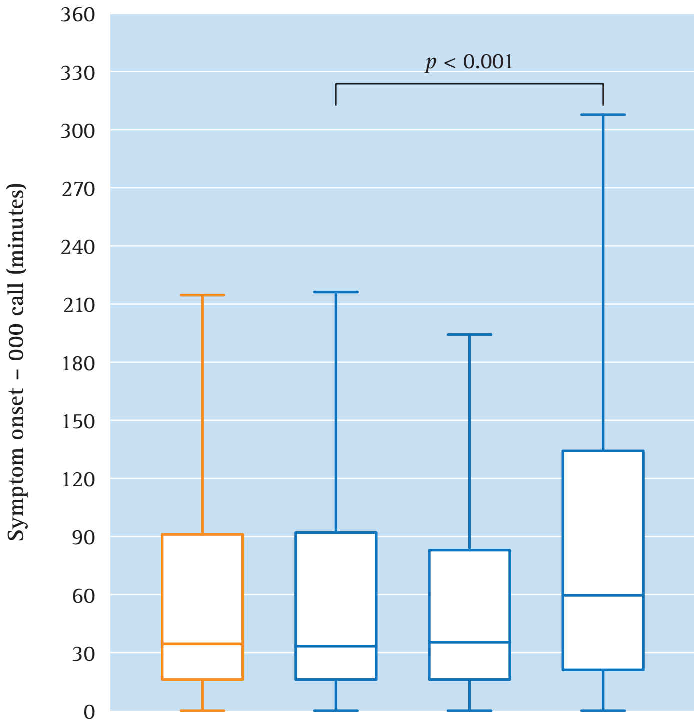


Figure 13. **Contraindications to reperfusion therapy.**

* Includes recent surgery, cancer, current anticoagulants, intracranial haemorrhage, left bundle branch block, brain tumour, transient ischaemic attack, internal bleeding, CPR > 10 minutes, suspected aortic dissection, allergy, ulcer, cerebrovascular lesion, and other unspecified contraindications.

8 Time from symptom onset to Triple Zero (ooo) call

The first source of potential delays in STEMI management begins with the timing of the patient's decision to make the Triple Zero (000) call following the onset of STEMI symptoms. The median (interquartile range, IQR) time between onset of symptoms to Triple Zero (000) call was 35 (14-94) minutes (Figure 14). Symptom onset inside or outside business hours did not appear to impact this time interval. The figures were comparable between metropolitan and regional areas, whereas the delay was greatest in remote locations (Figure 14). Minimising this patient-related delay is important to reduce total ischaemic time and improve patient outcomes. This delay can be reduced by awareness programs aimed at educating the public about the significance of chest discomfort and the importance of calling an ambulance as soon as symptoms are experienced.



	All patients	Metropolitan	Regional	Remote
Median	35	34	36	60
(IQR)	(14-94)	(14-95)	(14-86)	(20-137)

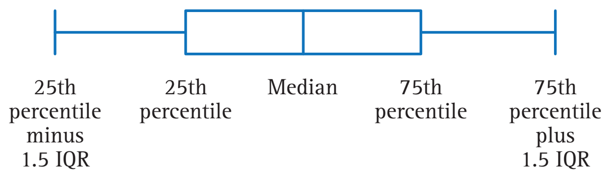


Figure 14. Time interval from symptom onset to Triple Zero (000) call.

9 Ambulance response time

The ambulance response time is measured from when Operations Centre staff receive the Triple Zero (000) call requesting ambulance attendance, to when the ambulance arrives at the scene of the incident. This time interval represents the first critical component of the ambulance response to STEMI cases. Across the study period, the median (IQR) response time was 9 (7-14) minutes. The response time remained consistent over the years and across geographic regions (Figure 15). This is significant given the increase in workload and the demand for ambulance services over the years as the result of the aging and growing population. Indeed, the demand for Code 1 and Code 2 ambulance response has increased substantially during the study period, from approximately 511,000 emergency responses in 2010 to 803,000 in 2018 (a 57% relative increase). The wider variance in response times in remote areas (IQR 6-21 minutes) is representative of the challenges inherent in delivering ambulance services across the expanse of a diverse and decentralised state.

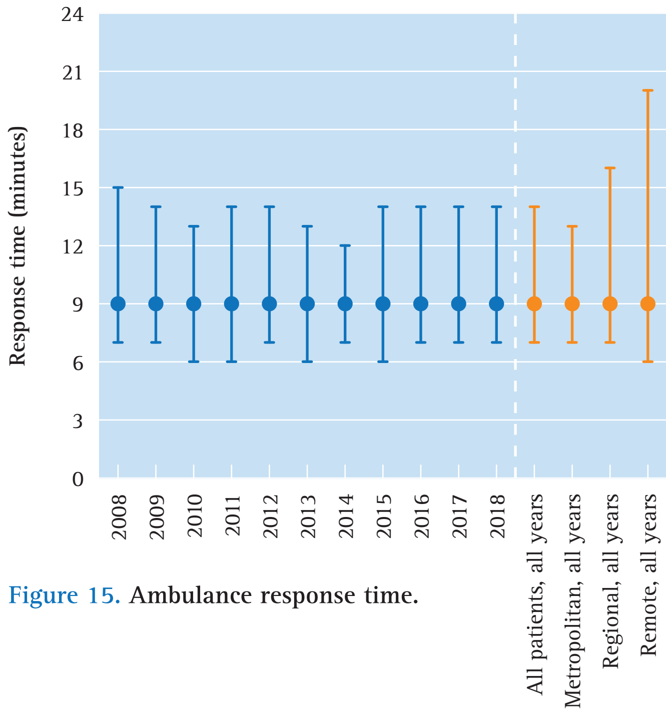


Figure 15. Ambulance response time.

10 Time from arrival at scene to first 12-lead ECG

Early identification of STEMI by paramedics, through the timely performance of a 12-lead ECG, is critical because it allows reperfusion therapies to be given in a prompt manner and facilitates pre-activation of CCL. Across the study period, there has been a significant improvement in this time interval. In 2009, when only CCPs were trained in STEMI management and therefore ACPs needed to await CCP backup for STEMI diagnosis and treatment, the time interval from arrival at scene to performance of first 12-lead ECG was 13 minutes. This has been more than halved following a change in guidelines and the expansion of 12-lead ECG acquisition to ACPs in 2009 (Figure 16). This time interval has remained consistently short in recent years, at approximately six minutes, which is well within the QAS 10-minute performance target. This means that patients can be referred for pPCI or administered prehospital fibrinolysis sooner.

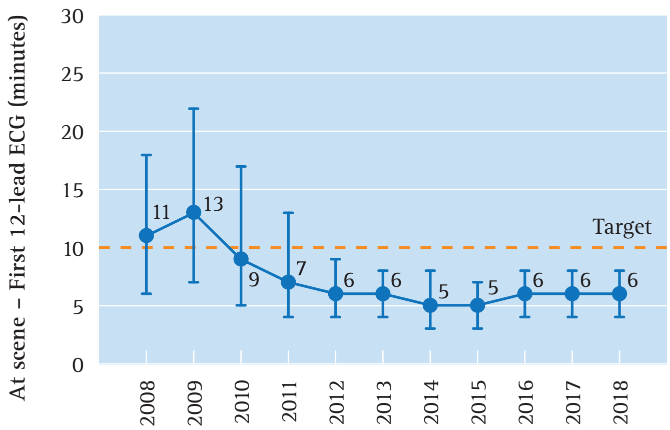


Figure 16. Time from paramedic arriving at scene to first 12-lead ECG.

11 Time from first STEMI 12-lead ECG to reperfusion treatment

The prognosis of STEMI is highly dependent on reperfusion times.[7,8] STEMI survival and long-term outcomes are improved when delays in reperfusion are minimal.[7,8] Accordingly, treatment strategies should aim to shorten reperfusion times as much as possible. Reperfusion times within 90 minutes after STEMI diagnosis for pPCI and 30 minutes for fibrinolysis are recommended by international guidelines.[8] Efficient coordination between the prehospital (QAS) and in-hospital (receiving facility) components of STEMI care is critical for ensuring patients receive reperfusion in a timely manner. Strategies to reduce delays to reperfusion include early and appropriate notification of CCLs by paramedics, with the timely response of the on-call PCI team upon receiving the prehospital notification of arriving cases from paramedics, and timely admission to the CCL when clinically appropriate (Figure 17).

Reperfusion time for pPCI patients was defined as time of TIMI-3 flow, where available. Where this timestamp was not available, the time of first device deployment was used as a surrogate for reperfusion time. Across the years from 2016 to 2018 (years where data were available), all-site median (IQR) time from first STEMI 12-lead ECG to reperfusion was 83 (72-101) minutes, with median (IQR) times for individual hospitals ranging from 66 (57-74) minutes (Cairns Hospital) to 92 (82-109) minutes (PAH) (Figure 18). Statewide, the median time from first STEMI 12-lead ECG to pPCI was significantly shorter when the STEMI incidence occurred inside business hours, compared to outside business hours (73 versus 91 minutes, $p < 0.001$) (Figure 18). Fifty-nine percent of QAS referred pPCI patients achieved time from first STEMI 12-lead ECG to reperfusion within 90 minutes. While these findings are superior to benchmarks in the literature, which reported that less than 50% of pPCI patients achieved the 90 minute benchmark,[9-11] additional refinements to the STEMI program is required to further optimise referral pathways such that more patients can receive reperfusion early.

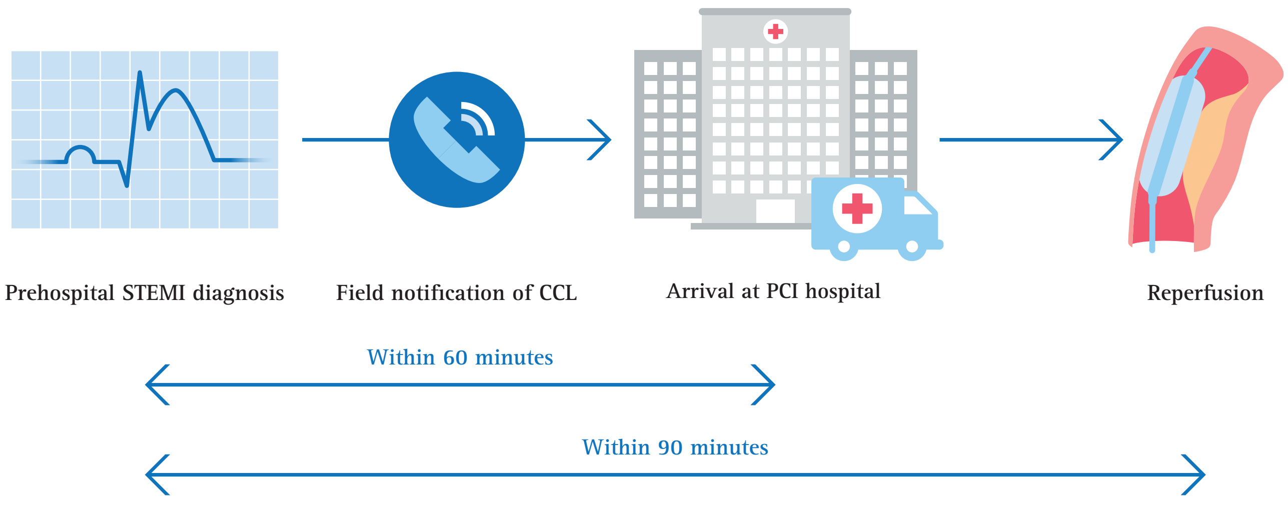


Figure 17. Recommended time intervals from STEMI diagnosis to pPCI.

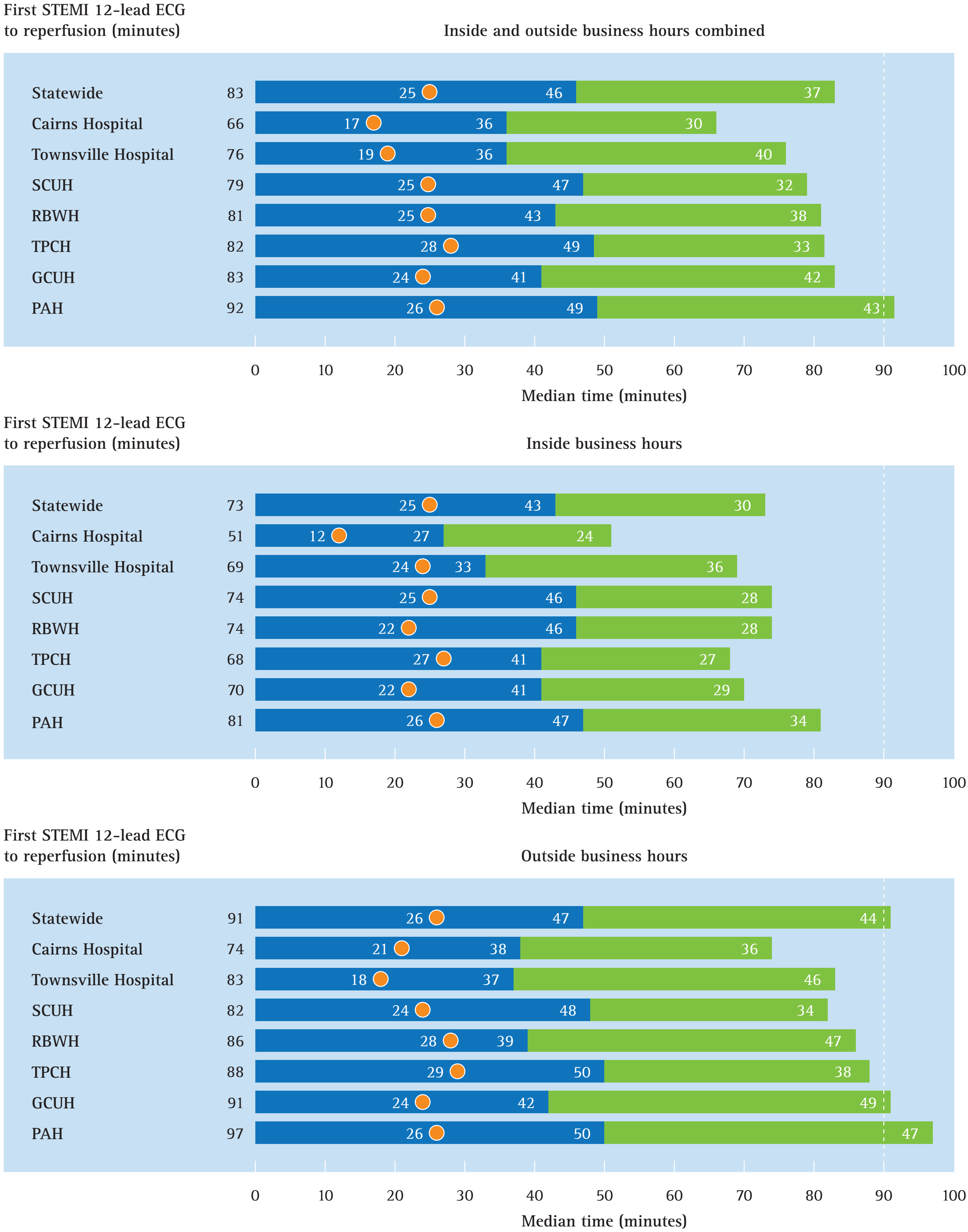


Figure 18. **Median time from first STEMI 12-lead ECG to pPCI.** Only STEMI patients who were directly referred to the eight public pPCI-capable hospitals for pPCI were included. Data regarding in-hospital processes only became available in 2016.

- First STEMI 12-lead ECG – Arrive at hospital
- Arrive at hospital – Reperfusion (in-hospital component)
- First STEMI 12-lead ECG – Notify hospital

Figure 19 shows the time from first STEMI 12-lead ECG to the administration of prehospital fibrinolysis (tenecteplase). For all years combined, the median time was 20 minutes (IQR 11-32). The most notable delay to the administration of tenecteplase was seen in remote areas. The longer delay observed in remote areas may be explained by a number of factors, including paramedic's lack of regular exposure to STEMI management, fewer paramedics attending a case, the need for decision support for STEMI management, and the inherent delays in obtaining decision support. Further interventions and refinements to guidelines will aim to reduce the occurrence of cases with extended time delays.

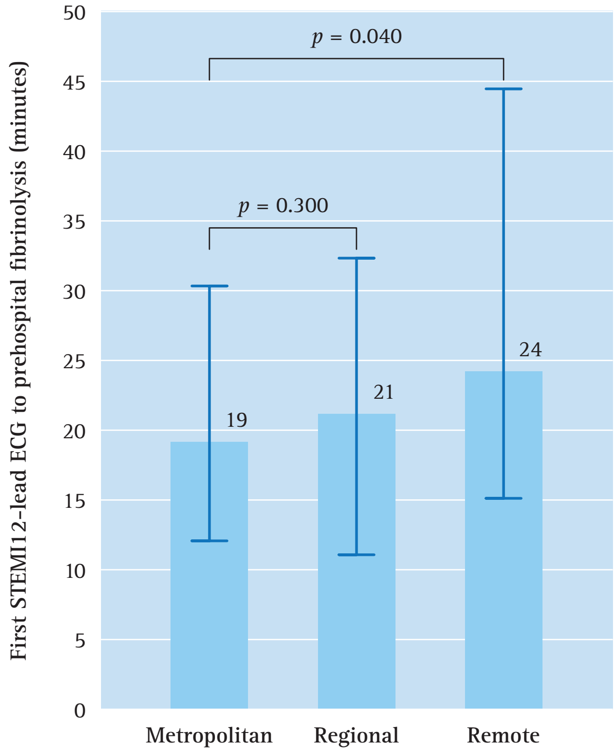


Figure 19. **Time from first STEMI 12-lead ECG to prehospital fibrinolysis.**

12 Survival outcomes

A separate analysis was performed to assess mortality in STEMI patients. Mortality in STEMI patients remains very low, with 30-day all-cause mortality rates of 2.4% in prehospital fibrinolysis patients and 1.8% in direct pPCI referral patients (Table 3). Our mortality rates compare favourably with previous studies, which reported 30-day mortality rates between 4.8% (combined analysis of all states and territories of Australia[12]) and 9.8% (United States[13]). Our data do not allow reporting of outcomes other than mortality, and in turn do not take into account clinical sequalae such as heart failure and unplanned cardiac readmissions. This is an important subject of future research. It would be expected that earlier treatment of STEMI patients would lower this complication burden.

A multivariate logistic regression analysis was performed to quantify the association between the time interval from first STEMI 12-lead ECG to reperfusion and 30-day mortality among direct pPCI referral patients. Age, gender, receiving hospital and remoteness were included in the model. Although overall mortality was low, every 10 minute delay in reperfusion would increase the odds of death by 1.25 times (95% CI 1.01-1.54, $p = 0.039$). Figure 20A displays the fitted curves and the associated 95% CI showing the probability of 30-day mortality as a function of the time from first STEMI 12-lead ECG to reperfusion. Increases in this time interval were associated with increased mortality. The probability of death increased exponentially as the time interval prolonged. The wide CIs at the right tail of the time distribution stemmed from the low proportion of individuals in the cohort with extreme time intervals. Similar curve shapes were found for the relationship between the probability of 30-day mortality and the time interval from first STEMI 12-lead ECG to hospital notification (Figure 20B). Indeed, for every 10 minute delay in hospital notification, the odds of 30-day mortality would increase 1.70 fold (95% CI 1.15-2.51, $p = 0.008$).

Table 3. 30-day all-cause mortality by public pPCI-capable hospital with a QAS paramedic referral pathway.

Hospital	Total STEMI cases	Number of deaths¥	Mortality (%)
Cairns Hospital	40	0	0
Gold Coast University Hospital	145	3	2.1
Mackay Hospital	1	0	0
Prince Charles Hospital	178	2	1.1
Princess Alexandra Hospital	279	3	1.1
Royal Brisbane and Women's Hospital	69	2	2.9
Townsville Hospital	36	2	5.6^
Sunshine Coast University Hospital*	135	4	3.0
Statewide	**883**	**16**	**1.8**

¥ Survival outcomes were obtained from QCOR and only became available in 2016.

^ Given the small sample size, the results should be interpreted with caution.

* Includes cases from Nambour Hospital.

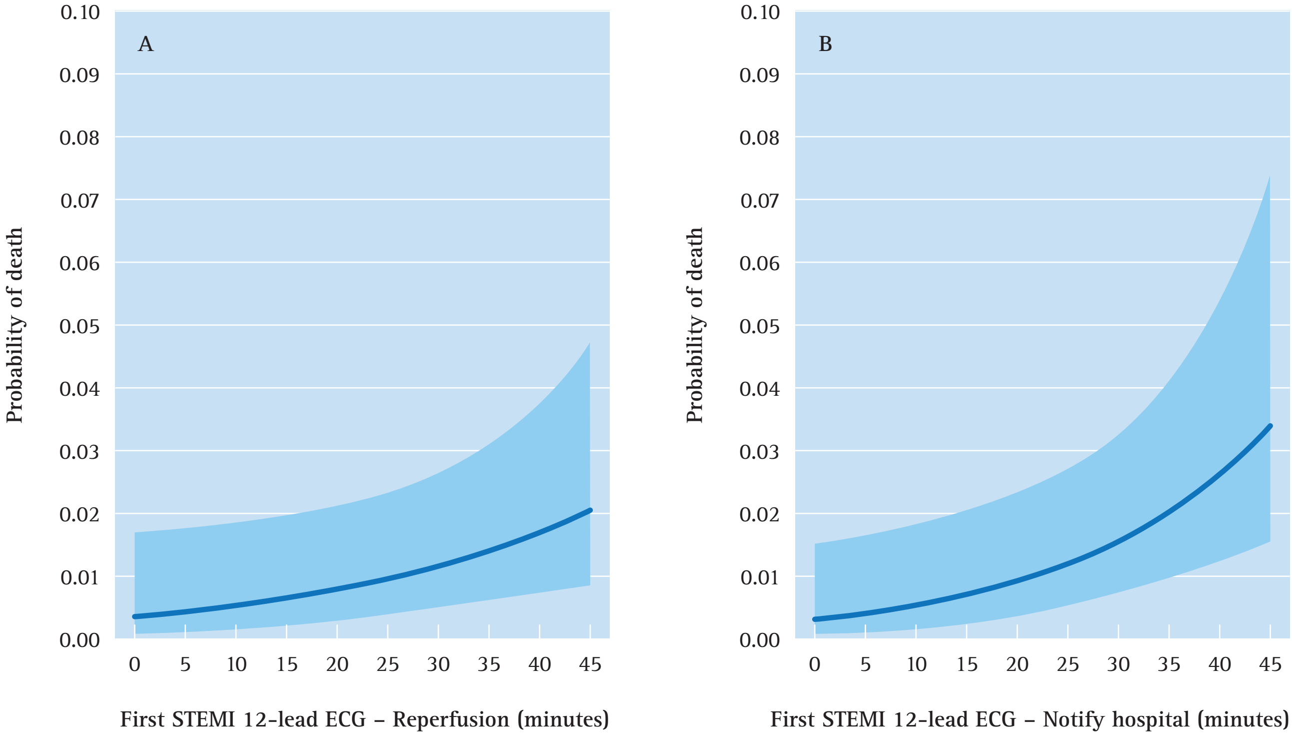


Figure 20. **Fitted curves and the associated 95% CI showing the relationship between the probability of 30-day all-cause mortality as a function of the time from first STEMI 12-lead ECG to reperfusion (A), and the time from first STEMI 12-lead ECG to hospital notification (B).** Predictions were based on the multivariate logistic regression models.

13 Conclusion

This report demonstrates that the QAS provides a high standard of prehospital care to STEMI patients. This is evidenced by rapid responses, timely on-scene 12-lead ECG for STEMI assessment and diagnosis, comprehensive treatment and, appropriate conveyance of patients to definitive care. The time interval from arrival at scene to performance of first 12-lead ECG has improved and remained well within the QAS 10-minute performance target. The findings show that reperfusion rates have improved, and nearly 60% of patients received pPCI within the ambitious international benchmark of 90 minutes following STEMI diagnosis. Mortality remained low, despite a varied and sometimes complex cohort of presenting patients.

Data contribution from QCOR in this report demonstrates the positive collaboration across the healthcare continuum. This collaboration has enabled 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. The findings of this report will form a basis to identify further opportunities for service improvement, with the focus on optimising patient outcomes. With the encouraging results demonstrated across all clinical indicators and benchmark activities, Queenslanders can be assured of high quality prehospital STEMI treatment, and that the STEMI data collection developed to promote this care is providing the support and evidence-base that clinicians require.

14 Acknowledgements

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