Queensland Ambulance Service

Prehospital ST-segment elevation myocardial infarction (STEMI) identified by paramedics in Queensland

2018-2019 report

Queensland Government

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

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Abbreviations

AMI	Acute Myocardial Infarction
BMI	Body Mass Index
CABG	Coronary Artery Bypass Graft
CCL	Cardiac Catheterisation Laboratory
CPR	Cardiopulmonary Resuscitation
ECG	Electrocardiogram
FMC	First Medical Contact
GCS	Glasgow Coma Scale
GCUH	Gold Coast University Hospital
IQR	Interquartile Range
LVEF	Left Ventricular Ejection Fraction
PAH	Princess Alexandra Hospital
PCI	Percutaneous Coronary Intervention
QAS	Queensland Ambulance Service
QCOR	Queensland Cardiac Outcomes Registry
QHAPDC	Queensland Hospital Admitted Patient Data Collection
RBWH	Royal Brisbane and Women's Hospital
SCUH	Sunshine Coast University Hospital
STEMI	ST-Segment Elevation Myocardial Infarction
TPCH	The Prince Charles Hospital

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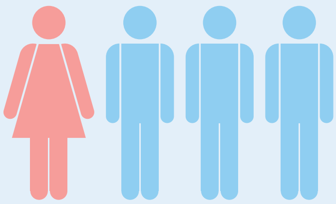
Key facts at a glance

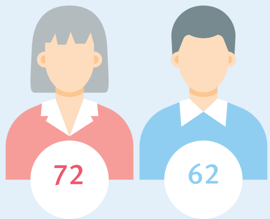
1080 STEMI patients

Identified by paramedics between 1 July 2018 and 30 June 2019

74.0% Male

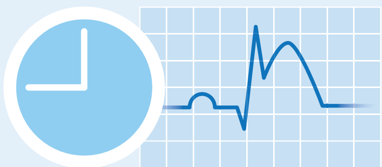


Median Age (years)



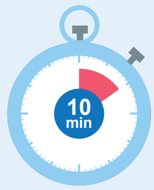
6 Minutes

Median time from scene arrival
to first 12-lead ECG



80.7%

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

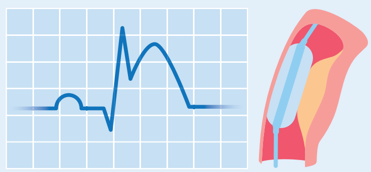


65.4%

Prehospital reperfusion
treatment rate

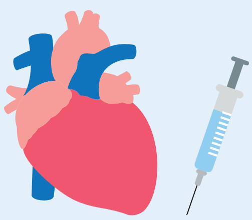
87 Minutes

Median time from STEMI
identification to primary PCI



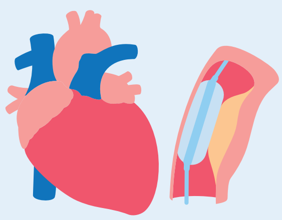
97.8%

30-day survival rate in patients
receiving prehospital fibrinolysis*



98.2%

30-day survival rate in patients
referred for primary PCI*



To increase sample size and for consistency with our published article, survival analysis was performed in all patients between 1 January 2016 and 31 December 2018.

1 Introduction

Since the Queensland Ambulance Service (QAS) introduced the Statewide Prehospital Reperfusion strategy in February 2008, over 10,000 patients across Queensland experiencing ST-segment elevation myocardial infarction (STEMI) have benefited from early prehospital reperfusion treatment. Expansion and enhancements to the program have continued to improve the availability and accessibility of prehospital cardiac reperfusion therapies for Queenslanders. Established as part of the program is an ever-developing STEMI data collection that comprehensively captures the epidemiology, clinical management, and outcomes of STEMI patients attended by QAS paramedics. A strong collaboration with the Queensland Cardiac Outcomes Registry (QCOR), Queensland Health, has enabled access to in-hospital treatment of STEMI patients, allowing for analysis of both the prehospital and in-hospital components of care.

Subsequent to our previous report[1] which presented information on the response, clinical care, and conveyance for STEMI patients treated by QAS paramedics between February 2008 and June 2018, this current report describes these important elements of prehospital STEMI management for the period between 1 July 2018 and 30 June 2019. This report also extends to provide detailed description of important in-hospital elements of STEMI care and survival outcomes through analysis of complementary datasets from QCOR, the Queensland Hospital Admitted Patient Data Collection (QHAPDC), and the Queensland Registry of Deaths.

2. Patient demographics

From 1 July 2018 to 30 June 2019, paramedics identified and treated a total of 1080 STEMI patients. Metropolitan areas accounted for the majority (64.7%) of cases, reflecting the concentration of state population in these areas. Three-quarters (74.0%) of patients were male. The median age (interquartile range, IQR) was 64 (56-74) years, with males being an average of 10 years younger than females (median age 62 versus 72 years) (Figure 1).

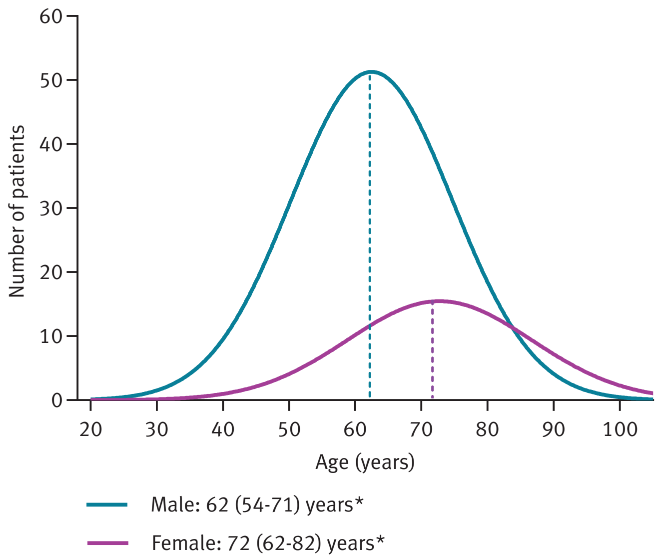


Figure 1. Age distribution, male versus female. *Median (IQR).

3. Reperfusion pathways and hospital destinations

Statewide, 65.4% (706/1080) of identified STEMI patients received a form of prehospital reperfusion therapy (direct referral for primary percutaneous coronary intervention [PCI] or prehospital fibrinolysis). The predominant treatment pathway was direct PCI referral (51.9%; 561/1080), whilst one-in-seven (13.4%; 145/1080) received prehospital fibrinolysis (Figure 2). Similar patterns were observed in metropolitan areas, whereas both prehospital reperfusion pathways were equally utilised in rural areas (Figure 2).

Among the PCI-capable hospitals that have a QAS paramedic referral pathway, The Princess Alexandra Hospital, The Prince Charles Hospital, Sunshine Coast University Hospital, Gold Coast University Hospital, and The Royal Brisbane and Women's Hospital accounted for the majority of direct PCI referral cases (Figure 3). Spatial distribution of direct PCI referral cases transported to each of these major hospitals is shown in Figure 4.

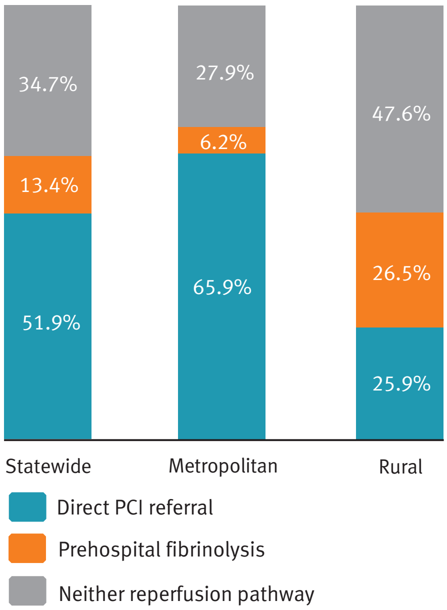


Figure 2. Prehospital reperfusion pathways. The sum of the percentages of "direct PCI referral" and "prehospital fibrinolysis" equals the percentage of "any form of reperfusion therapy."

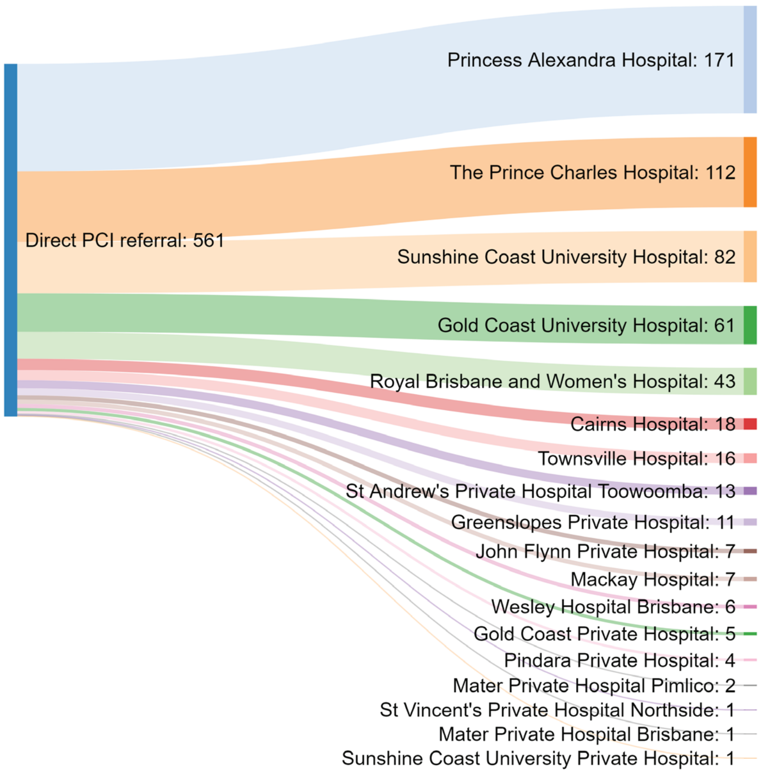


Figure 3. Flow diagram showing hospital destinations of direct PCI referral patients.

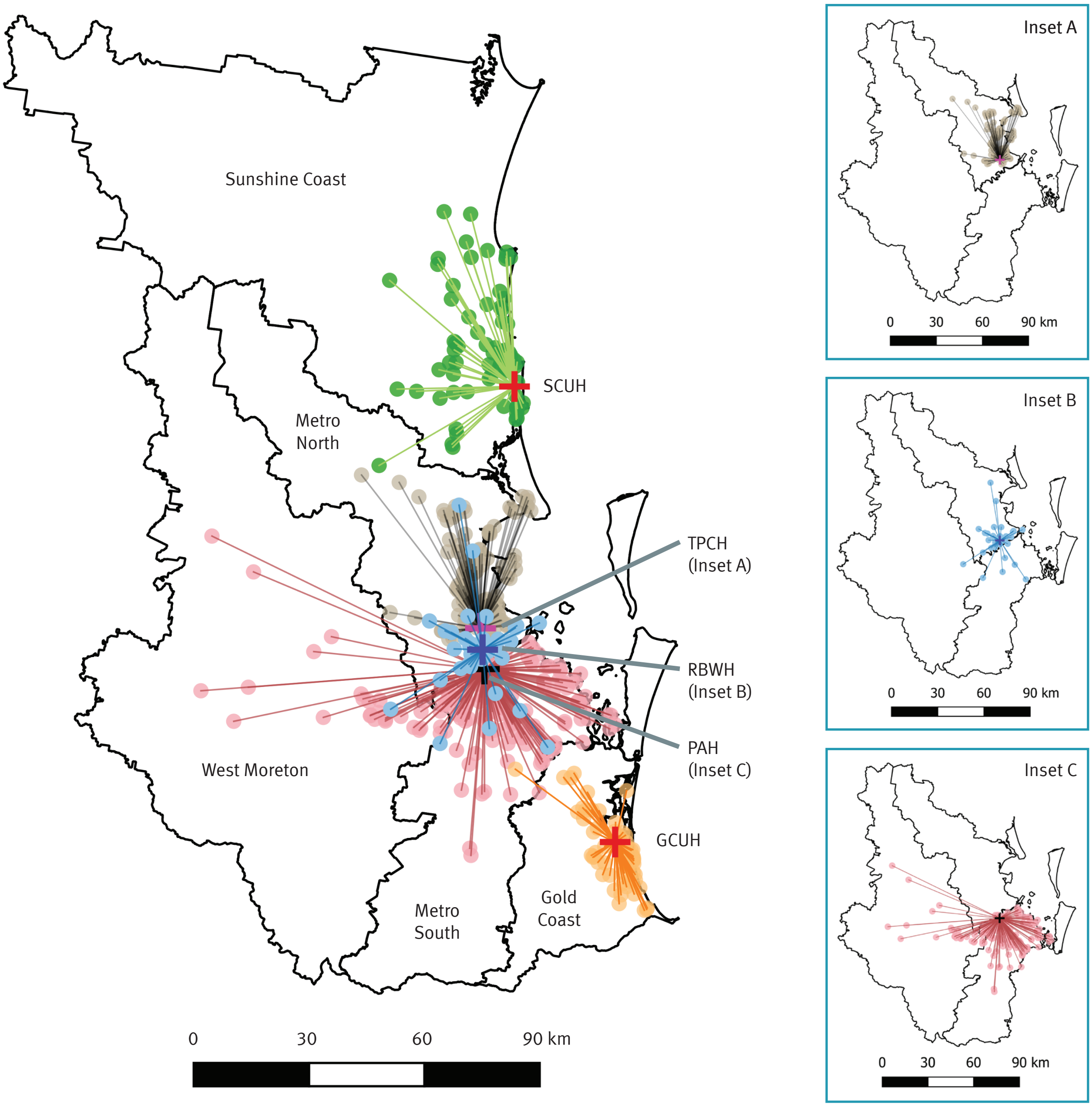


Figure 4. Spatial distribution of direct PCI referral cases transported to major PCI-capable hospitals. Each dot represents a patient, with the line representing the PCI-capable hospital to which the patient was transported.

Approximately half (46.9%; 68/145) of prehospital fibrinolysis patients were transported directly to a PCI-capable hospital following the index event, with The Princess Alexandra Hospital accounting for the largest proportion (42/68) of these cases (Figure 5). Nearly all patients initially transported to non-PCI hospitals were subsequently transferred to a PCI-capable hospital (Figure 6).

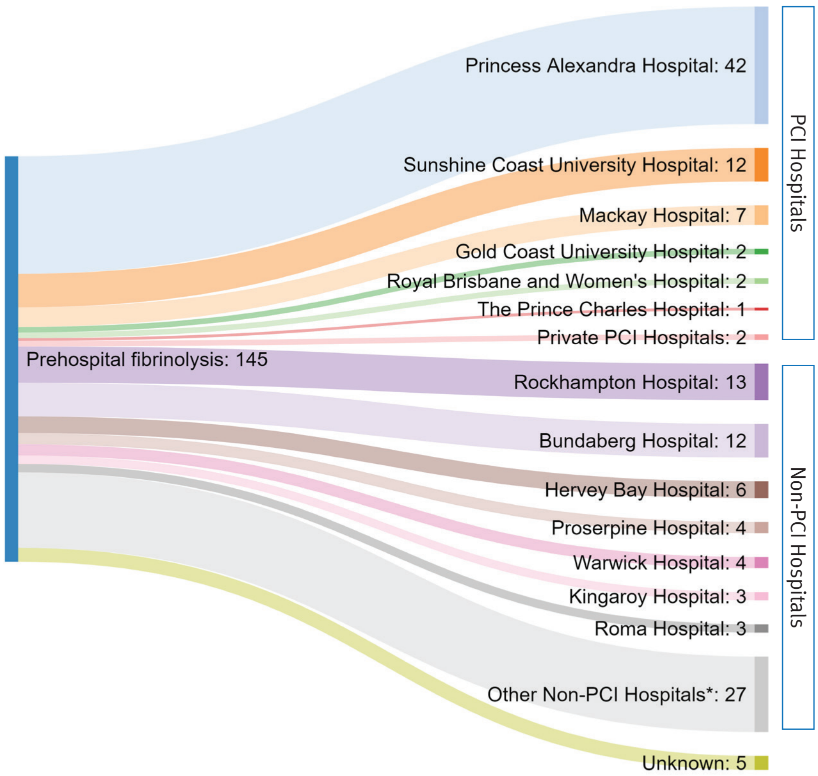


Figure 5. Receiving hospitals of prehospital fibrinolysis patients. *Between one and two patients for each hospital.

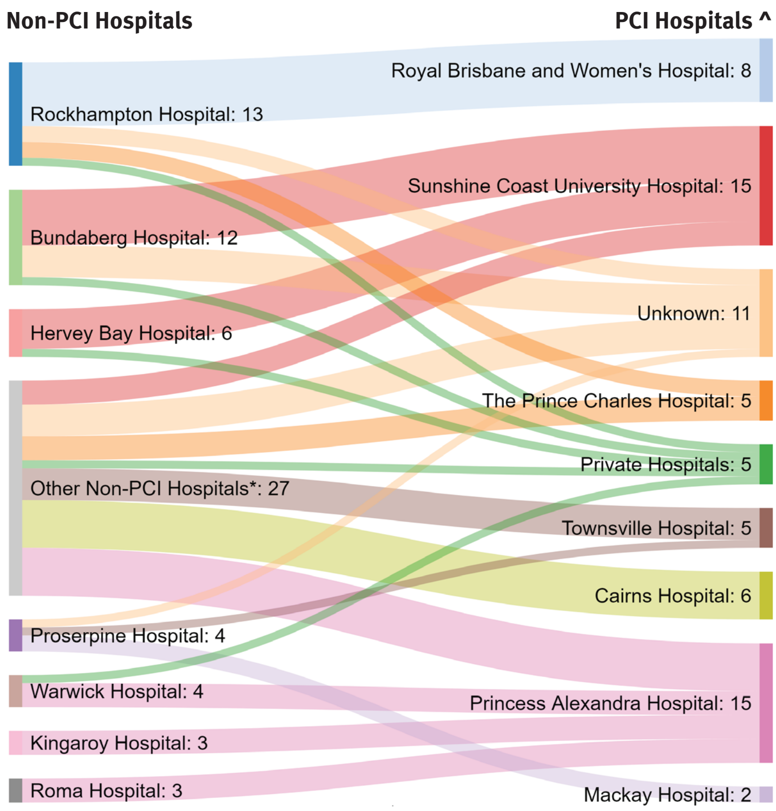


Figure 6. Subsequent transfer of prehospital fibrinolysis patients who were initially unable to be transported directly to a PCI-capable hospital. *Between one and two patients for each hospital. ^Could not be determined for unknown or private hospitals.

374 (34.7%) patients did not receive prehospital reperfusion therapy, all due to being contraindicated within the QAS reperfusion guidelines, with the exception of five patients who refused treatment and six patients without a known reason. The most common contraindication to reperfusion therapy was patient being pain free or experiencing atypical chest pain (accounted for 16.1% of the recorded contraindications), followed by Glasgow Coma Scale < 15 (13.9%), and close proximity to hospital (9.2%). The complete list of medical contraindications is displayed in Figure 7. These patients were still identified for prenotification to the receiving facility to ensure rapid assessment and treatment upon arrival.

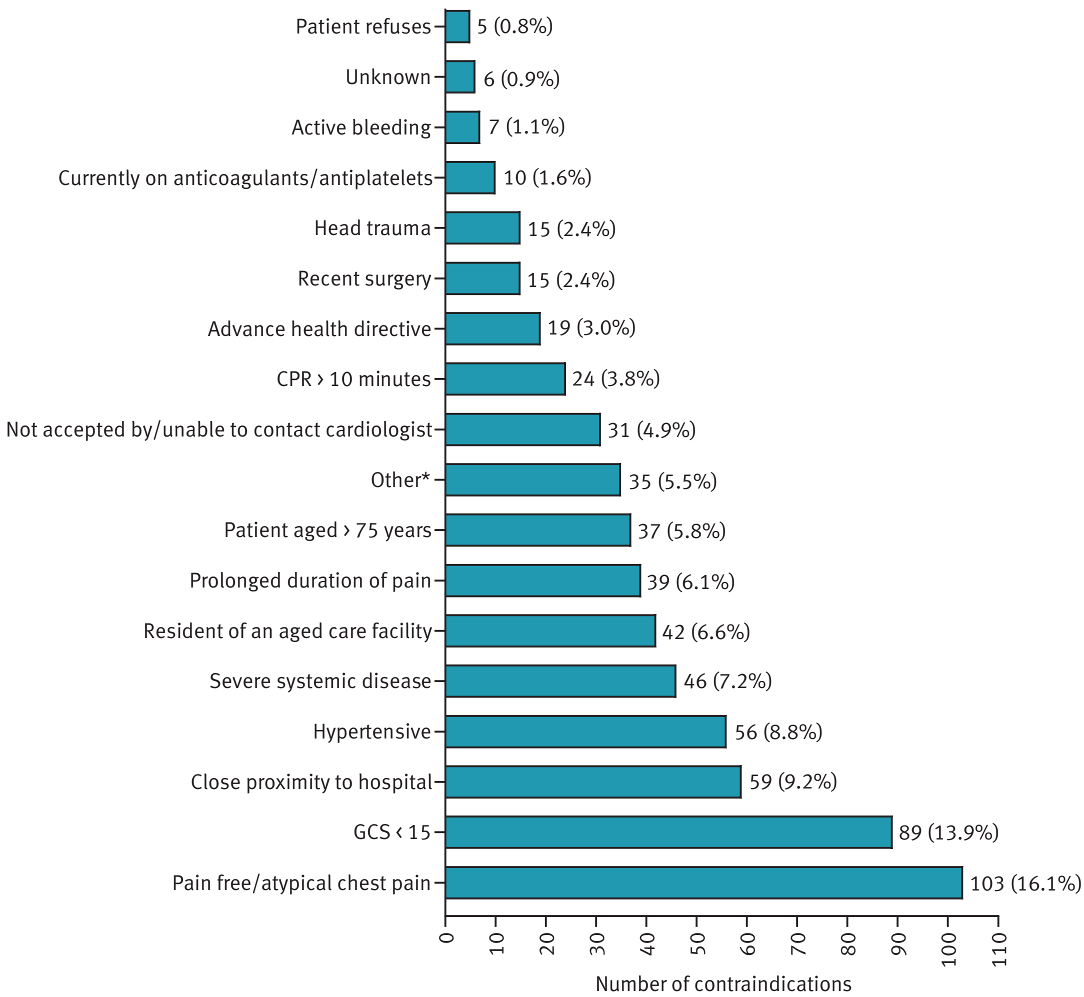


Figure 7. Contraindications to reperfusion therapy. *Includes unstable angina, unable to gain intravenous access, unable to contact QAS Clinical Consultation and Advice Line, unable to complete checklist due to patient not speaking English, suspected stroke, patient died at scene, acute pulmonary oedema, and abdominal aortic aneurysm.

4. Time from FMC to first 12-lead ECG

Early acquisition of a 12-lead electrocardiogram (ECG) in the field is critical because it allows for identification of STEMI, enables reperfusion therapies to be given in a prompt manner, and facilitates pre-activation of Cardiac Catheterisation Laboratory (CCL). During the reporting period (1 July 2018 – 30 June 2019), the median time (IQR) from first medical contact (FMC, defined as time of paramedic arrival at scene) to first 12-lead ECG was 6 (4-9) minutes (Figure 8). This time interval was well within the 10-minute benchmark recommended by international guidelines.[2] Statewide, this 10-minute benchmark was met in 80.7% of patients (Figure 8). The percentages of patients in metropolitan and rural areas who had first 12-lead ECG performed within 10 minutes of FMC were 83.0% and 76.3% (p = 0.009), respectively (Figure 8). For most patients (90.1%), STEMI was identified at first 12-lead ECG.

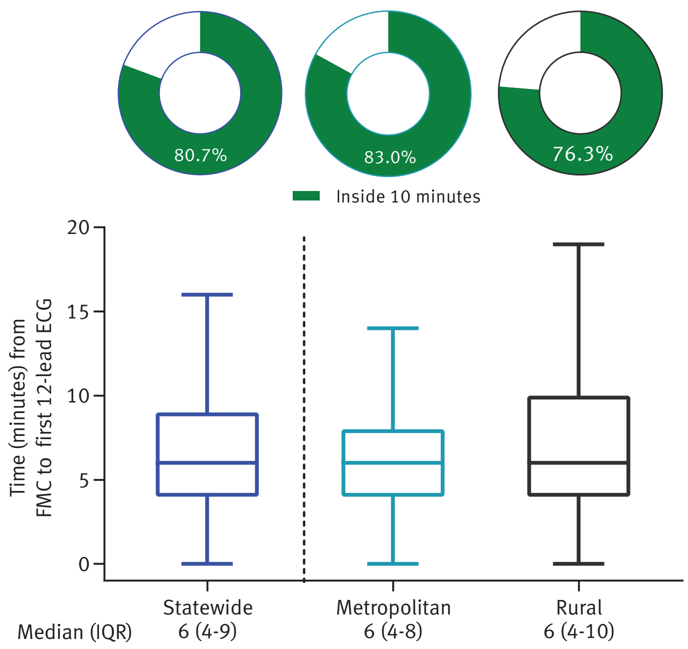


Figure 8. Time (minutes) from FMC to first 12-lead ECG. The middle line of the box represents median. The lower and upper hinges correspond to the 25th and 75th percentiles. The upper whisker extends from the hinge to the largest value no further than 1.5*IQR from the hinge. The lower whisker extends from the hinge to the smallest value at most 1.5*IQR of the hinge.

5. Time from STEMI identification to reperfusion treatment

For prehospital fibrinolysis patients, the median time (IQR) from STEMI identification to tenecteplase administration was 31 (24-40) minutes. For direct PCI referral patients, the median time (IQR) from STEMI identification to reperfusion was 87 (73-100) minutes. Our time from STEMI identification to reperfusion compares favourably with the literature, which reported door-to-reperfusion time between 88 and 120 minutes in the in-hospital setting.[3,4] Three-in-five (58.9%) direct PCI referral patients achieved reperfusion within 90 minutes following prehospital STEMI identification (Figure 9). For this patient group, time of reperfusion was defined as time of TIMI-3 flow where available, otherwise time of first device deployment. TIMI Grade Flow is a scoring system referring to levels of coronary blood flow assessed during PCI, with a score of 3 indicating normal flow.

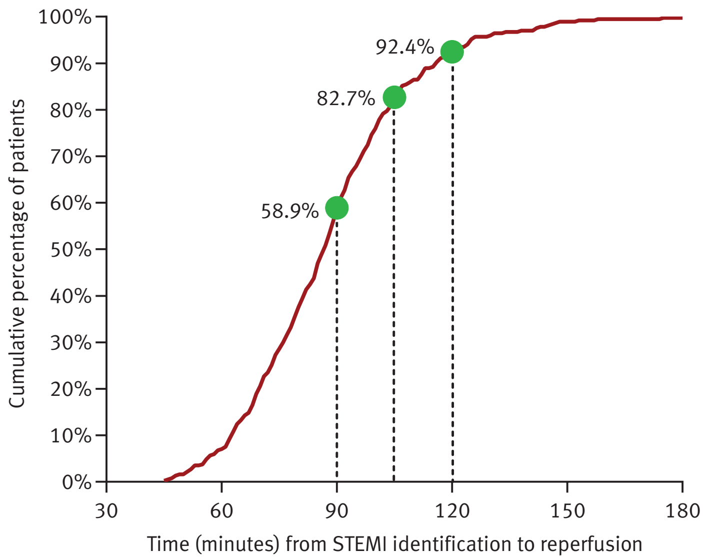


Figure 9. Distribution of time (minutes) from STEMI identification to reperfusion in direct PCI referral patients.

While our findings compare favourably with the broader literature, there is capacity for additional refinements to the STEMI strategy to deliver earlier reperfusion treatment for some patients. Figure 10 shows that time from arrival at the hospital to reperfusion was the largest time component and the main driver for delayed reperfusion. Ongoing quality improvement efforts are recommended for both the prehospital and in-hospital settings to further reduce delays in reperfusion.

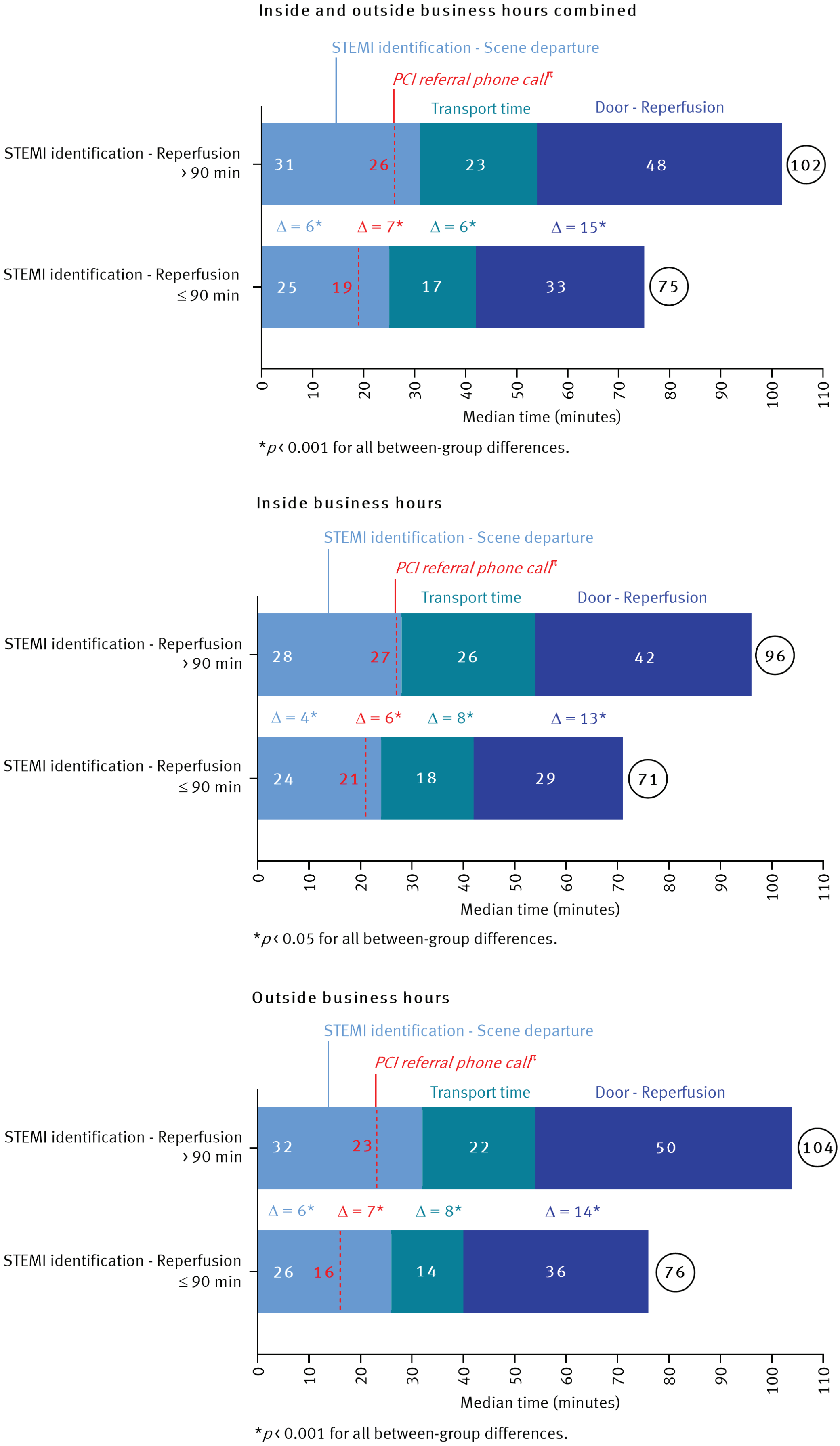


Figure 10. Comparison of time components between direct PCI referral patients who achieved reperfusion within 90 minutes following STEMI identification and those who achieved reperfusion after 90 minutes. [π]Time of PCI referral phone call was only available from 1 January 2019. Business hours were defined as Triple Zero call made between 8:00 and 15:59 on weekdays.

6. Survival and factors associated with survival

A separate analysis was performed to assess mortality in STEMI patients. This section is an excerpt from our recently published article.[5] Included in the analysis were all paramedic-identified STEMI patients between 1 January 2016 and 31 December 2018, who received prehospital reperfusion therapy (either prehospital fibrinolysis or direct PCI referral) and had QCOR and QHAPDC data. Of note, only data for patients presenting to public hospitals in Queensland were available in QCOR and QHAPDC datasets. Figure 11 shows how the study sample was derived.

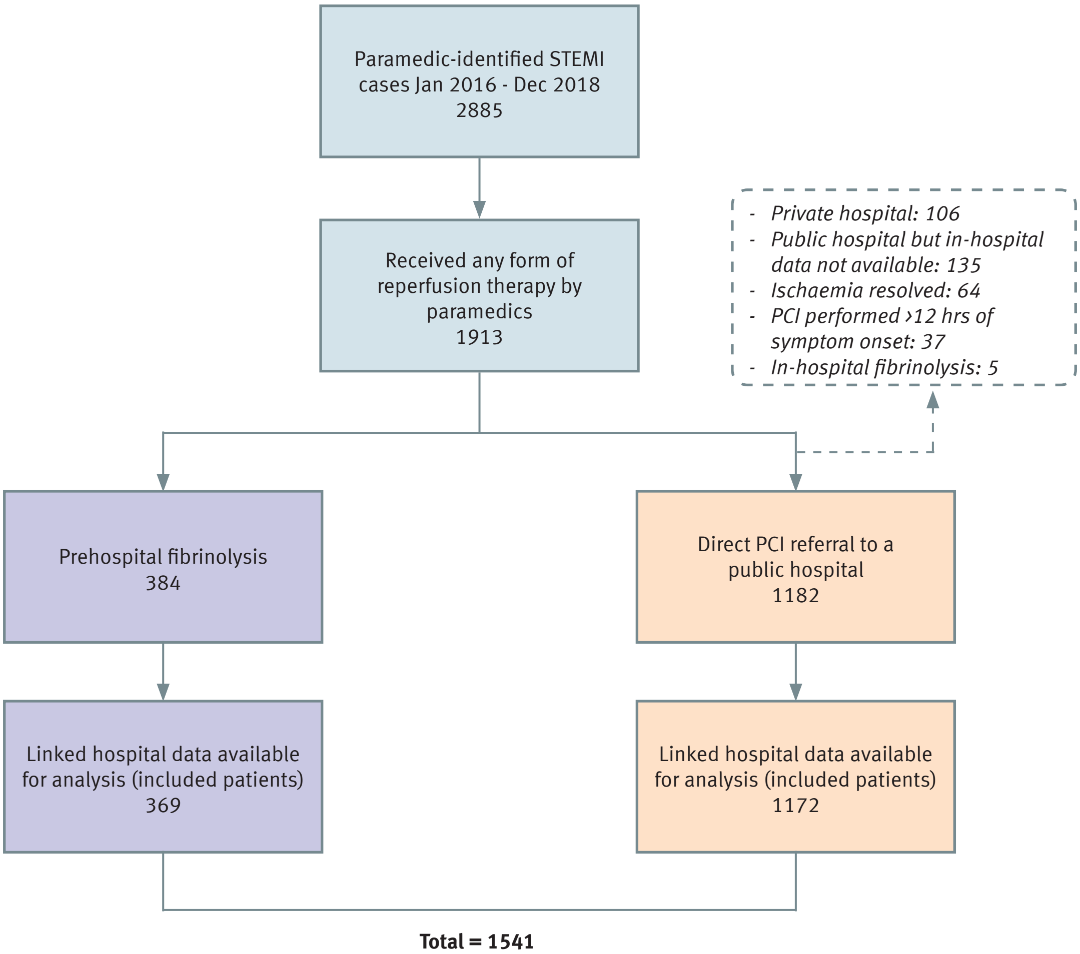


Figure 11. Flowchart showing how the study sample was derived.

30-day all-cause mortality was low, being 2.2% for the prehospital fibrinolysis group and 1.8% for the direct PCI referral group. One-year all-cause mortality for the two groups were 2.7% and 3.2%, respectively. Although there were numerical differences in mortality rates between the two groups, the differences were not statistically significant (between-group $p = 0.661$ for 30-day mortality and $p = 0.732$ for one-year mortality). The two groups also had comparable survival times (Figure 12). These 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)[6] and 9.8% (United States).[7]

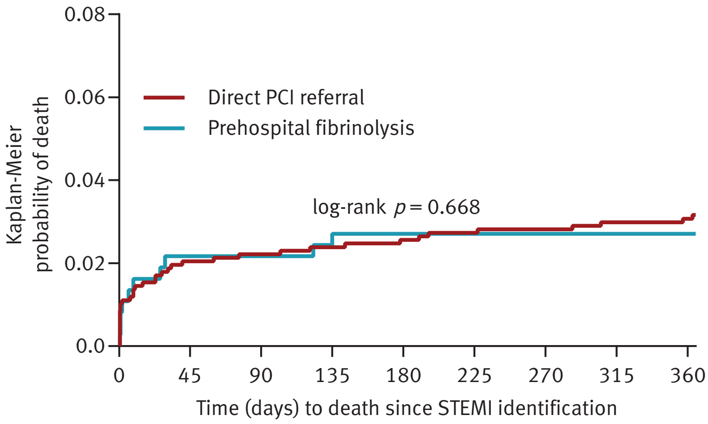


Figure 12. Kaplan-Meier curves showing survival times, stratified by prehospital reperfusion pathway.

For prehospital fibrinolysis patients, rate of failed fibrinolysis was reported and characteristics of patients with failed versus successful prehospital fibrinolysis were compared. Failed prehospital fibrinolysis was available in QCOR dataset and defined as unresolved pain and ST-segment elevation reduction less than 50% at 60 minutes following tenecteplase administration.[8] Failure to achieve reperfusion was observed in 20.1% of patients who received prehospital fibrinolysis. This figure compares favourably with the broader literature, which reported a rate of 27% in regional New South Wales,[9] 26% in New Zealand,[10] and 20.4% in Sweden.[11]

Table 1 compares the characteristics of patients with failed prehospital fibrinolytic therapy and those who achieved reperfusion with the therapy. Failed fibrinolysis patients had numerically higher rates of 30-day mortality (4.2% versus 1.4%, p = 0.148) and one-year mortality (4.2% versus 2.1%, p = 0.392) than successful fibrinolysis; however, such differences were not statistically significant. A higher proportion of patients with failed fibrinolysis were male (88.9% versus 78.3%, p = 0.046) and had history of heart failure (13.9% versus 5.6%, p = 0.022) than those with successful fibrinolysis (Table 1). After adjustment for confounding factors, both male gender and history of heart failure remained to be independent factors associated with failed fibrinolysis, increasing the likelihood of this event 2.3 times (95% confidence interval 1.04-5.08, p = 0.040) and 2.9 times (1.22-6.66, p = 0.016), respectively.

Table 1. Comparison of characteristics between patients with successful and failed prehospital fibrinolysis

Variable	Successful fibrinolysis n (%)	Failed fibrinolysis n (%)	*p*
Total number of patients*	286	72	-
Age[π]	58 (50-67)	57 (52-63)	0.363
Male	224 (78.3%)	64 (88.9%)	**0.046**
Time intervals (mins)[π]			
Paramedic response time[‡]	10 (7-17)	10 (7-17)	0.963
FMC – STEMI identification	6 (5-9)	6 (3-9)	0.403
STEMI identification – tenecteplase	32 (24-43)	32 (25-41)	0.931
Tenecteplase – arrival at hospital	29 (17-43)	31 (22-56)	0.096
BMI category			
Underweight	3 (1.0%)	0 (0.0%)	-
Overweight	111 (38.8%)	26 (36.1%)	0.786
Obese	109 (38.1%)	30 (41.7%)	0.591
Out-of-hospital cardiac arrest	33 (11.5%)	9 (12.5%)	0.838
Aboriginal and Torres Strait Islander	21 (7.3%)	3 (4.2%)	0.436
Medical history			
Diabetes mellitus	47 (16.4%)	11 (15.3%)	1.000
Hypertension	52 (18.2%)	10 (13.9%)	0.487
Current smoker	77 (26.9%)	12 (16.7%)	0.093
Cardiac arrhythmia	42 (14.7%)	13 (18.1%)	0.469
Heart failure	16 (5.6%)	10 (13.9%)	**0.022**
Previous PCI/CABG	24 (8.4%)	2 (2.8%)	0.128
Impaired kidney function on admission	30 (10.5%)	6 (8.3%)	0.668
30-day mortality	4 (1.4%)	3 (4.2%)	0.148
One-year mortality	6 (2.1%)	3 (4.2%)	0.392

**Unknown whether prehospital fibrinolytic therapy was successful or failed in 11 patients.*
[π]Presented as median (IQR).
[‡]Time from Triple Zero call to paramedic arrival at scene.
Bold p values indicate statistically significant ($p < 0.05$).

For direct PCI referral patients, factors associated with 30-day and one-year mortality were investigated. Low left ventricular ejection fraction on admission (LVEF ≤ 45%) and cardiogenic shock prior to PCI procedure were independent predictors of 30-day mortality (Table 2). In contrast, being overweight (body mass index 25-29.9 kg/m^2) was associated with lower risk of 30-day mortality (Table 2). Aboriginal and Torres Strait Islander status, low LVEF on admission, impaired kidney function on admission (estimated glomerular filtration rate < 60 mL/min/1.73m^2) and cardiogenic shock prior to PCI procedure were independently associated with one-year mortality (Table 3).

Table 2. Factors associated with 30-day mortality for direct PCI referral patients

Variable		Unadjusted hazard ratio (95% CI)	*p*	Adjusted hazard ratio (95% CI)‡	*p*
Age*		1.04 (1.01-1.08)	**0.029**	1.01 (0.96-1.05)	0.732
Male		5.32 (0.71-39.6)	0.103		
Aboriginal and Torres Strait Islander		3.30 (0.77-14.19)	0.108		
Inside business hours		0.81 (0.33-2.01)	0.648		
Out-of-hospital cardiac arrest		2.79 (0.82-9.46)	0.100		
BMI category					
	Underweight	5.91 (1.26-27.86)	**0.025**	3.34 (0.51-21.80)	0.203
	Overweight	0.29 (0.09-0.96)	**0.043**	0.24 (0.06-0.89)	**0.033**
	Obese	0.49 (0.16-1.51)	0.214	0.64 (0.19-2.17)	0.477
Time intervals$^{\pi}$					
	Paramedic response time	1.00 (0.94-1.07)	0.897		
	FMC – STEMI identification	1.02 (0.98-1.06)	0.297		
	STEMI identification – arrival at hospital	1.02 (0.99-1.04)	0.118		
	Arrival at hospital – reperfusion	1.01 (0.99-1.03)	0.073		
Medical history					
	Diabetes mellitus	1.14 (0.39-3.40)	0.808		
	Hypertension	1.07 (0.36-3.19)	0.901		
	Current smoker	0.67 (0.16-2.90)	0.597		
	Cardiac arrhythmia	2.82 (1.14-6.99)	**0.025**	1.31 (0.42-4.12)	0.643
	Previous PCI/CABG	1.88 (0.44-8.07)	0.396		
Low LVEF on admission		5.23 (1.46-18.75)	**0.012**	3.80 (1.05-13.68)	**0.042**
Impaired kidney function on admission		5.96 (2.06-17.19)	**0.001**	3.53 (0.84-14.86)	0.082
In-hospital events					
	Cardiogenic shock prior to PCI	47.24 (19.47-114.61)	**<0.001**	26.41 (7.55-92.44)	**<0.001**
	Intensive Care Unit admission	8.46 (3.28-21.80)	**<0.001**	1.47 (0.28-7.81)	0.641

**Hazard ratio for one-year increment.*
$^{\pi}$Hazard ratio for one-minute increment.
‡Variables statistically associated with mortality in the univariate analysis ($p < 0.05$) were included in the multivariate model.
Bold p values indicate statistically significant ($p < 0.05$).

Table 3. Factors associated with one-year mortality for direct PCI referral patients

Variable	Unadjusted hazard ratio (95% CI)	*p*	Adjusted hazard ratio (95% CI)‡	*p*
Age*	1.04 (1.01-1.07)	**0.009**	1.02 (0.99-1.06)	0.138
Male	2.21 (0.78-6.23)	0.134		
Aboriginal and Torres Strait Islander	3.84 (1.36-10.83)	**0.011**	4.95 (1.57-15.67)	**0.006**
Inside business hours	0.99 (0.51-1.92)	0.966		
Out-of-hospital cardiac arrest	1.48 (0.46-4.83)	0.512		
BMI category				
Underweight	4.41 (0.98-19.89)	0.054		
Overweight	0.74 (0.33-1.62)	0.449		
Obese	0.57 (0.23-1.42)	0.227		
Time intervals$^{\pi}$				
Paramedic response time	0.99 (0.93-1.04)	0.634		
FMC – STEMI identification	1.01 (0.98-1.04)	0.443		
STEMI identification – arrival at hospital	1.01 (0.99-1.03)	0.366		
Arrival at hospital – reperfusion	1.01 (0.99-1.02)	0.231		
Medical history				
Diabetes mellitus	1.14 (0.50-2.59)	0.762		
Hypertension	1.07 (0.47-2.43)	0.878		
Current smoker	0.77 (0.27-2.19)	0.630		
Cardiac arrhythmia	2.73 (1.37-5.44)	**0.004**	1.58 (0.73-3.41)	0.245
Previous PCI/CABG	1.03 (0.25-4.27)	0.972		
Low LVEF on admission	4.69 (1.89-11.61)	**0.001**	3.60 (1.41-9.23)	**0.009**
Impaired kidney function on admission	4.29 (2.12-8.66)	**<0.001**	2.39 (1.11-5.15)	**0.026**
In-hospital events				
Cardiogenic shock prior to PCI	23.75 (10.82-52.15)	**<0.001**	10.82 (3.88-30.19)	**<0.001**
Intensive Care Unit admission	6.03 (2.75-13.18)	**<0.001**	1.55 (0.54-4.51)	0.416

**Hazard ratio for one-year increment.*
$^{\pi}$Hazard ratio for one-minute increment.
‡Variables statistically associated with mortality in the univariate analysis ($p < 0.05$) were included in the multivariate model.
Bold p values indicate statistically significant ($p < 0.05$).

The finding that being overweight was associated with lower risk of 30-day mortality is in agreement with previous studies.[12,13] This finding is another example of the “obesity paradox” that has been described in patients with acute myocardial infarction (AMI), in which overweight and obese patients are found to have lower short-term mortality after AMI than normal weight patients.[12,13] Several theories have been proposed to explain this obesity paradox. It is hypothesised that excess weight confers a protective advantage by providing nutritional reserves to overcome acute stress and increased metabolic demands during AMI.[13] Another theory suggests that clinicians may treat overweight and obese patients more aggressively due to their perceived high risks of cardiovascular disease associated with obesity.[14] Because of their cardiovascular risk factors, patients with elevated BMI may also receive more aggressive secondary prevention after discharge.[13]

Aboriginal and Torres Strait Islander status was found to be associated with increased risk of one-year mortality, consistent with previous studies in Queensland[15] and New South Wales.[16] Poorer prognosis in Aboriginal and Torres Strait Islander persons may be attributable to differences in cultural, behavioural, psychosocial, lifestyle, biological, and environmental risk factors. The finding reinforces the need to identify and address factors impacting on the health and welfare of Aboriginal and Torres Strait Islander Australians.

7. Conclusions

This report demonstrates the high standard of prehospital STEMI care that QAS paramedics provide to Queenslanders. This is effected by rapid response, timely diagnosis and treatment, and appropriate conveyance of patients to definitive care. The time interval from FMC to first 12-lead ECG is well within the 10-minute benchmark recommended by international guidelines. Notably, three-in-five patients received primary PCI within the ambitious international benchmark of 90 minutes following STEMI identification. Mortality remains low, and our real-world data show that prehospital fibrinolysis is a safe and effective reperfusion strategy, and results in similar survival to primary PCI.

The positive collaboration with QCOR has enabled a detailed examination of important in-hospital elements of STEMI management, to enable evaluation of patient outcomes across the continuum of care. Data contribution from QCOR allows the capture of a more complete picture of health service performance, patient journey and outcomes. The findings of this report will form a basis to identify further opportunities for service improvement, with the focus on optimising patient outcomes.

8. Acknowledgements

This report was prepared by Dr Tan Doan and Associate Professor Emma Bosley with contributions from Dr Stephen Rashford, Ms Kirsten Wilson, Mr Brett Rogers and Ms Elizabeth Cardwell. We would like to thank Mr William Vollbon and Mr Marcus Prior at the Statewide Cardiac Clinical Informatics Unit for their contribution of data relating to in-hospital processes.

9. References

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2018-2019 report

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