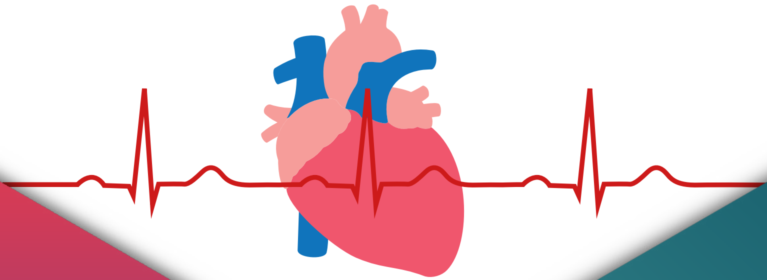
Queensland Ambulance Service

Out of Hospital Cardiac Arrest in Queensland:

With comparison of pre-COVID-19 and COVID-19 periods



2020
ANNUAL REPORT

Queensland Government

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Abbreviations

ACP	Advanced Care Paramedic
ALS	Advanced Life Support
AOR	Adjusted Odds Ratio
CCP	Critical Care Paramedic
CI	Confidence Interval
CO	Carbon Monoxide
CPR	Cardiopulmonary Resuscitation
DNR	Do Not Resuscitate
ECG	Electrocardiogram
EIDS	Emerging Infectious Disease Surveillance
FAST	Focused Assessment with Sonography for Trauma
GI	Gastrointestinal
HARU	High Acuity Response Unit
HHS	Hospital and Health Service
IQR	Interquartile Range
IV	Intravenous
LASN	Local Ambulance Service Network
LGA	Local Government Area
OHCA	Out-of-Hospital Cardiac Arrest
PEA	Pulseless Electrical Activity
PPE	Personal Protective Equipment
QAS	Queensland Ambulance Service
QLD	Queensland
RACF	Residential Aged Care Facility
ROSC	Return of Spontaneous Circulation
RR	Relative Risk
SIDS	Sudden Infant Death Syndrome
TCA	Traumatic Cardiac Arrest
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia
WHO	World Health Organization

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Key facts at a glance

5703 cardiac arrests attended

2298 resuscitations attempted

Utstein patient group

- 44% survived event
- 26% discharged alive
- 26% survived to 30 days

COVID-19 and OHCA

Community transmission and number of cases in QLD were very low

COVID-19 did not affect OHCA rates, time metrics and survival

	Pre-COVID-19 (16/3 – 31/12/2019)	COVID-19 (16/3 – 31/12/2020)
Number of patients*	1429	1454
Response time	8 mins	8 mins
At scene – CPR/Defibrillation	2 mins	2 mins
Survived event	28%	25%
Discharged alive	11%	10%
30-day survival	11%	10%

* Adult, not paramedic-witnessed, attempted-resuscitation

Spatiotemporal variation in risk of OHCA occurrence

Regional variation in risk of OHCA occurrence existed

Highest risk in northern half of the state

Traumatic cardiac arrests

- 62% pronounced deceased on paramedic arrival
- 38% receiving a resuscitation attempt from paramedics
- Motor vehicle collision was the most common mechanism of injury
- Traumatic OHCA can be salvageable. Survival outcomes among attempted-resuscitation patients:
  - 15% survived event
  - 10% discharged alive
  - 10% survived to 6 months

Amiodarone for refractory VF

Cases where amiodarone was administered earlier were associated with higher survival rates, with optimal time window being within 23 mins following arrest

1. About this report

This annual report presents findings from the 2020 calendar year for out-of-hospital cardiac arrest (OHCA) patients who were attended by Queensland Ambulance Service (QAS) paramedics. It describes important information on the response, management, conveyance, and survival outcomes for those patients. Presented as a special focus in this report is a description of the QAS activities and initiatives in response to COVID-19. It describes and compares important prehospital time intervals, patient and arrest-related characteristics, and survival outcomes between the COVID-19 period within this report (16/03 – 31/12/2020) and a matched pre-COVID-19 period from the previous year (16/03 – 31/12/2019).

This report extends to provide a spatiotemporal (i.e. space-time) analysis of OHCA risk in Queensland. With 78 local government areas (LGAs) spanning over a vast landmass (1.73 million km^2), there exists disparities in health risk across Queensland due to region-specific demographic and geographic factors.[1,2] It is therefore imperative to identify region-specific risks of OHCA so that interventions (e.g. public training in cardiopulmonary resuscitation [CPR], public-access defibrillators) and resource allocation can be targeted and optimised. This report estimates and thematically maps the risk of OHCA for all regions in Queensland over a 13-year period between January 2007 and December 2019. A mathematical approach that accounts for temporal and spatial heterogeneity, and demographic features is used. All paramedic-attended OHCA cases during the study period are included.

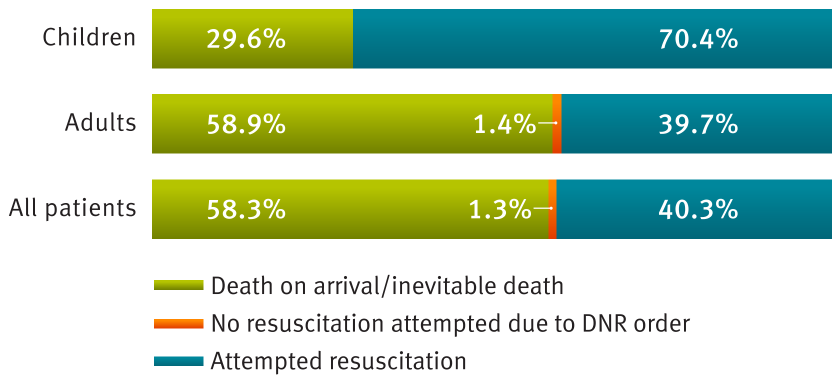
Out-of-hospital traumatic cardiac arrests (TCA) are a sub-group of OHCA patients in which regional variation is prevalent regarding epidemiology, management and outcomes.[3-9] This report analyses a cohort of out-of-hospital TCA patients over a 13-year period between January 2007 and December 2019. Mechanisms of injury, survival outcomes, and factors associated with survival are investigated. The information generated from this analysis is valuable for guiding public health responses and identifying areas where improvements in management and survival can be achieved.

OHCA patients with refractory ventricular fibrillation (VF) represent another group of patients that require a nuanced approach to management. Arrests that present with a VF initial rhythm generally have a relatively good prognosis, provided that they receive early defibrillation. Some patients however suffer refractory VF; that is, they are resistant to defibrillation, with VF persisting after three defibrillation attempts. International guidelines recommend the use of amiodarone (an antiarrhythmic agent) on OHCA patients with refractory VF.[10,11] For OHCA interventions broadly, studies have consistently shown a negative association between time to intervention and subsequent outcome, with earlier administration associated with better survival.[12-14] However, such literature regarding timing of amiodarone administration remains scarce. This report examines a cohort of refractory VF patients who receive a resuscitation attempt from QAS paramedics between January 2015 and December 2019. It investigates the association between time to amiodarone administration and survival outcomes. Optimal time window for the administration of amiodarone is also examined.

2. Incidence and demographics

In 2020, QAS paramedics attended a total of 5703 OHCA cases. Of these, 108 (1.9%) were children (< 16 years of age), and 5595 (98.1%) were adults. Table 1 compares the characteristics between children and adults. Seven-in-ten (70.4%) children received a resuscitation attempt from paramedics, compared to four-in-ten (39.7%) adults. Sudden infant death syndrome (SIDS) was the most common aetiology in children (20.4%); whereas presumed cardiac aetiology (51.6%) was the primary cause of OHCA in adults. The rate of bystander CPR was two times higher in children (63.0%) than in adults (30.7%).

Table 1. Comparison of characteristics between children and adults

<table>
<tr><th>Variable</th><th>All patients</th><th>Adults</th><th>Children</th></tr>
<tr><td>Total number</td><td>5703</td><td>5595</td><td>108</td></tr>
<tr><td>Male</td><td>3818 (66.9%)</td><td>3764 (67.3%)</td><td>54 (50.0%)</td></tr>
<tr><td>Median age (years)</td><td>66</td><td>66</td><td>2</td></tr>
<tr><td>Arrest occurring at home</td><td>4714 (82.7%)</td><td>4630 (82.8%)</td><td>84 (77.8%)</td></tr>
<tr><td>Attempted resuscitation</td><td colspan="3">
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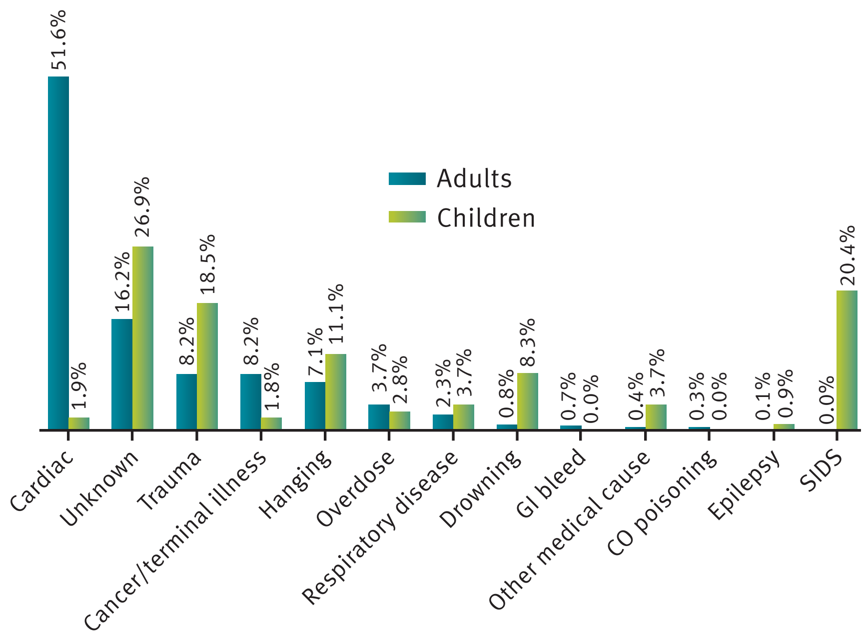
<tr><td>Aetiology</td><td colspan="3">
</td></tr>
<tr><td>Bystander CPR</td><td>1786 (31.3%)</td><td>1718 (30.7%)</td><td>68 (63.0%)</td></tr>
</table>

3. Paramedic time intervals

In 2020, the median response time (from receipt of Triple Zero call to first paramedic arrival at scene) of 8.5 minutes was comparable between metropolitan and rural areas (Figure 1). For bystander-witnessed arrest, the median time from collapse (assumed to be the time of Triple Zero call) to first paramedic arrival at scene was 8 minutes. For those patients, the time interval from paramedic arrival at scene to CPR or defibrillation (whichever occurred earlier) was 2 minutes, and to intravenous cannulation was 10 minutes (Figure 2). For paramedic-witnessed arrest, CPR/defibrillation was performed immediately following collapse, and intravenous cannulation on average 10 minutes following collapse (Figure 2).

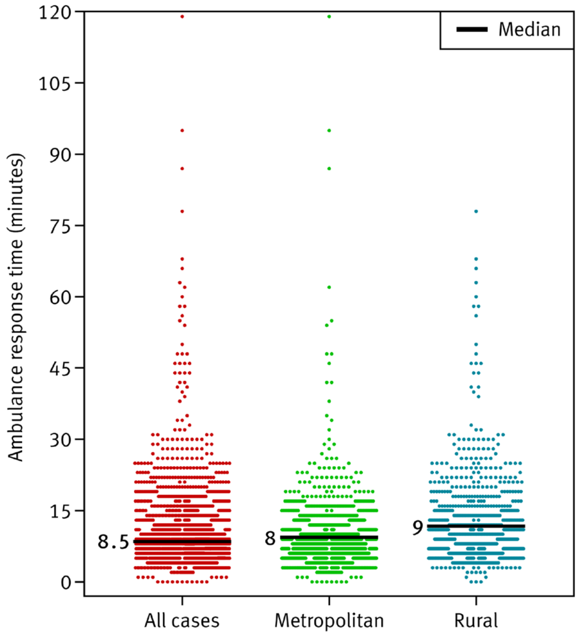


Figure 1. Ambulance response time.

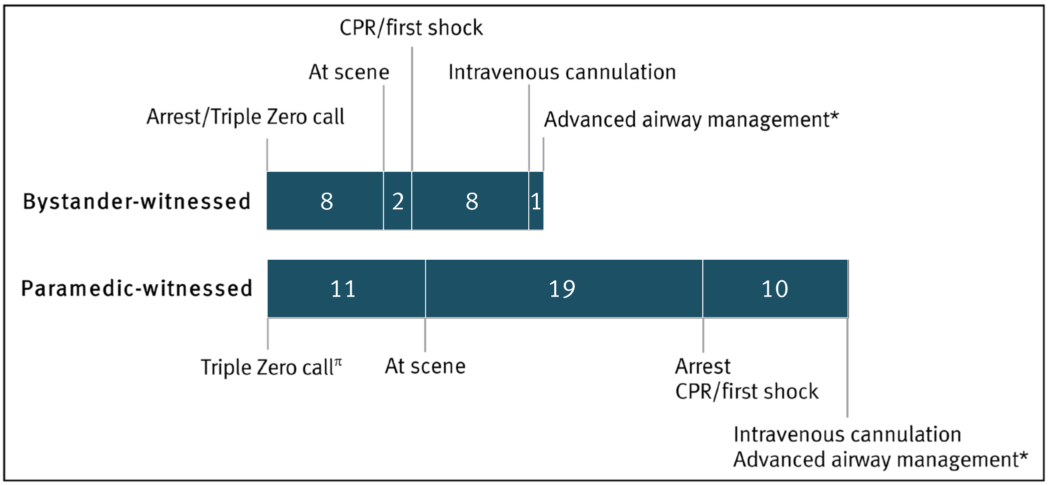


Figure 2. Paramedic time intervals (minutes).

*Endotracheal intubation or laryngeal mask airway.

^π For paramedic-witnessed arrest, time of Triple Zero call relates to the original reason for calling, not the arrest.

4. Survival outcomes

Survival outcomes of various patient groups are presented in Figure 3. For all patients who received an attempted resuscitation from paramedics, rates of event survival (return of spontaneous circulation [ROSC] that sustained to hospital arrival), survival to hospital charge, and 30-day survival were 29.2%, 14.2%, and 14.2%, respectively.

Cardiac arrest in the presence of paramedics has the benefit of receiving immediate intervention by paramedics. It is well-established that paramedic witness status is a strong predictor of survival. Indeed, Figure 3 shows that paramedic-witnessed patients had the highest survival rates among the investigated patient groups, with event survival, survival to discharge, and 30-day survival rates being 48.9%, 36.6%, and 36.6%, respectively (Figure 3).

Arrest witnessed by a bystander and having initial shockable rhythm (the Utstein patient group) is another strong predictor of survival. In 2020, there were 322 cardiac arrests attended by QAS paramedics that met the Utstein criteria (all-cause, resuscitation attempted, initial shockable rhythm, bystander-witnessed). For this patient group, the rates of event survival, survival to discharge, and 30-day survival were 44.1%, 26.4%, and 26.1%, respectively (Figure 3).

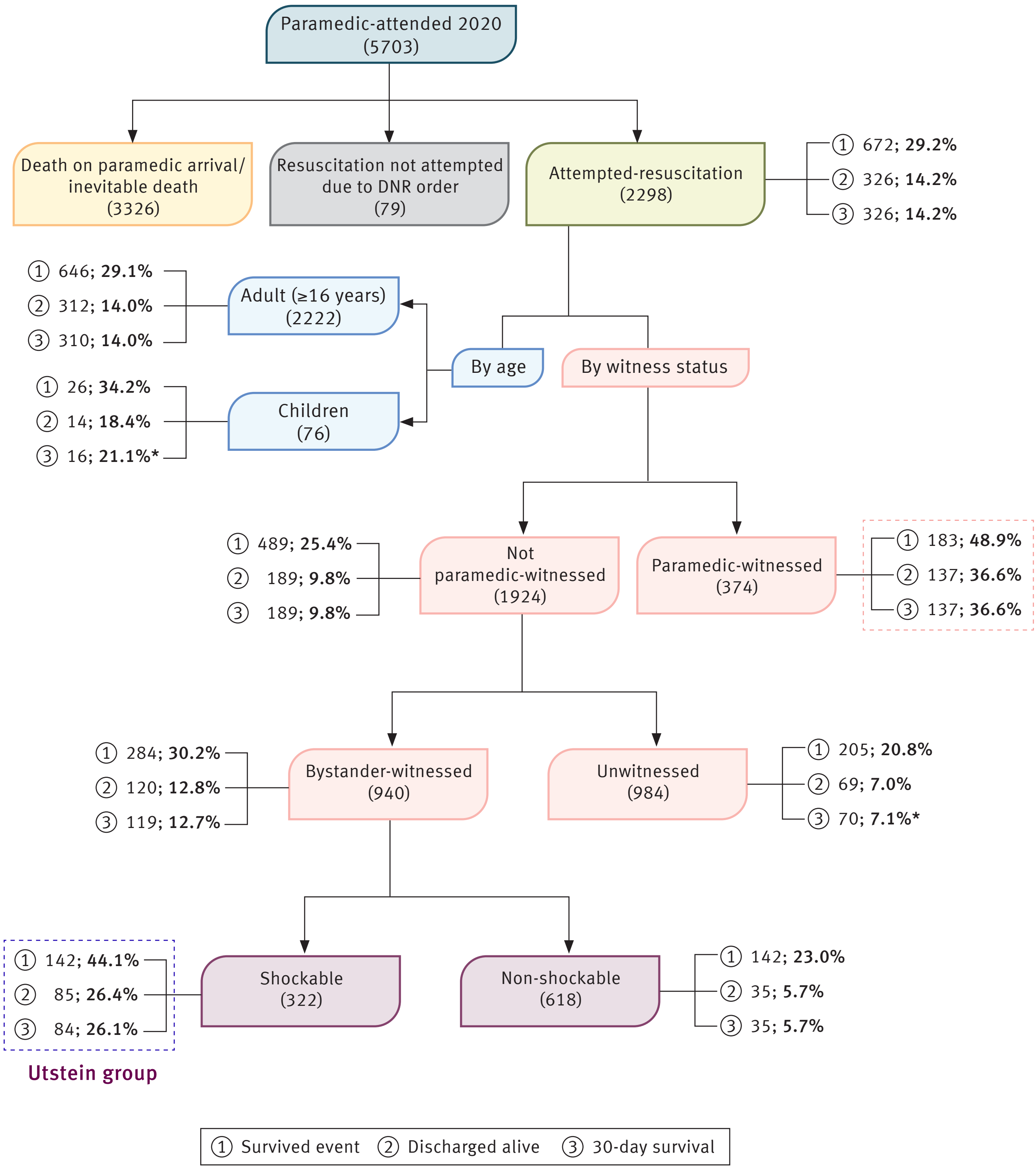


Figure 3. Survival rates of different patient groups.

*30-day survival was higher than survival to discharge because some patients stayed in the hospital for more than 30 days (and died on discharge).

5. COVID-19 and OHCA

Figure 4 shows timeline of COVID-19 in Queensland, and the QAS key clinical policies and procedures in response to the pandemic. Queensland's first COVID-19 case was confirmed on 28 January 2020, three days after Australia reported its first case. COVID-19 created unprecedented challenges for the QAS workforce, as well as for the community more broadly. The QAS was agile and rapid in undertaking preparatory activities and initiatives, and in implementing clinical procedures and policies. This was to ensure we mitigated the risks of COVID-19 with a world-leading health response, while continuing to provide the highest level of clinical care to all patients and maintain the health and safety of QAS staff. Along with other health and emergency services, the QAS played an integral part in protecting Queensland community.

Regarding OHCA-specific PPE requirements, full PPE (protective eyewear, P2/N95 mask, gloves, thumb gown) was mandated for attendance of OHCA patients during periods of heightened risks. Outside those periods, PPE with protective eyewear, P2/N95 mask and gloves were required, with the addition of thumb gown if the patient was a suspected or confirmed COVID-19.

The aforementioned initiatives and procedures that the QAS has undertaken have ensured that the QAS continued to provide timely and quality ambulance services to Queensland community, as well as maintaining the safety and wellbeing of QAS staff.

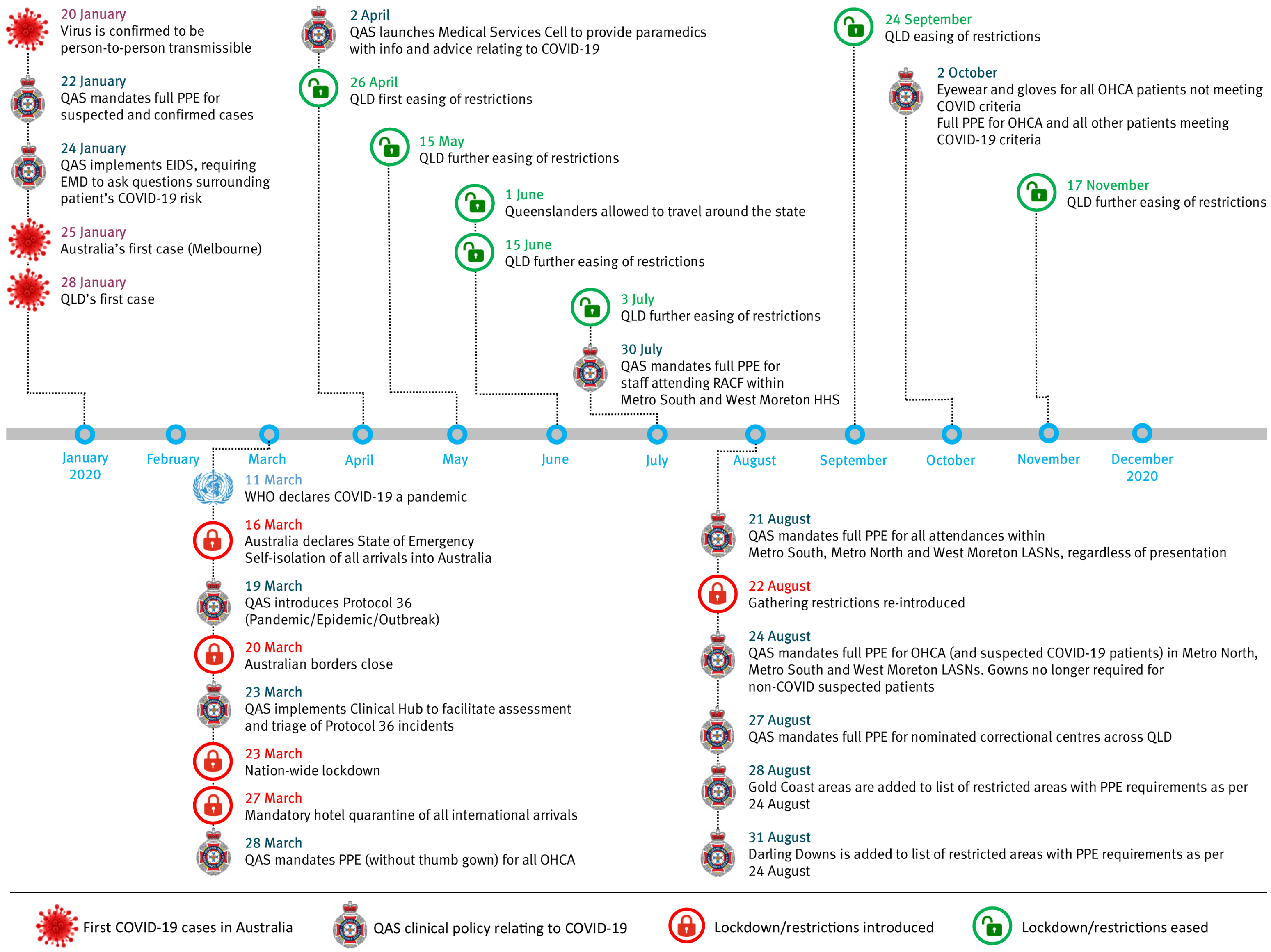


Figure 4. Timeline of COVID-19 in Queensland, and QAS key clinical procedures and policies in response to the pandemic.

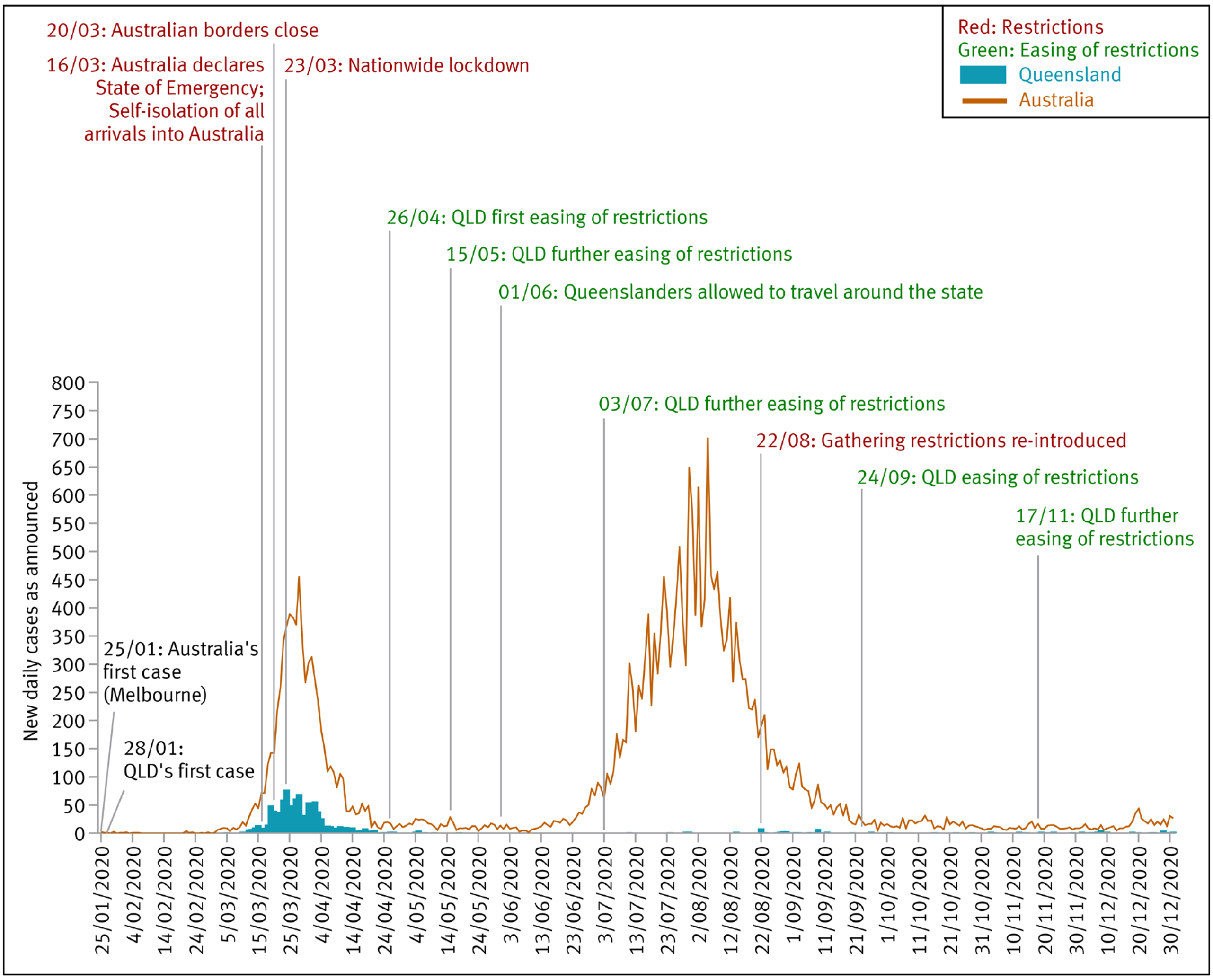


Figure 5. New daily cases of COVID-19 as announced, Queensland versus Australia total.

To examine the potential impact of COVID-19 and associated changes to clinical practices on OHCA in Queensland, we conducted an analysis of adult patients attended by QAS paramedics during the COVID-19 period, which was defined as 16 March 2020 (Australia declared State of Emergency) through to 31 December 2020 (cut-off day of this report). The pre-COVID-19 comparator period was from the same dates 2019. Paramedic-witnessed events and patients who had a DNR order were excluded.

Community transmission rates and number of new daily cases of COVID-19 in Queensland were very low during the reporting period (Figure 5) and there was no systematic variation in ambulance time intervals during this period (Figure 6). Table 2 summarises patient and arrest characteristics in the COVID-19 and comparator periods. The proportion of patients that received an attempted resuscitation from paramedics were comparable between the two periods (38.4 versus 38.0%, $p = 0.705$). Age and gender distribution did not differ between the two periods. However, arrests occurring in public locations significantly decreased by more than 30% in the COVID-19 period compared to the pre-COVID-19 period (8.4 versus 12.0%, $p < 0.001$). Rates of bystander CPR (70.9 versus 75.8%, $p = 0.003$) and initial shockable rhythm (22.8 versus 26.4%, $p = 0.027$) also significantly decreased during the COVID-19 period (Table 2). This highlights the need for public CPR training. Furthermore, understanding the factors that prevent bystanders from performing CPR is important so that those barriers can be mitigated. Previous research has shown that the close relationship between patients and their family members can cause the potential helper to experience significant psychological stress and consequently fail to initiate CPR.[15] A smaller proportion of arrests was caused by medical aetiology during the COVID-19 period, although the difference was not statistically significant (80.1 versus 82.7%, $p = 0.069$). This may reflect people's reluctancy to go to the hospital due to fear of COVID-19. Whilst survival rates during the COVID-19 period were numerically lower than the comparator period, such differences were not statistically significant (Figure 7). It should be noted that any true impact of COVID-19 on survival outcomes may not have been able to be identified due to the small numbers of patients.

Table 2. Comparison of patient and arrest characteristics between pre-COVID-19 and COVID-19 periods

Variable	Pre-COVID-19 (16/03 – 31/12/2019)	COVID-19 (16/03 – 31/12/2020)	*p*
(A) ≥ 16 years, not paramedic-witnessed, did not have a DNR order.			
Number of patients	3764	3785	-
Attempted resuscitation	1429 (38.0%)	1454 (38.4%)	0.705
(B) ≥ 16 years, not paramedic-witnessed, did not have a DNR order, attempted-resuscitation. This is a subset of (A).			
Number of patients	1429	1454	-
Male	998 (69.8%)	1015 (69.8%)	1.000
Age ≥ 65 years old	728 (50.9%)	696 (47.9%)	0.101
Location of arrest			**< 0.001**
Private residence	1049 (73.4%)	1160 (79.8%)	
Public place	172 (12.0%)	122 (8.4%)	
Bystander-witnessed	743 (52.0%)	710 (48.8%)	0.094
Bystander CPR	1083 (75.8%)	1031 (70.9%)	**0.003**
Medical aetiology	1182 (82.7%)	1164 (80.1%)	0.069
Initial shockable rhythm	377 (26.4%)	332 (22.8%)	**0.027**

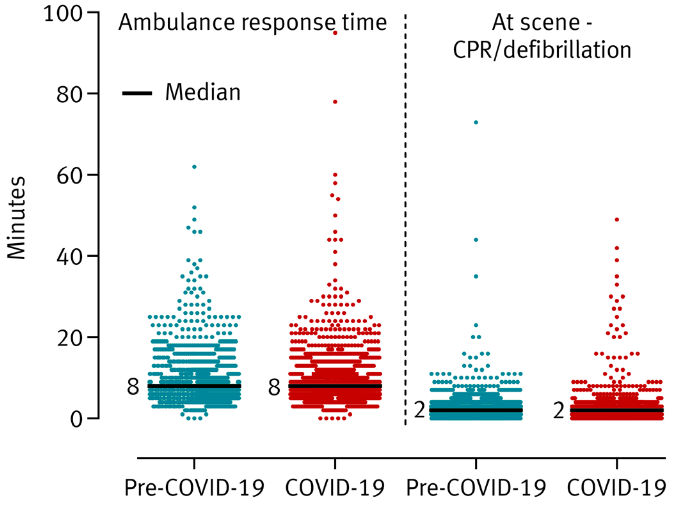


Figure 6. Comparison of time intervals (ambulance response time, and time from first paramedic arrival at scene to CPR/defibrillation) between the COVID-19 and pre-COVID-19 periods.

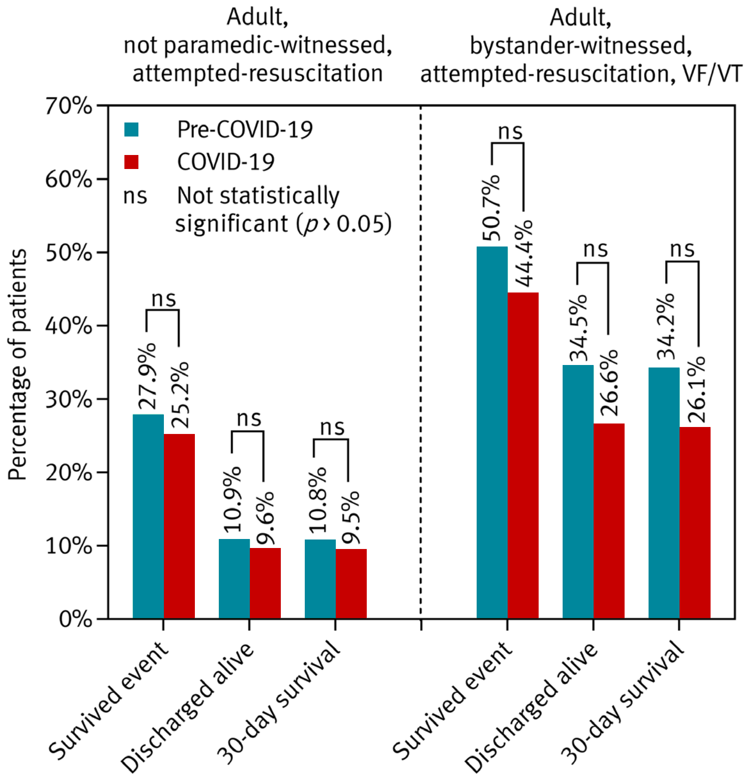
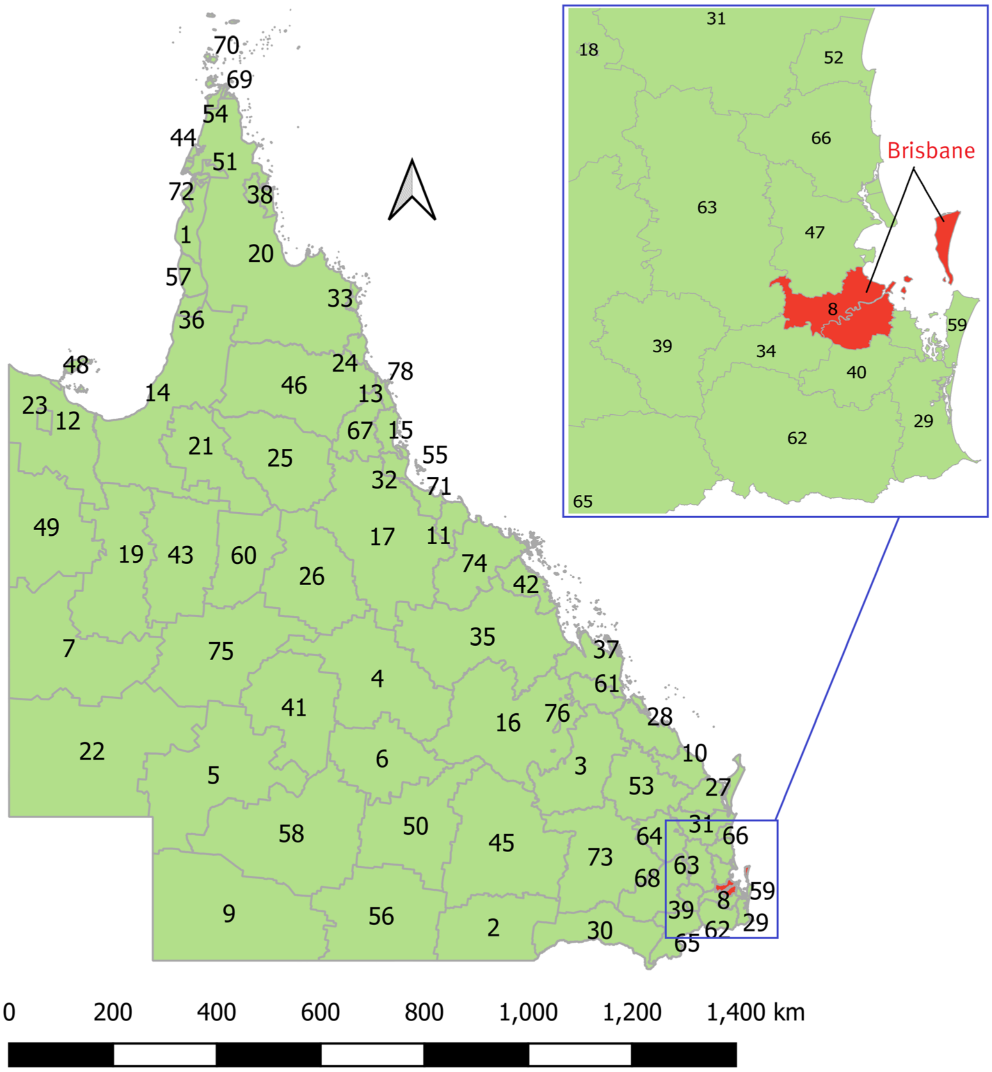


Figure 7. Comparison of survival outcomes between the COVID-19 and pre-COVID-19 periods.

6. Spatiotemporal variation in OHCA risk

6.1 Rationale and aims

Data from within Australia and internationally suggest significant regional variation in OHCA risk due to region-specific demographic and geographic factors.[2] Having a vast landmass (1.73 million km^2) and a population density (3 people per km^2) below the national average in one of the world's most sparsely populated countries, Queensland is faced with unique challenges in the management of OHCA.[16,17] The state is divided into 78 local government areas (LGAs) (Figure 8); 65 of which are classified as either regional or remote.[1] There exists regional disparities in health risk across Queensland.[1] It is therefore imperative to identify region-specific risks of OHCA so that interventions (e.g. public training in CPR, public-access defibrillators) and resource allocation can be targeted and optimised. In this analysis, we estimated and thematically mapped OHCA risk for all LGAs in Queensland using a mathematical model that accounted for temporal (time) and spatial (space) variability, and demographic features (population composition by age and gender), in the distributions of OHCA risk. In this study, OHCA risk referred to relative risk (RR), which quantified whether a specific LGA in a specific year has higher (RR > 1) or lower (RR < 1) risk of OHCA occurrence than the overall state-wide risk. This analysis included all OHCA cases that were attended by QAS paramedics between 1 January 2007 and 31 December 2019. We also calculated the probabilities of OHCA risk estimates being greater than a given threshold value. A threshold of 1.5 was used as suggested in the literature.[19] These probabilities are called exceedance probabilities and are useful to identify areas where there is an unusual elevation of risk.



ID	LGA	ID	LGA	ID	LGA	ID	LGA
1	Aurukun	21	Croydon	41	Longreach	61	Rockhampton
2	Balonne	22	Diamantina	42	Mackay	62	Scenic Rim
3	Banana	23	Doomadgee	43	McKinlay	63	Somerset
4	Barcaldine	24	Douglas	44	Mapoon	64	South Burnett
5	Barcoo	25	Etheridge	45	Maranoa	65	Southern Downs
6	Blackall-Tambo	26	Flinders	46	Mareeba	66	Sunshine Coast
7	Boulia	27	Fraser Coast	47	Moreton Bay	67	Tablelands
8	Brisbane	28	Gladstone	48	Mornington	68	Toowoomba
9	Bulloo	29	Gold Coast	49	Mount Isa	69	Torres
10	Bundaberg	30	Goondiwindi	50	Murweh	70	Torres Strait Island
11	Burdekin	31	Gympie	51	Napranum	71	Townsville
12	Burke	32	Hinchinbrook	52	Noosa	72	Weipa
13	Cairns	33	Hope Vale	53	North Burnett	73	Western Downs
14	Carpentaria	34	Ipswich	54	Northern Peninsula	74	Whitsunday
15	Cassowary Coast	35	Isaac	55	Palm Island	75	Winton
16	Central Highlands	36	Kowanyama	56	Paroo	76	Woorabinda
17	Charters Towers	37	Livingstone	57	Pormpuraaw	77	Wujal Wujal
18	Cherbourg	38	Lockhart River	58	Quilpie	78	Yarrabah
19	Cloncurry	39	Lockyer Valley	59	Redland		
20	Cook	40	Logan	60	Richmond		

Figure 8. Names and boundaries of the 78 LGAs of Queensland.

6.2 Findings, interpretations and caveats

A total of 61,279 OHCA cases were recorded for all 78 LGAs combined for the entire 13-year study period, with an average number of cases per year per LGA ranging from 0 to 946. Figure 10 shows the average event count per year and average incidence rate per 1000 population per year for each LGA across the study period. As expected, data on event counts show a spatial concentration of cases in more populated LGAs situated on the east coast of the state, especially the south-east corner, reflecting the patterns of population distribution in Queensland (Figure 9, panel A). The spatial distribution of event counts markedly differed to that of incidence rates, which was higher in less populated LGAs (Figure 9, panel B).

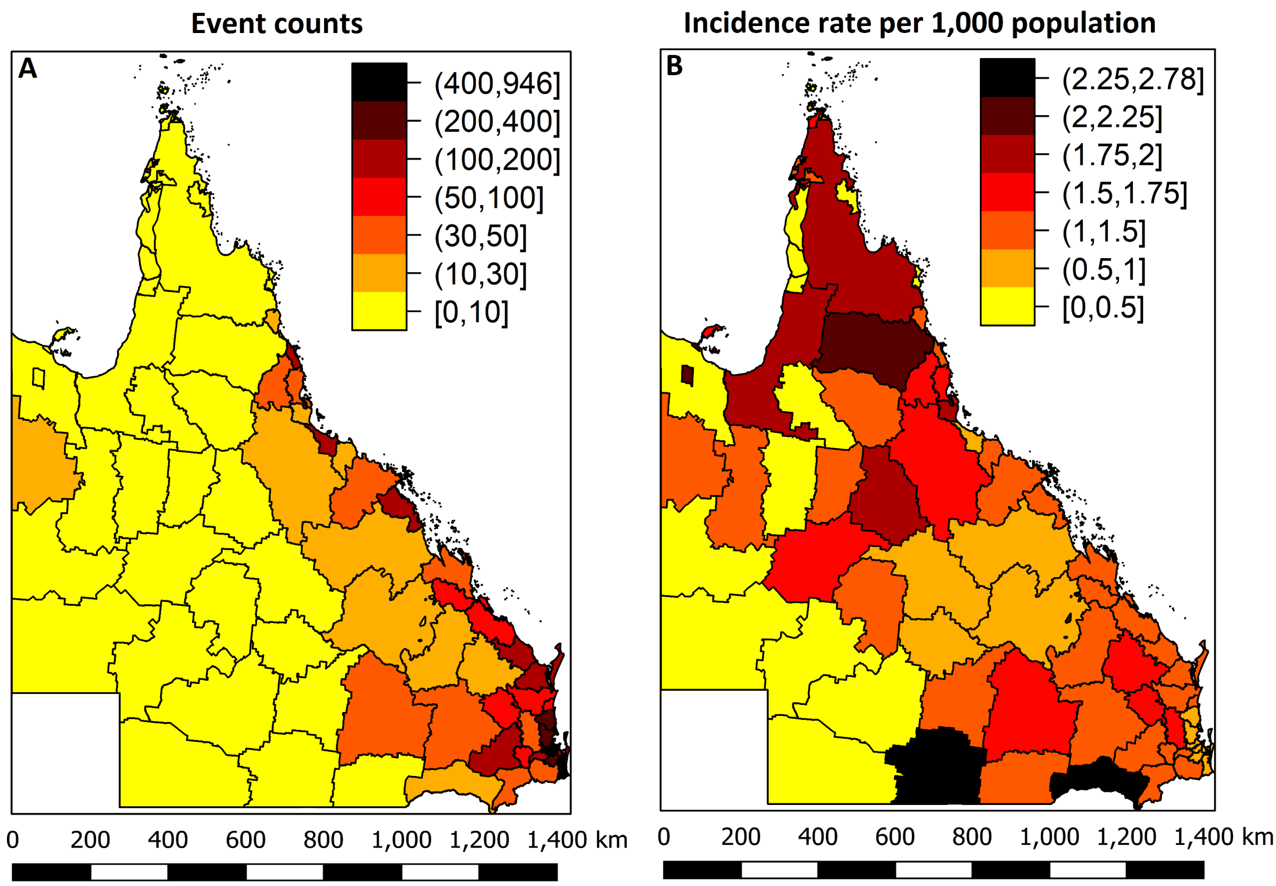


Figure 9. Crude event counts (panel A) and crude incidence rate per 1,000 population per year (panel B) of the 78 LGAs.

The risk of OHCA over time for each LGA is shown in Figure 10 with darker colours corresponding to relatively higher risk. The risk was generally stable across the years for the majority of LGAs. Across the study period, the highest risk was observed throughout the north half of the state and a few areas in the south. The west areas of the state generally exhibited the lowest risk.

Figure 11 shows the maps of the probabilities of risk estimates being greater than 1.5 for all years. During the entire study period, results divided the state into two geographic-based risk groups: those with a significant excess risk (more than 150%) in the northern half, and those with low risk in the remaining parts of the state; with a few exceptions in the south and south-east. These findings highlight the role for public education and a targeted approach in high-risk communities to help reduce disparities in risk experienced across areas.

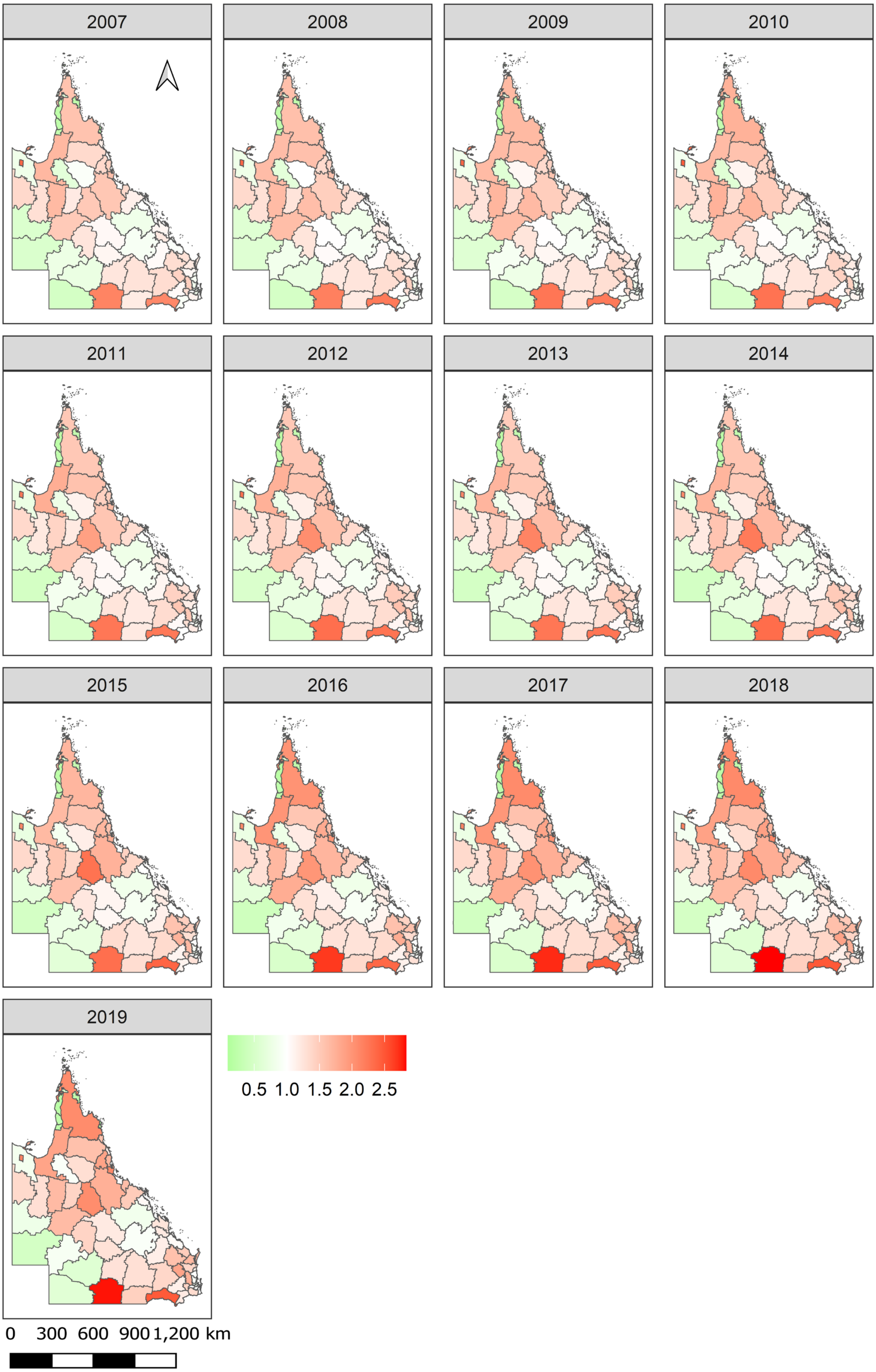


Figure 10. Risk of OHCA over time for each of the 78 LGAs.

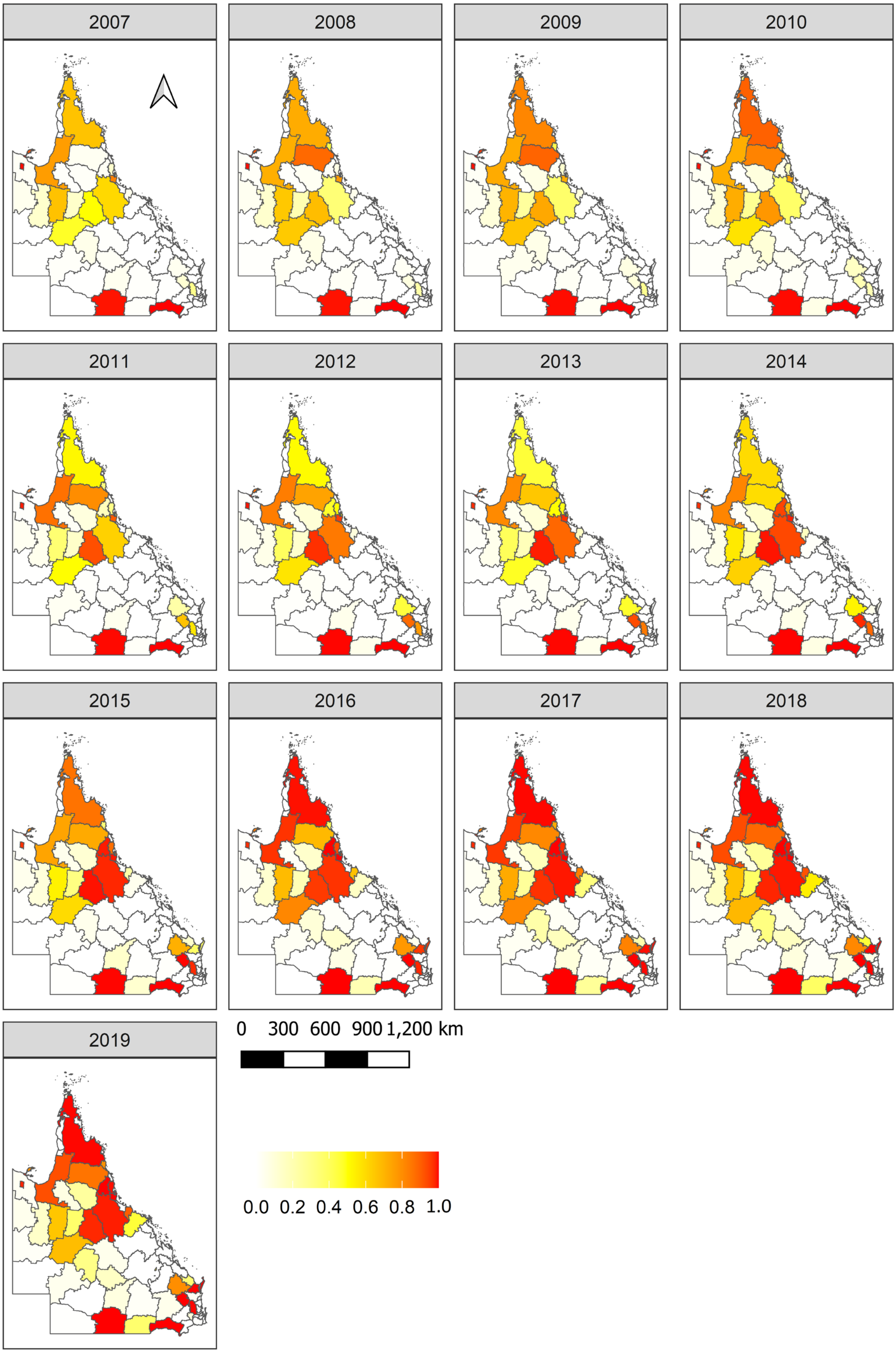


Figure 11. Map of exceedance probabilities.

An exceedance probability is the probability of an LGA having OHCA risk greater than 1.5.

7. Traumatic cardiac arrest

7.1 Rationale and aims

TCA occurs when a severely injured patient ceases to produce spontaneous cardiac output. It is a significant cause of morbidity and mortality, being responsible for more than 5 million deaths globally each year.[20] Survival from TCA is poor, with reported rates of survival to hospital discharge ranging between 2% and 8% among patients who receive a resuscitation attempt from paramedics in countries with advanced emergency ambulance service including the United States,[3,4] Canada,[3] England,[5,6] Wales,[6] Spain[7] and Taiwan.[21] In Australia, trauma accounts for approximately 9% of the total burden of disease and around 8% of the total health expenditure, making it the third most costly condition in the country.[22,23] To date, Alqudah et al.[9] and Beck et al.[8,24] are the only Australian studies in out-of-hospital TCA. Those studies were conducted in Victoria[8,9] and Western Australia,[24] and reported rates of survival to hospital discharge to be 2.7%,[9] 3.8%[8] and 1.7%[24] in patients with attempted resuscitation from paramedics.

Citing the futility and excessive cost of resuscitation measures, and occupational risk to emergency personnel during "lights and sirens" transports, various organisations, such as the National Association of Emergency Services Physicians (United States) and the American College of Surgeons Committee on Trauma, have previously advocated for withholding resuscitation or termination of resuscitation in TCA patients with very poor prognosis.[25] However, these guidelines have been challenged by reports which demonstrated that certain TCA patients can be salvageable if the underlying cause of arrest is rapidly addressed.[26] Accordingly, current guidelines emphasise the importance of advanced life support (ALS) procedures in addressing reversible causes of arrest. However, there exists significant regional variation regarding prehospital ALS interventions in trauma, and little is known about the survival benefit of those interventions, with existing few studies showing discordant results.[3,26] Other prehospital determinants of survival, such as patient- and event-related factors, have only had limited examination. Furthermore, previous studies in out-of-hospital TCA did not differentiate between patients who received an attempted resuscitation from paramedics and those who were pronounced deceased on paramedic arrival at scene, or did not include the latter group at all.[3,5,8,21,27-31]

The present analysis investigated a cohort of adult out-of-hospital TCA patients attended by QAS paramedics over a 13-year period between 1 January 2007 and 31 December 2019. TCA was defined as cardiac arrest resulting from blunt, penetrating or burn injury, and excluded hanging, drowning, electrocution, asphyxiation, foreign body airway obstruction, and intoxication.[32] This study included both patients who were pronounced deceased on paramedic arrival at scene and those who received a resuscitation attempt from paramedics. Patients were excluded if the mechanism of injury was unknown. This study had three aims: (1) to describe and compare the characteristics and mechanisms of injury of patients who received a resuscitation attempt from paramedics versus who were pronounced deceased on paramedic arrival; (2) to describe the contemporary prehospital management and survival outcomes among resuscitation-attempted patients; and (3) to determine prehospital factors, including ALS procedures, that were associated with survival. In addition, survival rates were compared between the two periods 2007-2009 and 2010-2019, given the introduction of needle chest decompression for Advanced Care Paramedics (ACPs) in 2010 and the implementation of High Acuity Response Unit (HARU) in the same year.

7.2 Findings, interpretations and caveats

Between 1 January 2007 and 31 December 2019, QAS paramedics attended a total of 3891 adult out-of-hospital TCA with known mechanism of injury. Of those, 2394 (61.5%) were pronounced deceased on paramedic arrival at scene, and 1497 (38.5%) received a resuscitation attempt from paramedics. Patient characteristics and mechanisms of injury are shown in Table 3. Patients were predominantly young male (median age 44 years). Blunt injuries accounted for the majority of traumatic arrests, being responsible for 75.8% of patients pronounced deceased on paramedic arrival and 86.2% of resuscitation-attempted patients. Motor vehicle collision (42.4%) and gunshot wound (17.7%, primarily self-inflicted) were the two most common mechanisms of injury leading to arrest in those who were pronounced deceased on paramedic arrival; whereas motor vehicle collision (31.3%) and motor cycle collision (20.6%) were the two most common causes of arrest in attempted-resuscitation patients (Table 3). Most attempted-resuscitation patients initially presented in asystole (43.6%) or pulseless electrical activity (41.9%) rhythm. Approximately one-third (33.6%) of attempted-resuscitation cases were attended by HARU officers (Table 3).

Table 4 shows intra-arrest interventions performed by QAS paramedics on attempted-resuscitation patients. CPR was performed on all attempted-resuscitation patients. Almost three-quarters (73.5%) of these patients received advanced airway management (endotracheal tube intubation or laryngeal mask airway). More than half (54.0%) of patients received chest decompression (needle, thoracostomy, or both). Focused assessment with sonography for trauma (FAST) ultrasound and transfusion of packed red blood cells were performed on 13.5% and 5.2% of attempted-resuscitation patients, respectively (Table 4). Around one-third (31.9%) of attempted-resuscitation patients were transported to a healthcare facility; of these, 71.7% to a facility with trauma services (Table 4).

Table 3. Characteristics of traumatic arrests

Variable	All patients*	Attempted-resuscitation*	Deceased on paramedic arrival*
Number of patients	3891	1497	2394
Age (median, IQR), years	44 (30-60)	42 (30-59)	45 (30-61)
Male	3068 (78.8%)	1170 (78.2%)	1898 (79.3%)
Type of trauma			
Blunt	3106 (79.8%)	1291 (86.2%)	1815 (75.8%)
Penetrating	772 (19.8%)	193 (12.9%)	579 (24.2%)
Burn	13 (0.3%)	13 (0.9%)	0 (0.0%)
Mechanism of injury			
Motor vehicle collision	1482 (38.1%)	468 (31.3%)	1014 (42.4%)
Motorcycle collision	531 (13.6%)	309 (20.6%)	222 (9.3%)
Bicycle collision	52 (1.3%)	37 (2.5%)	15 (0.6%)
Pedestrian	266 (6.8%)	126 (8.4%)	140 (5.8%)
Fall from height < 3 m	154 (4.0%)	86 (5.7%)	68 (2.8%)
Fall from height ≥ 3 m	333 (8.6%)	126 (8.4%)	207 (8.6%)
Gunshot wound	474 (12.2%)	50 (3.3%)	424 (17.7%)
Stabbing	195 (5.0%)	113 (7.5%)	82 (3.4%)
Laceration	79 (2.0%)	16 (1.1%)	63 (2.6%)
Blunt assault	63 (1.6%)	41 (2.7%)	22 (0.9%)
Crushed by blunt object	164 (4.2%)	59 (3.9%)	105 (4.4%)
Struck by blunt object	50 (1.3%)	33 (2.2%)	17 (0.7%)
Other	35 (0.9%)	20 (1.3%)	15 (0.6%)

Table 3 (continued). Characteristics of traumatic arrests

Variable	All patients*	Attempted-resuscitation*	Deceased on paramedic arrival*
Location type of arrest			
Private residence	1105 (28.4%)	347 (23.2%)	758 (31.7%)
Public place	2598 (66.8%)	1088 (72.7%)	1510 (63.1%)
Metropolitan[ϖ]	1589 (40.8%)	776 (52.0%)	813 (34.2%)
Witness status			
Unwitnessed/Unknown	2392 (61.5%)	501 (33.5%)	1891 (79.0%)
Bystander-witnessed	1049 (27.0%)	580 (38.7%)	469 (19.6%)
Paramedic-witnessed	450 (11.6%)	416 (27.8%)	34 (1.4%)
Bystander CPR	915 (23.5%)	694 (46.4%)	221 (9.2%)
Initial arrest rhythm			
VF/VT	106 (2.7%)	106 (7.1%)	0 (0.0%)
PEA	704 (18.1%)	627 (41.9%)	77 (3.2%)
Asystole	1602 (41.2%)	652 (43.6%)	950 (39.7%)
Other	74 (1.9%)	54 (3.6%)	20 (0.8%)
Unknown/ECG not taken	1405 (36.1%)	58 (3.9%)	1347 (56.3%)
Paramedic skill level			
ACP only	2272 (58.4%)	349 (23.3%)	1923 (80.3%)
ACP backed up by non-HARU CCP	1116 (28.7%)	645 (43.1%)	471 (19.7%)
ACP backed up by HARU	503 (12.9%)	503 (33.6%)	0 (0.0%)

* Shown are numbers (percentages), unless indicated otherwise.
[ϖ] Missing data for 24 patients.

Table 4. Intra-arrest interventions performed by paramedics in traumatic arrests

Variable	Number (%)
Number of attempted-resuscitation patients	1497
Paramedic response time (median, IQR), minutes	9 (6-15)
Transported and arrived at a hospital[ø]	474 (31.9%)
Hospital without trauma services	124
Major trauma centre	227
Regional trauma centre	113
Prehospital time (median, IQR), minutes	50 (33-72)
Intra-arrest intervention by paramedics	
Cardiopulmonary resuscitation	1497 (100%)
Advanced airway management[∂]	1100 (73.5%)
Insertion of intravenous line[λ]	1184 (79.1%)
Adrenaline administration	764 (51.0%)
Hypertonic saline	12 (0.8%)
Tranexamic acid	9 (0.6%)
FAST ultrasound	202 (13.5%)
Transfusion of packed red blood cells	78 (5.2%)
Resuscitative thoracotomy	17 (1.1%)
Chest decompression – any method	808 (54.0%)

[ø] Missing hospital name for 10 patients; therefore, whether the facility provides trauma services could not be determined.
[∂] Endotracheal tube intubation or laryngeal mask airway.
[λ] Or intraosseous infusion needle when intravenous cannulation could not be performed successfully.

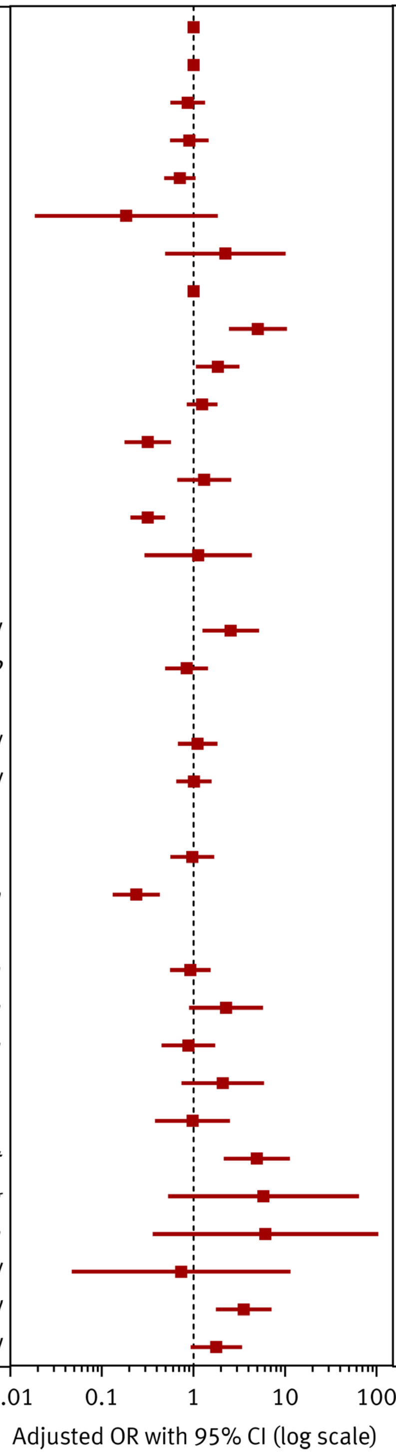
Of all patients where resuscitation was attempted, 15.3% (229/1497) survived to hospital handover. The rate of survival to hospital discharge was 9.8% (147/1497), with most survivors remaining alive to 6 months (6-month survival rate 9.8%, 146/1497). There was no statistically significant difference in survival rates between the two periods 2007-2009 and 2010-2019 (survival to hospital handover 15.6 versus 15.2%, $p = 0.856$; survival to hospital discharge 11.8 versus 9.4%, $p = 0.224$; 6-month survival 11.8 versus 9.3%, $p = 0.224$).

Our rate of survival to hospital discharge of 9.8% among attempted-resuscitation patients compares favourably with the broader literature, which reported survival rates between 2% and 8% from diverse settings with advanced emergency ambulance service.[3,5-7,21,33] Our figure is higher than that reported by Alqudah et al.[9] (2.7%) and Beck et al.[8] (3.8%) in the state of Victoria, despite the fact that we used a similar definition of TCA, had a similar proportion of traffic-related injuries (62.8% in our study versus 64.6% in Alqudah et al.[9] and 64.1% in Beck et al.[8]), and similar proportion of blunt trauma (86.2% in our study versus 81.1% in Beck et al.[8]). Such disparity highlights a wide regional variation in survival outcomes following out-of-hospital TCA that may be attributable to patient, event, and system-related factors. In addition, there may be a variation among ambulance services with regard to who constitutes the group of attempted-resuscitation patients (denominator of survival figures). For instance, in Alqudah et al.[9] and Beck et al.[8] in Victoria, this population refers to patients who receive an attempted resuscitation from paramedics as well as eligible first responders such as fire fighters. In our study, attempted-resuscitation patients include only those who receive a resuscitative effort from QAS paramedics. Our discharge survival figure (9.8%) is similar to the 11% reported in France in out-of-hospital TCA patients who were treated by physician-staffed mobile intensive care unit in the field and survived to hospital handover.[31] Our rate of survival to hospital discharge (9.8%) was similar to the 11.9% that we recently reported in adult OHCA of medical aetiology from the same database.[34] This confirms observations that the prognosis of adult out-of-hospital TCA, where resuscitation is attempted, can be comparable to that of medical OHCA.[7,26,27]

We found that trauma type (blunt or penetrating) was not associated with survival. Existing evidence about the association between trauma type and survival following out-of-hospital TCA is conflicting. Some studies[3,8,27] found that survival rates from blunt injuries were better than penetrating TCA; whereas the opposite was observed in other studies.[35,36] Like our study, Konesky and Guo[28] did not find trauma type to be a prognostic factor of survival, nor did a recent meta-analysis.[37] Given that our definition of TCA and inclusion criteria were similar to those in the aforementioned studies, our findings contribute to the ongoing controversy of this topic that warrants further research.

In the present study, the performance of FAST ultrasound and chest decompression was associated with decreased odds of survival (Figures 12 and 13). This negative relationship may be explained by "confounding by indication".[3,38] Patients who required and received those procedures, by nature of their being indicated for the procedure, may have more severe underlying injury that caused the arrest and therefore potentially poorer prognosis than those who did not. In this case, the association between the procedure and the outcome is biased by the uncontrolled confounding effect of injury severity.

We demonstrated that HARU attendance increased the odds of survival to hospital handover 2.5 times (Figure 12) and had a non-significant point estimate favouring survival to hospital discharge (Figure 13). There remains a scarcity of data on the impact that different levels of skillsets of ambulance personnel may have on outcomes. Barnard et al.[5] in England found that more highly trained ambulance personnel (helicopter paramedics) improved survival to hospital handover but not to hospital discharge; whereas Alqudah et al.[9] in Victoria reported no such association. Although we could not show that HARU-initiated interventions were associated with improved odds of survival due to "confounding by indication" for some interventions as discussed earlier and lack of statistical power for others, the survival benefit associated with the presence of HARU may be attributable to non-technical factors such as advanced clinical decision making and leadership skills.[39] It should be noted that the dispatch of HARU is likely to be dictated by the perceived prognosis of the patient, which in turn affects survivability. The retrospective nature of the study did not allow us to account for this.



Variable	AOR (95% CI)	*p*
Year of study	1.00 (0.95-1.05)	0.908
Age[a]	1.00 (0.99-1.01)	0.977
Bystander CPR	0.87 (0.56-1.34)	0.518
Public place (ref = private residence)	0.90 (0.55-1.46)	0.663
Arrest occurring in rural area	0.71 (0.48-1.06)	0.091
Penetrating trauma (ref = blunt)	0.18 (0.02-1.84)	0.149
Burn trauma (ref = blunt)	2.22 (0.49-10.15)	0.302
Paramedic response time[b]	1.00 (0.99-1.01)	0.858
Insertion of intravenous line[c]	**5.04 (2.43-10.45)**	**<0.001**
Advanced airway management[d]	**1.84 (1.06-3.17)**	**0.029**
Adrenaline administration	1.24 (0.84-1.83)	0.272
FAST ultrasound	**0.32 (0.18-0.57)**	**<0.001**
Packed red blood cells	1.31 (0.66-2.57)	0.440
Chest decompression (any method)	**0.32 (0.20-0.49)**	**<0.001**
Resuscitative thoracotomy	1.12 (0.29-4.32)	0.869
Paramedic skill level (ref = ACP only)		
ACP backed up by HARU	**2.54 (1.25-5.18)**	**0.010**
ACP backed up by non-HARU CCP	0.84 (0.49-1.44)	0.526
Witness status (ref = unwitnessed arrest)		
Paramedic-witnessed	1.11 (0.67-1.82)	0.689
Bystander-witnessed	1.01 (0.65-1.58)	0.957
Initial rhythm (ref = VF/VT)		
PEA	0.97 (0.56-1.68)	0.916
Asystole	**0.24 (0.13-0.43)**	**<0.001**
Injury mechanism (ref = motor vehicle collision)		
Motorcycle collision	0.92 (0.55-1.54)	0.757
Bicycle collision	2.26 (0.89-5.73)	0.087
Pedestrian	0.88 (0.45-1.73)	0.708
Struck by blunt object	2.08 (0.74-5.88)	0.167
Crushed by blunt object	0.97 (0.38-2.50)	0.956
Blunt assault	**4.90 (2.13-11.29)**	**<0.001**
Stabbing	5.80 (0.53-63.90)	0.151
Laceration	6.10 (0.36-103.7)	0.211
Gunshot wound	0.73 (0.05-11.49)	0.826
Low energy fall	**3.53 (1.75-7.10)**	**<0.001**
High energy fall	1.77 (0.93-3.78)	0.082

Figure 12. Factors associated with survival to hospital handover in traumatic arrests.

Bold values indicate statistical significance ($p < 0.05$).
[a] Odds ratio for one-year increment.
[b] Odds ratio for one-minute increment.
[c] Or intraosseous infusion needle when intravenous cannulation could not be performed successfully.
[d] Endotracheal tube intubation or laryngeal mask airway.

Variable	AOR (95% CI)	*p*
Year of study	0.96 (0.91-1.02)	0.200
Age[a]	0.99 (0.98-1.00)	0.118
Bystander CPR	0.83 (0.49-1.38)	0.470
Public place (ref = private residence)	1.53 (0.85-2.75)	0.156
Arrest occurring in rural area	0.92 (0.60-1.43)	0.715
Penetrating trauma (ref = blunt)	0.65 (0.07-5.90)	0.700
Paramedic response time[b]	1.00 (0.99-1.01)	0.868
Insertion of intravenous line[c]	1.49 (0.83-2.67)	0.186
Advanced airway management[d]	1.14 (0.65-2.00)	0.643
Adrenaline administration	0.78 (0.50-1.21)	0.261
FAST ultrasound	**0.31 (0.15-0.65)**	**0.002**
Packed red blood cells	1.57 (0.74-3.37)	0.242
Chest decompression (any method)	**0.46 (0.28-0.75)**	**0.002**
Resuscitative thoracotomy	1.28 (0.33-4.98)	0.721
Paramedic skill level (ref = ACP only)		
ACP backed up by HARU	1.96 (0.89-4.34)	0.095
ACP backed up by non-HARU CCP	0.96 (0.54-1.72)	0.901
Witness status (ref = unwitnessed arrest)		
Paramedic-witnessed	1.59 (0.91-2.80)	0.106
Bystander-witnessed	0.88 (0.51-1.52)	0.649
Transported to a trauma centre* (ref = transported to a facility without trauma services)		
Major trauma centre	1.88 (0.84-4.24)	0.126
Regional trauma centre	1.11 (0.52-2.38)	0.782
Initial rhythm (ref = VF/VT)		
PEA	**0.36 (0.20-0.63)**	**<0.001**
Asystole	**0.11 (0.06-0.21)**	**<0.001**
Injury mechanism (ref = motor vehicle collision)		
Motorcycle collision	1.17 (0.67-2.04)	0.591
Bicycle collision	2.37 (0.79-7.12)	0.124
Pedestrian	**2.04 (1.03-4.05)**	**0.041**
Struck by blunt object	0.92 (0.19-4.39)	0.917
Crushed by blunt object	1.60 (0.55-4.65)	0.388
Blunt assault	**4.64 (1.79-12.07)**	**0.002**
Stabbing	4.20 (0.42-42.19)	0.223
Laceration	4.18 (0.27-65.03)	0.307
Gunshot wound	0.77 (0.05-11.11)	0.845
Low energy fall	**2.54 (1.09-5.89)**	**0.030**
High energy fall	1.58 (0.70-3.59)	0.274

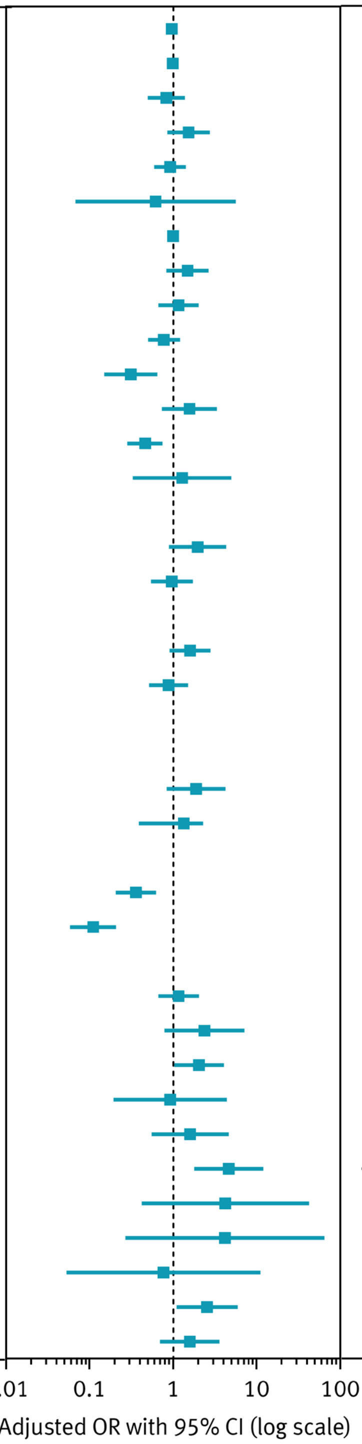


Figure 13. Factors associated with survival to hospital discharge in traumatic arrests.

Bold values indicate statistical significance ($p < 0.05$).
[a] Odds ratio for one-year increment.
[b] Odds ratio for one-minute increment.
[c] Or intraosseous infusion needle when intravenous cannulation could not be performed successfully.
[d] Endotracheal tube intubation or laryngeal mask airway.
* Only applicable to transported cases.

8. Time to amiodarone administration and outcomes in refractory VF

8.1 Rationale and aims

OHCA that present with an initial shockable rhythm generally have a good prognosis, provided that they receive early defibrillation.[34,40] Some patients however suffer refractory VF; that is, they are resistant to defibrillation with VF persisting after three defibrillation attempts. To date, data on the prevalence of refractory VF are scarce. One study in Japan reported that refractory VF accounted for 4.5% of all witnessed OHCA of presumed cardiac aetiology, or 22.6% of those with an initial VF rhythm.[41]

International guidelines recommend the use of an antiarrhythmic agent (amiodarone or lidocaine) on OHCA patients with refractory VF.[10,11] These drugs can terminate VF by primarily blocking potassium channels in the heart, reducing myocardial excitability, and preventing re-entry mechanisms and ectopic foci from perpetuating tachyarrhythmias.[42] This helps reduce sinoatrial node automaticity and atrioventricular node conduction velocity, further assisting the reversion of VF.[42]

For OHCA interventions broadly, studies have consistently showed a negative association exists between time to intervention and subsequent outcome, with earlier administration associated with better survival.[12-14] However, such literature regarding time of administration of antiarrhythmic drugs in refractory VF remains scarce. To date, Lee et al.[43] is the only study that examined the relationship between time to amiodarone administration and outcome in refractory VF patients. The study investigated a cohort of 134 refractory VF patients and found that early amiodarone administration improved neurological outcome at hospital discharge. More studies with larger sample sizes are needed to validate this relationship.

The present analysis investigated the association of time to amiodarone administration with survival outcomes in adult OHCA of medical aetiology who received a resuscitation attempt from QAS paramedics between 1 January 2015 and 31 December 2019, and were administered amiodarone for refractory VF. Optimal time window for the administration of amiodarone was also examined. This section is an excerpt from our recent publication.[44]

8.2 Findings, interpretations and caveats

A total of 502 patients were included. The median dose of amiodarone administered was 450 mg (IQR 300-450). Table 5 describes the characteristics and survival outcomes of the included patients. The majority of patients were male (80.5%). Most arrests occurred in private residence (67.9%) and were witnessed (69.3%). The median time from arrest to amiodarone administration was 24 minutes (IQR 19-31). The rates of event survival, survival to discharge, and 30-day survival were 28.9%, 17.1%, and 16.9%, respectively. Exclusion of paramedic-witnessed arrests did not notably change the results. Specifically, the median time from arrest to amiodarone administration was 25 (IQR 20-31) minutes with the exclusion of paramedic-witnessed arrests; and the survival rates were 29.2%, 17.1% and 16.9%, respectively.

Table 5. Characteristics and outcomes of patients who received amiodarone for refractory VF

Variable		Number (%)
Number of patients		502
Age (median, IQR), years		63 (52-73)
Male		404 (80.5%)
Location of arrest[µ]		
	Private residence	341 (68.9%)
	Public place	109 (22.0%)
Metropolitan		371 (73.9%)
Witness status of arrest		
	Witnessed[∂]	348 (69.3%)
	Unwitnessed/Unknown	154 (30.7%)
Bystander CPR[λ]		405 (84.4%)
Number of shocks by paramedics (median, IQR)		9 (7-12)
Adrenaline administration		500 (99.6%)
Time intervals (median, IQR), minutes		
	Paramedic response time	8 (6-11)
	Time from arrest to IV access[ø]	16 (13-21)
	Time from arrest to amiodarone	24 (19-31)
Survival outcomes		
	Survived event	145 (28.9%)
	Discharged alive	86 (17.1%)
	30-day survival	85 (16.9%)

[µ] Type of location of arrest could not be determined for 7 patients.

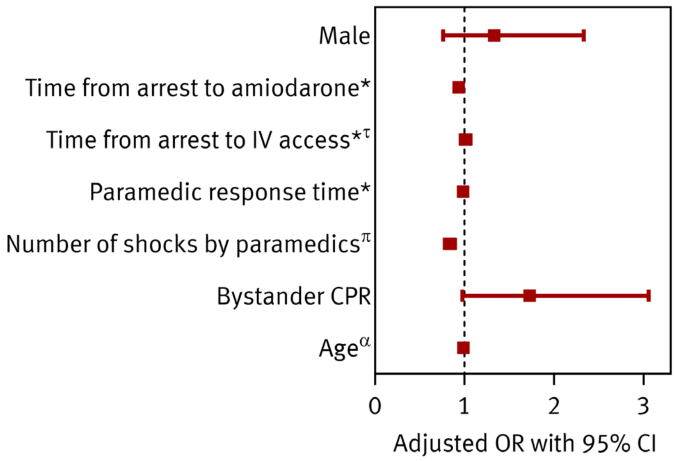
[∂] Includes bystander-witnessed (326/502 patients) and paramedic-witnessed (22/502 patients).

[λ] Paramedic-witnessed arrests were excluded from the denominator.

[ø] Or intraosseous access when intravenous access was not successful.

Every minute delay in amiodarone administration following arrest reduced the odds of event survival by 7% (Figure 14). The probability of event survival diminished exponentially as the time to amiodarone administration prolonged (Figure 15).

The optimal time window for amiodarone administration was within 23 minutes after arrest. The same optimal time window was found in a sensitivity analysis in which paramedic-witnessed arrests were excluded. Approximately 47% (235/502) of the included patients received amiodarone within this optimal time window. Those who received the drug within this time window had significantly higher survival rates than those who did not (Figure 16). Patients receiving amiodarone within the optimal time window had higher survival rates than those receiving the drug outside this time window. It should be noted that those were unadjusted results. Given that time to amiodarone administration is a function of rapid response time, paramedic-witnessed arrest and early paramedic interventions, such differences in survival rates may likely be attributable to any or all of those factors.



	AOR (95% CI)	*p*
Male	1.33 (0.76-2.33)	0.316
Time from arrest to amiodarone*	**0.93 (0.89-0.97)**	**0.002**
Time from arrest to IV access*τ	1.01 (0.96-1.07)	0.722
Paramedic response time*	0.98 (0.94-1.03)	0.432
Number of shocks by paramedicsπ	**0.83 (0.78-0.89)**	**‹0.001**
Bystander CPR	1.73 (0.98-3.06)	0.060
Ageα	0.99 (0.97-1.00)	0.093

Figure 14. Factors associated with event survival in refractory VF.

* Odds ratio for one-minute increment.

τ Or intraosseous access when intravenous access was not successful.

π Odds ratio for one-shock increment.

α Odds ratio for one-year increment.

Bold values indicate statistical significance ($p < 0.05$).

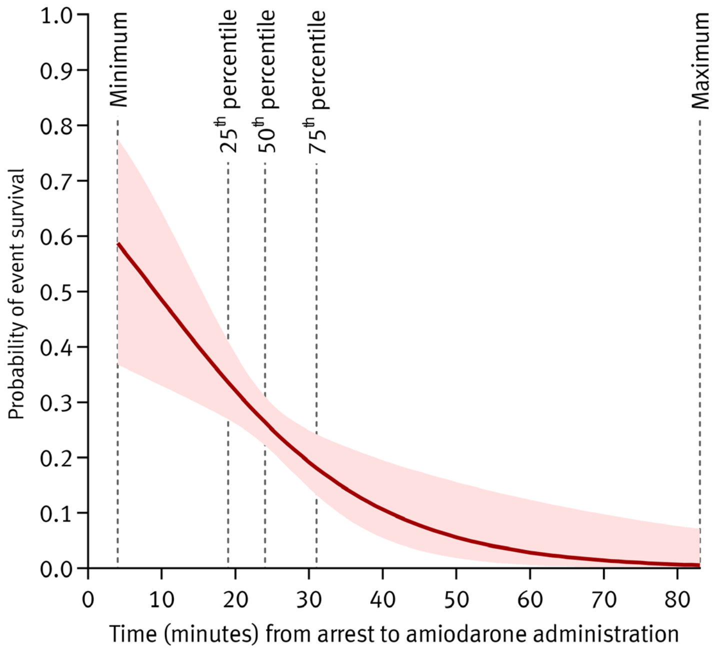


Figure 15. Probability of event survival in refractory VF, and the associated 95% confidence interval (shaded area) as a function of time from arrest to amiodarone administration.

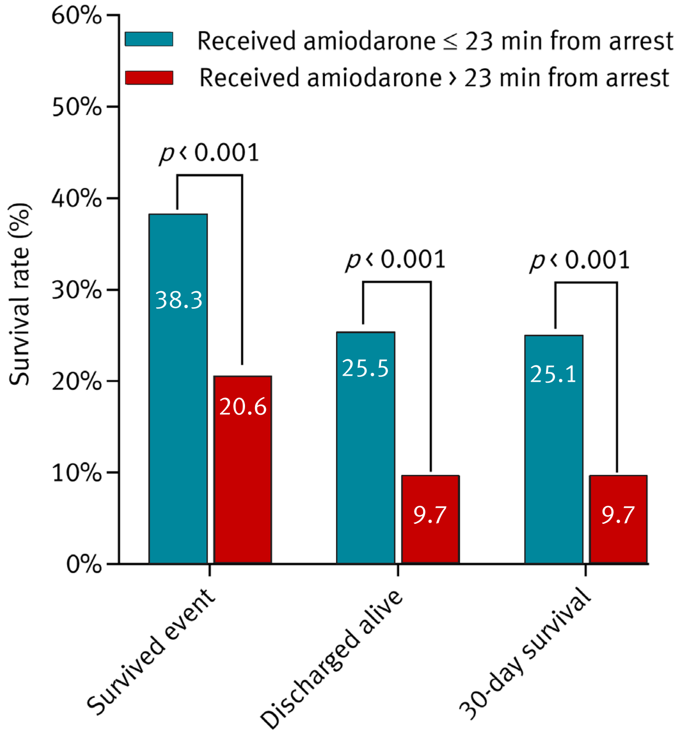


Figure 16. Comparison of survival outcomes between those who received amiodarone within the optimal time window (within 23 minutes following arrest) and those who did not.

Patients who received amiodarone within 23 minutes following arrest had a shorter paramedic response time (median 7 versus 10 minutes, $p < 0.001$) and shorter time from arrest to intravenous access (13 versus 21 minutes, $p < 0.001$) than those who received the drug outside this time window. For every minute delay in paramedic response time, there was a 4% decrease in the odds of receiving amiodarone within the optimal time window. Every minute delay in intravenous access reduced the odds of receiving amiodarone within the optimal window by 29%. This indicates that shortening these time intervals will reduce delay to amiodarone administration and potentially improve survival. Although our response time to OHCA incidents, at 8.5 minutes, is among the shortest nationwide[45-47] and internationally[48-51], there is opportunity for further shortening this time interval for some patients. In particular, expanding the scope of practice of ACPs to include amiodarone as an intervention for this patient cohort would enable amiodarone administration as soon as clinically indicated, without having to await the arrival of CCPs who currently carry this pharmacological adjunct. This coupled with education regarding the importance of obtaining timely intravenous access in patients presenting with shockable rhythms would potentially shorten time from arrest to amiodarone administration. While efforts should be focussed on administering amiodarone early where possible, the fact that 20.6% of our patients who received amiodarone outside the optimal time window achieved sustained ROSC on hospital arrival (i.e. event survival) suggests that amiodarone administration should still occur after 23 minutes following arrest for those where it is not possible.

The findings of this study need to be interpreted in the context of the following limitations. The database does not record some information that may influence patient outcomes, such as comorbidities, as well as in-hospital and post-resuscitation care. Like any observational cardiac arrest research, this study is subject to “resuscitation time bias” with regard to intra-arrest interventions,[52] specifically time to amiodarone administration in the context of our study. This occurs because amiodarone administration (and more broadly, the implementation of any intra-arrest intervention) is related to time in that it is more likely to be administered the longer the duration of the arrest.[52] Because longer cardiac arrest is associated with worse outcomes, estimates of the relationship between time to amiodarone administration and survival will be biased toward a harmful effect.[52]

9. Conclusions

This report demonstrates the outstanding quality of prehospital care delivered to OHCA patients by QAS paramedics. Despite the unprecedented challenges presented by COVID-19 to operational management, the QAS mitigated the risks of the pandemic to staff and patients, whilst maintaining an efficient response to deliver the highest level of clinical care. Along with other health and emergency services, the QAS played an integral part in protecting Queensland community from COVID-19.

This report constructed OHCA risk maps for Queensland using a novel mathematical approach. By identifying high risk areas, this analysis provides valuable information to guide public health policy and resource allocation. This report also contributes to a scant but growing literature regarding the epidemiology and outcomes of out-of-hospital TCA, especially from an Australian perspective. Unlike previous studies that excluded TCA who were pronounced deceased on paramedic arrival, this report described the characteristics and mechanisms of injury of all paramedic-attended patients regardless of whether resuscitation was performed by paramedics. In doing so, it provides a more complete understanding of the mechanisms of underlying injuries of out-of-hospital TCA. This in turn helps predict pattern of injuries and guide public health policy. The report shows that out-of-hospital TCA is far from unsalvageable, with certain subgroups demonstrating survival similar to medical aetiologies. However, further improvement could be driven through primary prevention. Factors identified in this study as associated with survival of out-of-hospital TCA are useful to guide prognostication and treatment. In addition, this report provides a novel investigation into the association between time to amiodarone administration and outcomes in refractory VF. Identification of an optimal time window for amiodarone administration (within 23 minutes following arrest) is valuable to inform amendments of clinical guidelines to prioritise amiodarone administration. Whether amiodarone can be given within the optimal time window is influenced by paramedic response time and time from arrest to intravenous access. Strategies aimed at shortening those time intervals, coupled with expanding the scope of practice of ACPs to include amiodarone as an intervention for this patient cohort, will reduce delay to amiodarone administration and improve outcome.

10. Contributors

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