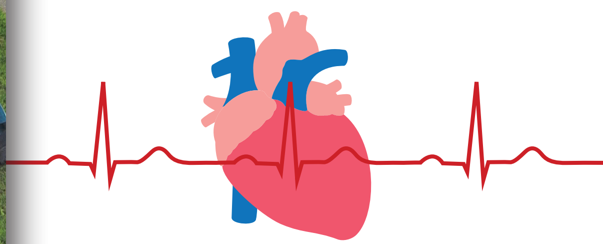
Queensland Ambulance Service

2019 ANNUAL REPORT

Out of Hospital Cardiac Arrest in Queensland



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Abbreviations

CPR	Cardiopulmonary Resuscitation
GCUH	Gold Coast University Hospital
IQR	Interquartile Range
LASN	Local Ambulance Service Network
OHCA	Out-of-Hospital Cardiac Arrest
OR	Odds Ratio
PAH	Princess Alexandra Hospital
QAS	Queensland Ambulance Service
QCH	Queensland Children's Hospital
RBWH	Royal Brisbane and Women's Hospital
ROSC	Return of Spontaneous Circulation
RR	Relative Risk
SCUH	Sunshine Coast University Hospital
TPCH	The Prince Charles Hospital
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia

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Key facts at a glance

5444 cardiac arrests attended

2210 resuscitations attempted

8 minutes (average) **response time** in both **metropolitan** and **rural** areas

75% received **bystander CPR**

Utstein patient group

- **51% survived event**
- **35% discharged alive**
- **35% survived to 30 days**

Heatwaves increased OHCA risk up to **two-fold**

1. About this report

Out-of-hospital cardiac arrest (OHCA) is the most time-critical and time-dependent condition that paramedics respond to. Early interventions by bystanders during the first moments after the patient collapses are crucial for survival. In addition to bystander interventions, the swiftness of ambulance response, and prehospital treatment by paramedics have a strong influence on survival. Ongoing systematic analysis of data about OHCA is essential for the evaluation of prehospital care, to inform ongoing quality improvement initiatives. This annual report presents findings from the 2019 calendar year for OHCA patients who were attended by Queensland Ambulance Service (QAS) paramedics.

Also presented as a special focus in this report is an analysis of the association of temperatures and heatwaves with OHCA risk, using OHCA and meteorological data over a 13-year period between January 2007 and December 2019. The health impacts of extreme temperatures, in particular heatwaves, are gaining attention both in Australia and worldwide. Acute cardiovascular diseases, including OHCA, are among the health conditions that are affected by temperatures. Quantifying the exposure-response association between temperatures and OHCA risk is useful for the development of mitigation strategies aimed at minimising temperature-related OHCA burden, informing service planning, and subsequently reducing avoidable increase in ambulance demand.

2. Incidence and geographic distribution

In 2019, QAS paramedics attended a total of 5444 cases, equating an incidence rate of 107 cases per 100,000 population. Figure 1 shows a steady increase in the count of OHCA cases attended by paramedics over the past decade, whereas incidence rates remained relatively stable due to population increases over this time period. The east coast, especially south-east areas of the state, accounted for the majority of cases, reflecting the patterns of population distribution in Queensland (Figure 2).

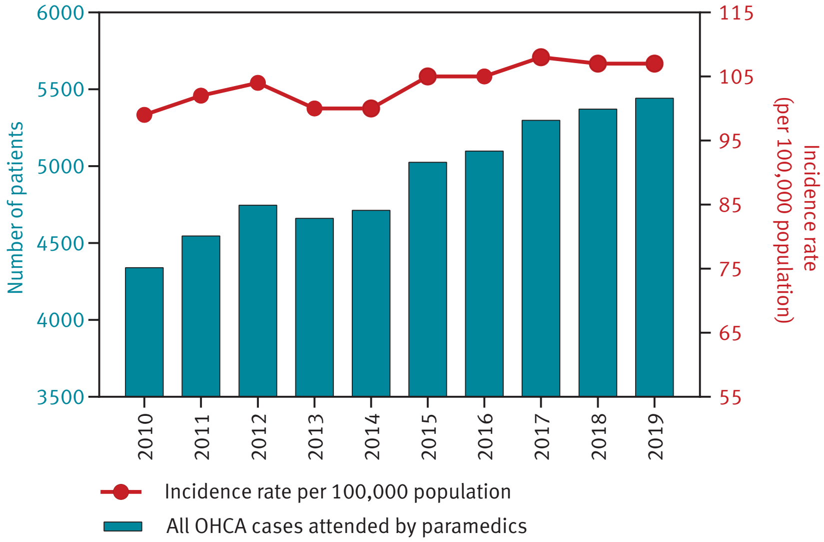

Figure 1. Number of OHCA cases and incidence rates per 100,000 population.

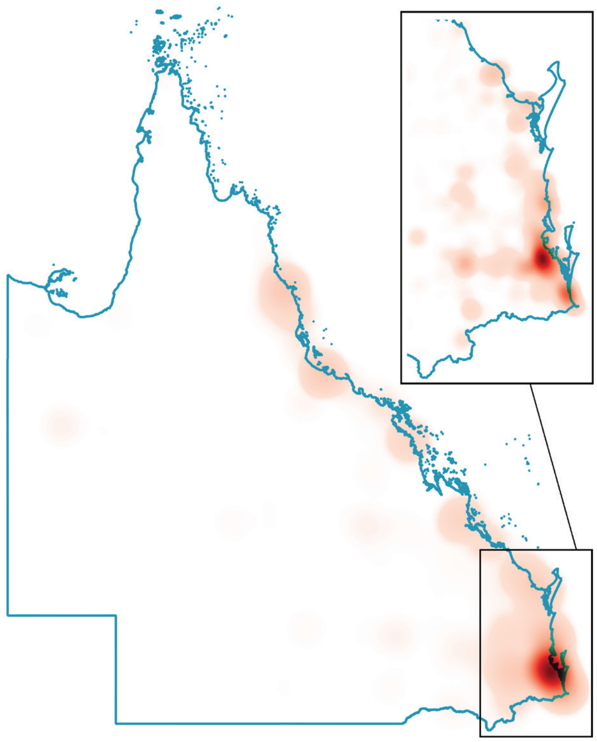

Figure 2. Heatmap showing spatial distribution of OHCA cases across Queensland. A spatial concentration was observed on the east coast, especially south-east areas of the state.

Figure 3 and Table 1 show the number of cases and incidence rates per 100,000 population for each Local Ambulance Service Network (LASN) geographic areas. As expected, data on event counts show a concentration of cases in more populated LASN areas, especially Metro North and Metro South. The spatial distribution of event counts markedly differed to that of incidence rates, which were highest in South West, Wide Bay and Darling Downs LASN areas.

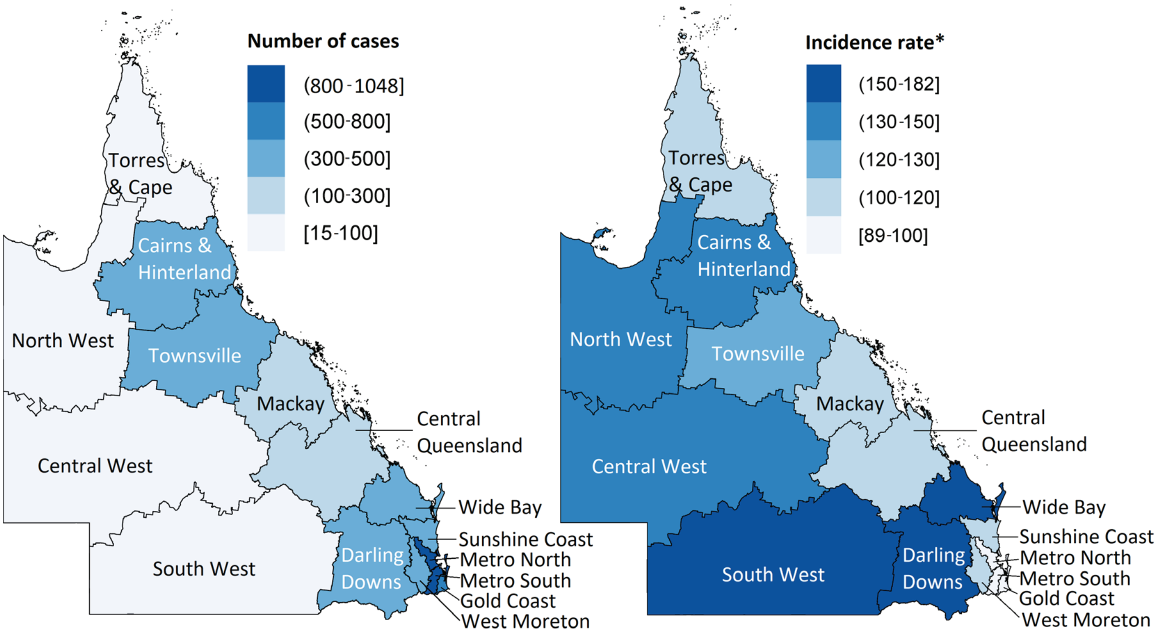

Figure 3. Maps of number of OHCA cases (left) and incidence rates (right) by LASN.
*per 100,000 population.

Table 1. Number of OHCA cases and incidence rates per 100,000 population by LASN

Number of cases	LASN	Incidence rate (per 100,000 population)
30	Torres and Cape	109
39	North West	144
15	Central West	144
44	South West	182
378	Cairns and Hinterland	146
308	Townsville	129
186	Mackay	108
261	Central Queensland	119
366	Wide Bay	168
469	Sunshine Coast	110
915	Metro North	89
1048	Metro South	90
603	Gold Coast	97
344	West Moreton	117
430	Darling Downs	152

3. Resuscitation attempts

Of the 5444 patients attended by paramedics, 2210 (40.6%) received resuscitation from paramedics (Figure 4), and are the subject of all analyses in Sections 3, 4 and 5 of this report.

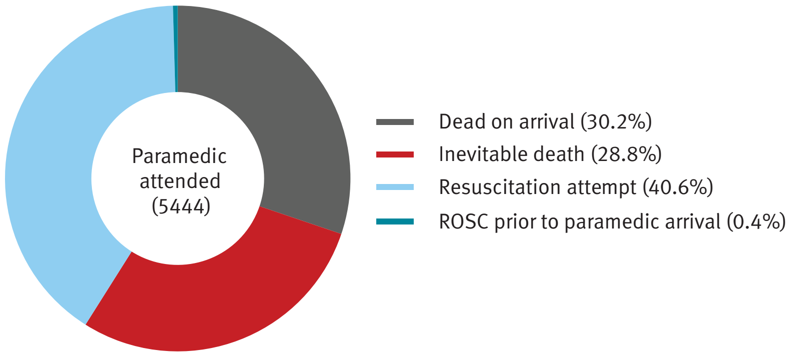

Figure 4. Case classifications among paramedic-attended patients.

Males accounted for 68.3% of all resuscitation attempted cases, being on average four years younger than females (median age 63 versus 67 years, $p < 0.001$) (Figure 5). The majority of arrests (72.7%) occurred in residential homes, followed by public places (11.0%) and aged care facilities (3.5%). Medical aetiology (primarily presumed cardiac) was the predominant cause of arrests (82.9%), followed by trauma (7.0%) and asphyxia (5.2%) (Figure 6). Around a quarter of cases (26.2%) had initial shockable rhythm (ventricular fibrillation or ventricular tachycardia, VF/VT).

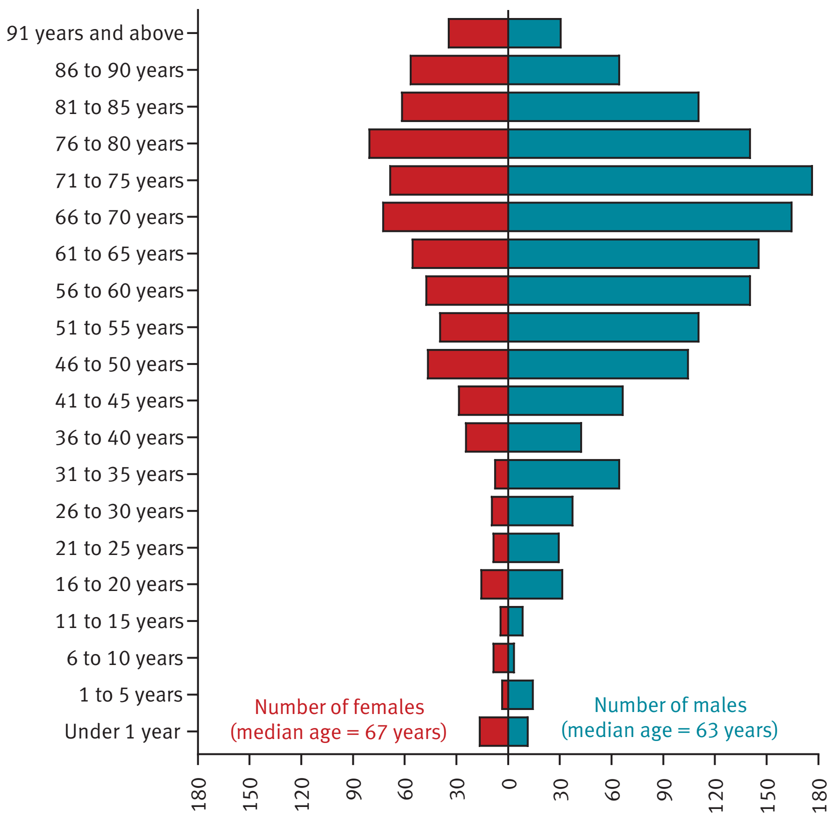

Figure 5. Age distribution by gender.

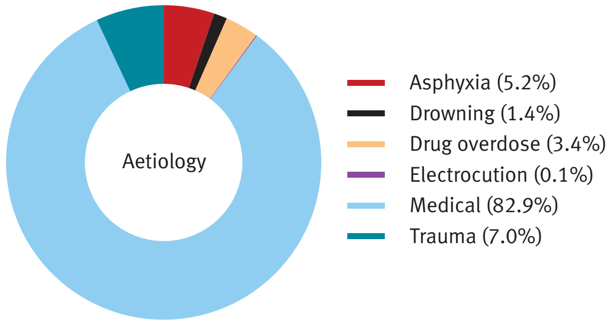

Figure 6. Aetiology of arrest.

In 2019, of all non-paramedic witnessed patients who subsequently received resuscitation by paramedics, 75.3% had received bystander-initiated cardiopulmonary resuscitation (CPR). As expected, bystander CPR rate was highest, at 78.7%, among those whose arrest was witnessed by a bystander (Figure 7).

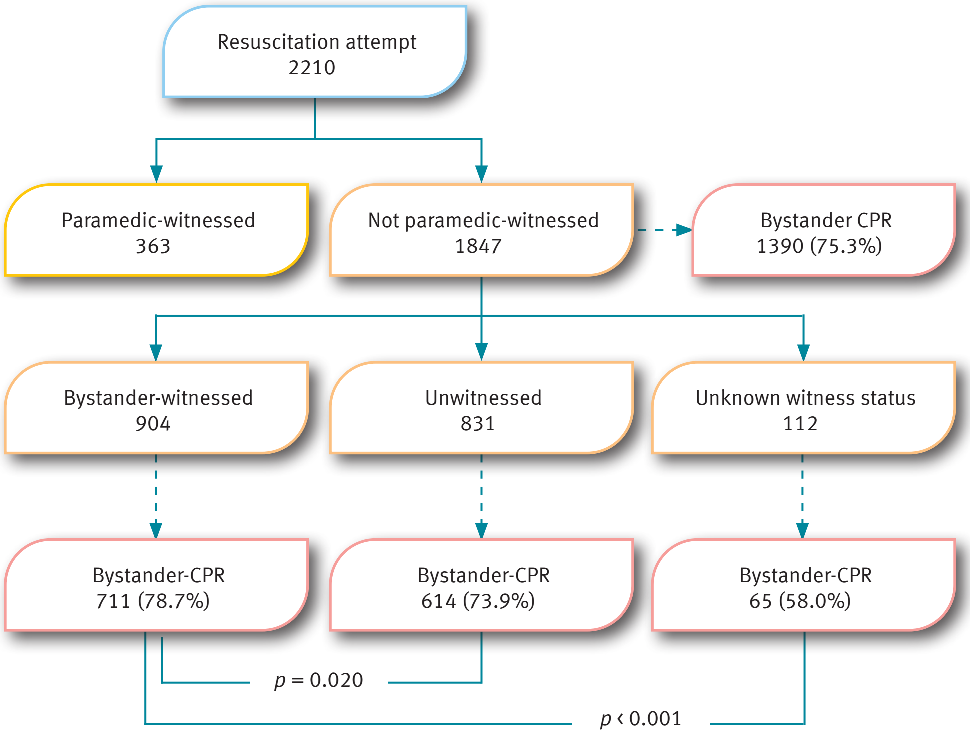

Figure 7. Bystander CPR rates.

Of all resuscitation attempted patients, 1288 (58.3%) were not transported to a hospital (died at scene). For those who were transported (922, 41.7%), The Princess Alexandra Hospital (PAH) was the most common destination, followed by Gold Coast University Hospital (GCUH), The Royal Brisbane and Women's Hospital (RBWH), Sunshine Coast University Hospital (SCUH), and The Prince Charles Hospital (TPCH) (Figure 8). Figure 9 shows the locations of the hospitals to which patients were transported.

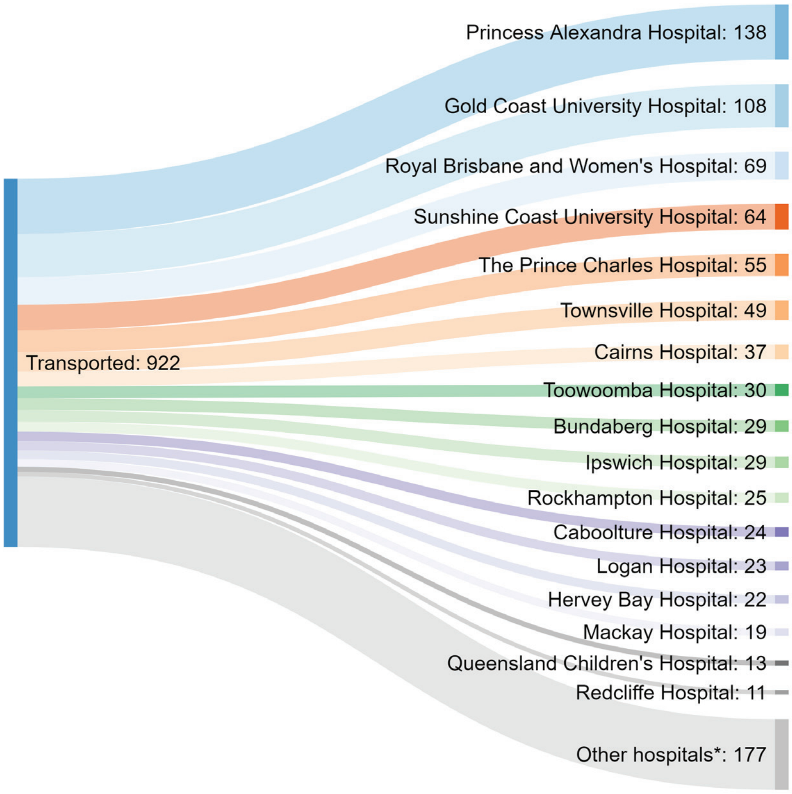

Figure 8. Hospital destinations. *62 different hospitals, each with fewer than 10 cases. Refer to Figure 9 for locations of hospitals.

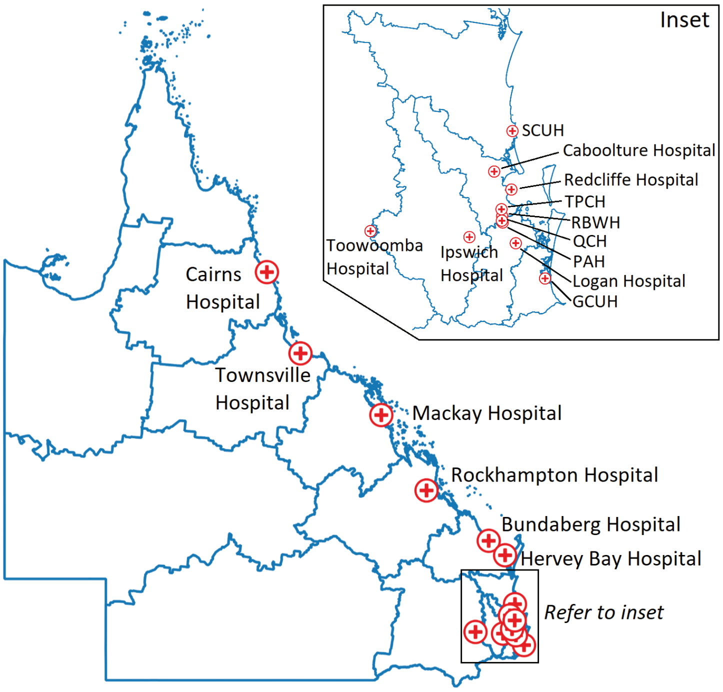

Figure 9. Hospital locations. Shown is Queensland map with LASN geographic boundaries.

4. Survival outcomes

For all patients who received resuscitation from paramedics, the rates of event survival (return of spontaneous circulation [ROSC] on hospital arrival), survival to discharge, and 30-day survival were 30.9%, 14.4% and 14.3%, respectively (Figure 10).

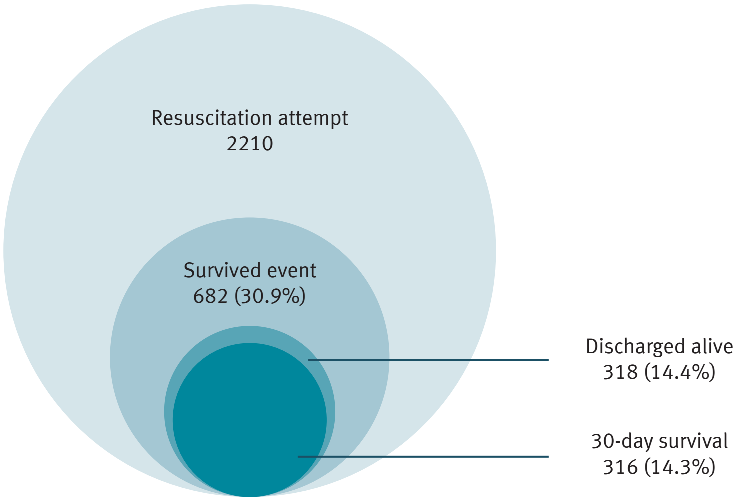

Figure 10. Survival outcomes of patients who received resuscitation from paramedics.

For those who achieved ROSC on hospital arrival (event survival) and across all aetiologies, 78.9% did so within 20 minutes following first paramedic-initiated resuscitation intervention (CPR or defibrillation), and 93.6% achieved ROSC with the first 30 minutes (Figure 11). Trauma aetiology had the highest percentage of patients achieving ROSC within 20 minutes (86.2%); whereas drug overdose had the lowest figure (71.0%) (Figure 12).

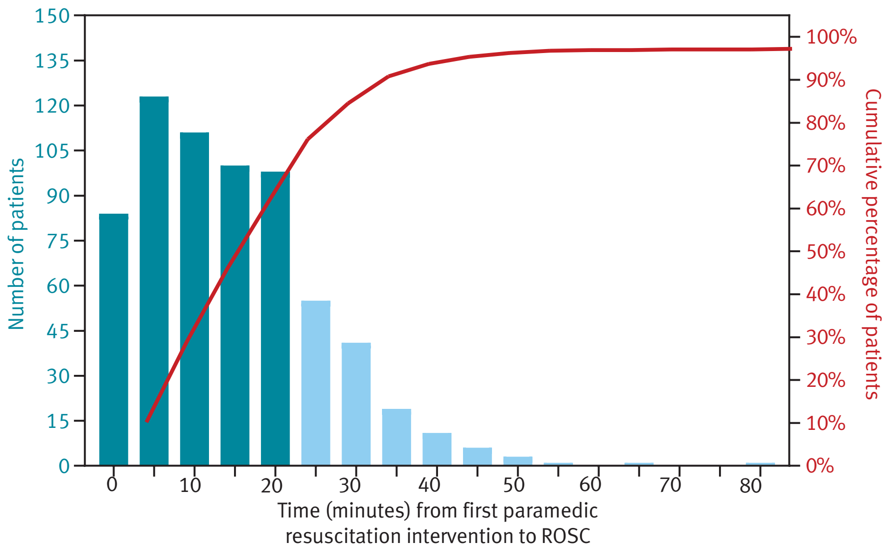

Figure 11. Time from first paramedic resuscitation intervention to ROSC.

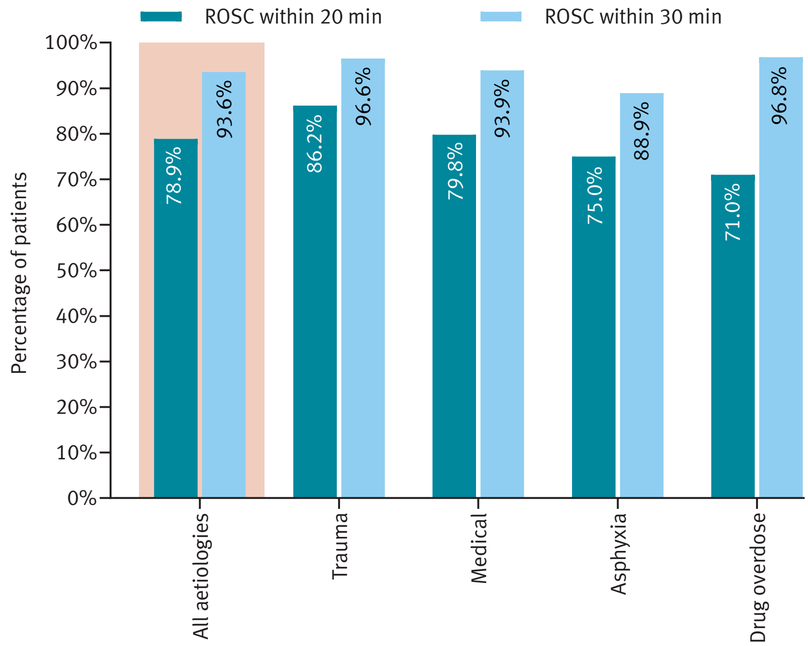

Figure 12. Percentage of patients achieving ROSC by time of ROSC (within 20 or 30 minutes following first paramedic-initiated resuscitation intervention) and by aetiology of arrest.

Figure 13 shows event survival rates for various patient groups. With regard to aetiology of arrest, drowning had the highest rate of event survival (46.7%), whereas the event survival rate was lowest for trauma (19.5%). Witnessed arrests had substantial survival benefit compared to unwitnessed arrests. Patients whose arrest was witnessed by paramedics had an event survival rate of 50.4%. The corresponding figure for bystander-witnessed arrests was 33.8%, and for unwitnessed arrests was 20.5%. Better survival was also observed in patients who received bystander CPR compared to those who did not.

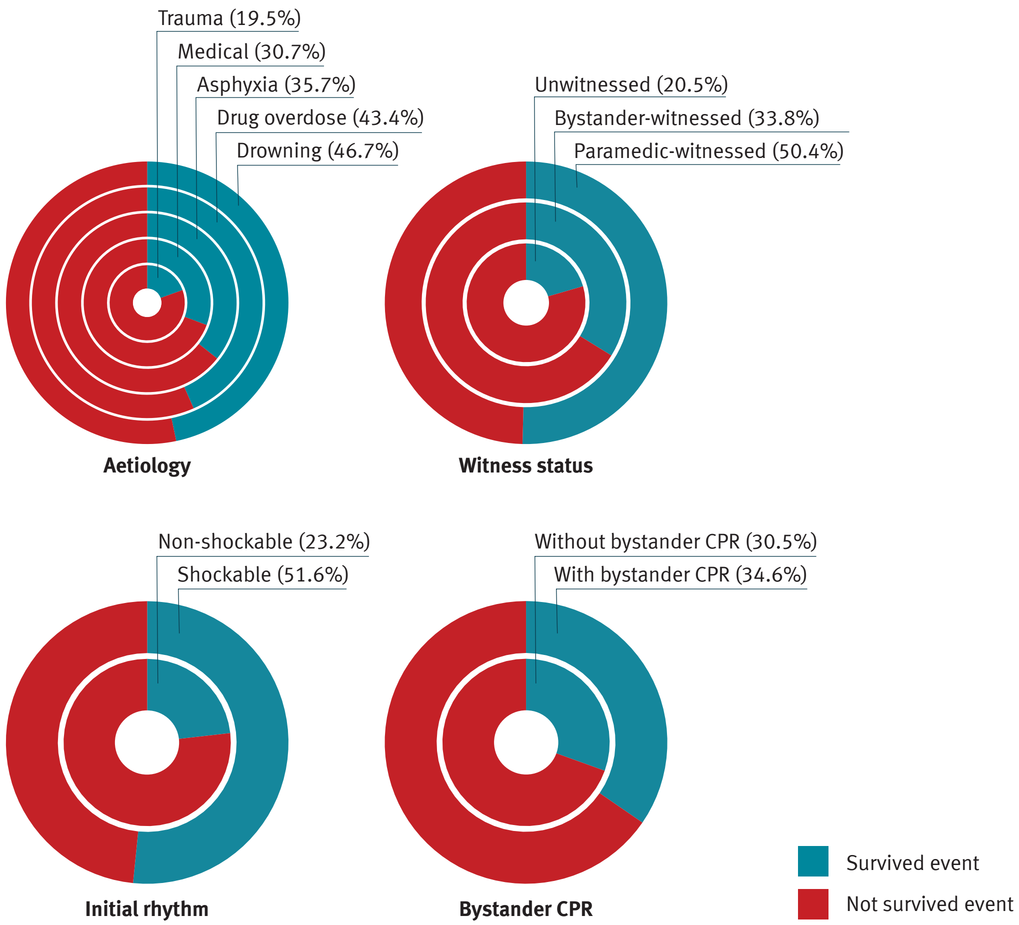

Figure 13. Event survival rates for various patient groups.

In 2019, there were 335 cardiac arrests attended by QAS paramedics that met the Utstein criteria. The following criteria define the Utstein patient group: all-cause, resuscitation attempted, initial shockable rhythm, and bystander-witnessed.[1] For this patient group, the rates of event survival, survival to discharge, and 30-day survival were 51.0%, 34.9% and 34.6%, respectively (Figure 14). These figures compare favourably with other ambulance services in Australia and worldwide (Figure 15),[2-10] which given the state's challenging geography is a notable achievement.

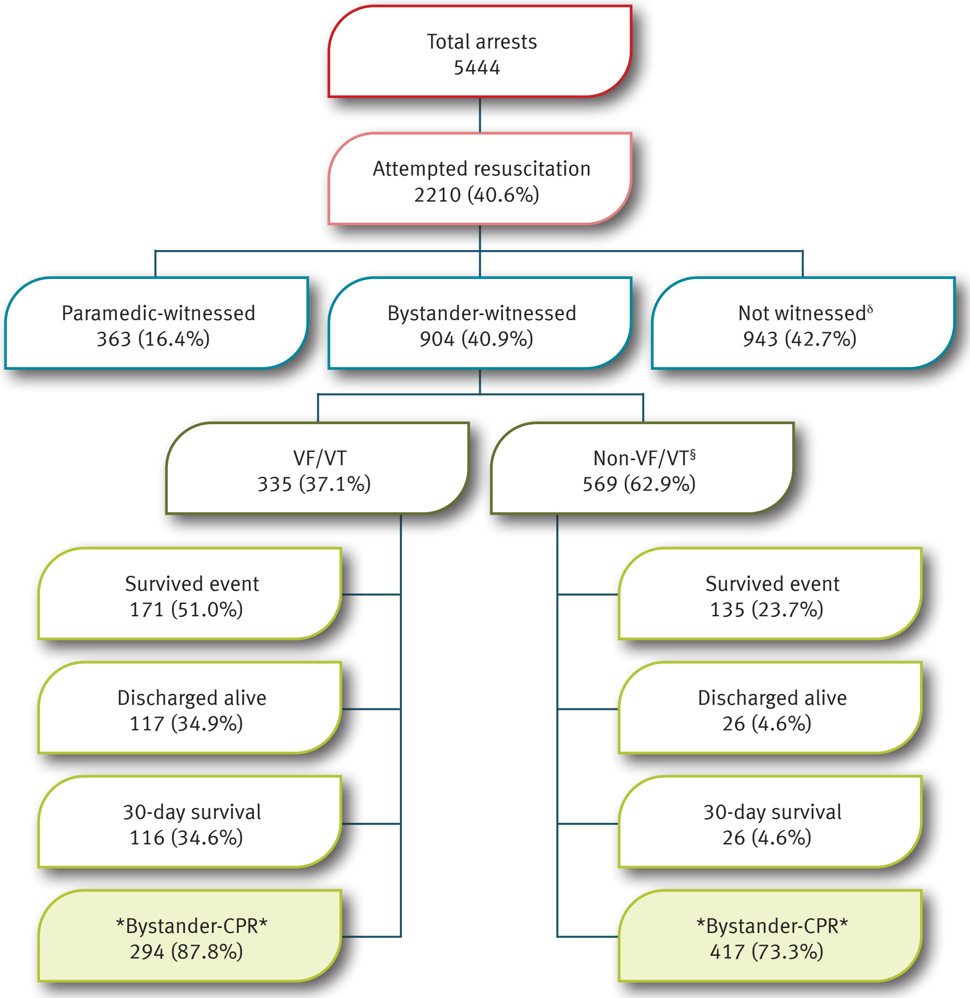

Figure 14. Breakdown of OHCA events according to paramedic-attempted resuscitation, witness status and initial rhythm. ᵟIncluding unknown witness status. §Including unknown initial rhythm.

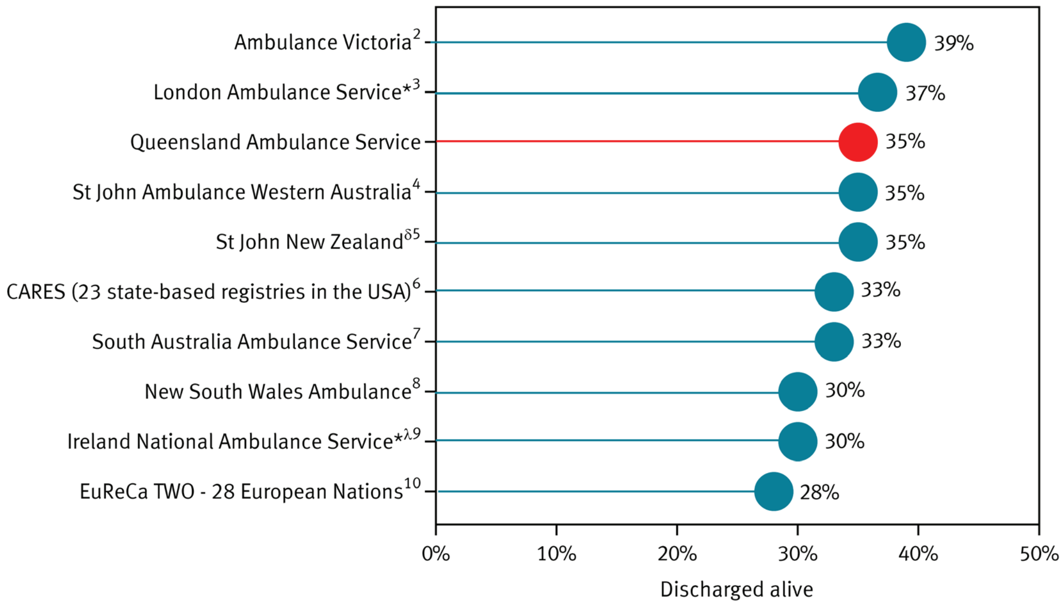

Figure 15. Survival outcomes (discharged alive) of the Utstein patient group reported by various ambulance services. All ambulance services reported data for the calendar year 2018 or financial year 2018/2019, with the exception of St John Ambulance Western Australia (2019), EuReCa TWO (2017) and South Australia Ambulance Service (2016/2017). ᵟ30-day survival, only included adults (≥ 15 years). *Only included arrests of cardiac aetiology. ᵡOnly included adults (› 17 years).

5. Paramedic time intervals

In 2019, the median (interquartile range, IQR) response time, from when the Triple Zero (000) call requesting ambulance attendance is received to when the ambulance arrives at the scene of the incident, was 8 (6-12) minutes. The response time has remained consistently short, at 8 minutes, across geographic regions, and between day-time (07:00 – 18:59) and night-time (Figure 16).

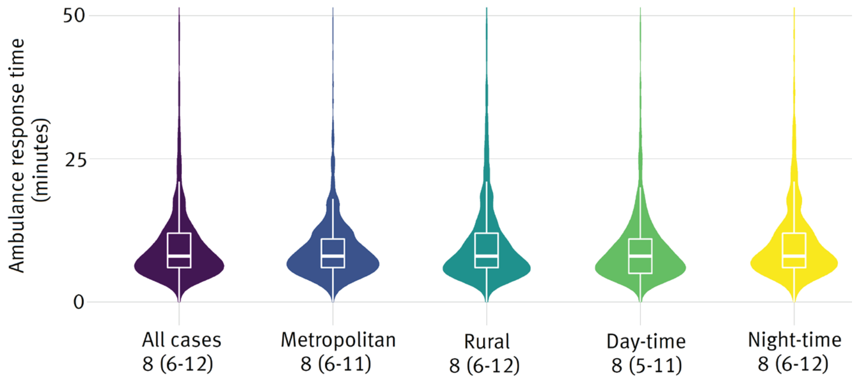

Figure 16. Ambulance response time. The numbers outside the brackets are medians, and inside the brackets are IQR. For the box-and-whisker plot, the middle line of the box represents median. The lower and upper hinges correspond to the 25th and 75th percentiles. The upper whisker extends from the hinge 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. For readability, outliers are not shown.

The median (IQR) time from collapse to intravenous cannulation was 16 (10-22) minutes, and to administration of first adrenaline dose was 20 (15-26) minutes (Table 2). The median (IQR) time from collapse to first advanced airway procedure (endotracheal intubation or laryngeal mask airway) was 18 (13-25) minutes. The probability of survival from OHCA diminished with prolonged time intervals, with the exception of time from collapse to advanced airway procedure, which was not found to significantly affect survival (Table 2, Figure 17). Every minute increase in time from collapse to cannulation was associated with a reduced likelihood of event survival, survival to discharge and 30-day survival by 4.0%, 7.0% and 6.0%, respectively (Table 2). The corresponding figures for every minute delay in time from collapse to adrenaline administration were 3.0%, 4.0% and 4.0%, respectively (Table 2).

Table 2. Odds ratios of the association between paramedic time intervals and survival

Time intervals (minutes)	Median (IQR)	Unadjusted OR* (95% confidence interval)		
		Survived event	Discharged alive	30-day survival
Response time	8 (6-12)	**0.99 (0.97-1.00)**	0.99 (0.98-1.01)	0.99 (0.98-1.01)
Collapse‡ – Cannulation	16 (10-22)	**0.96 (0.95-0.97)**	**0.93 (0.92-0.95)**	**0.94 (0.92-0.95)**
Collapse‡ – Adrenaline	20 (15-26)	**0.97 (0.96-0.99)**	**0.96 (0.94-0.98)**	**0.96 (0.94-0.98)**
Collapse‡ – Advanced airway procedure#	18 (13-25)	1.00 (0.98-1.01)	1.01 (0.99-1.03)	1.01 (0.99-1.03)

**For one-minute increment.*
‡Only bystander-witnessed or paramedic-witnessed cases were included. Time of collapse was time of Triple Zero call for the former, and time of paramedic witness arrest for the latter.
#Endotracheal intubation or laryngeal mask airway. When both procedures were performed on a patient, time of the earlier procedure was used.
Bold numbers indicate statistically significant ($p < 0.05$).

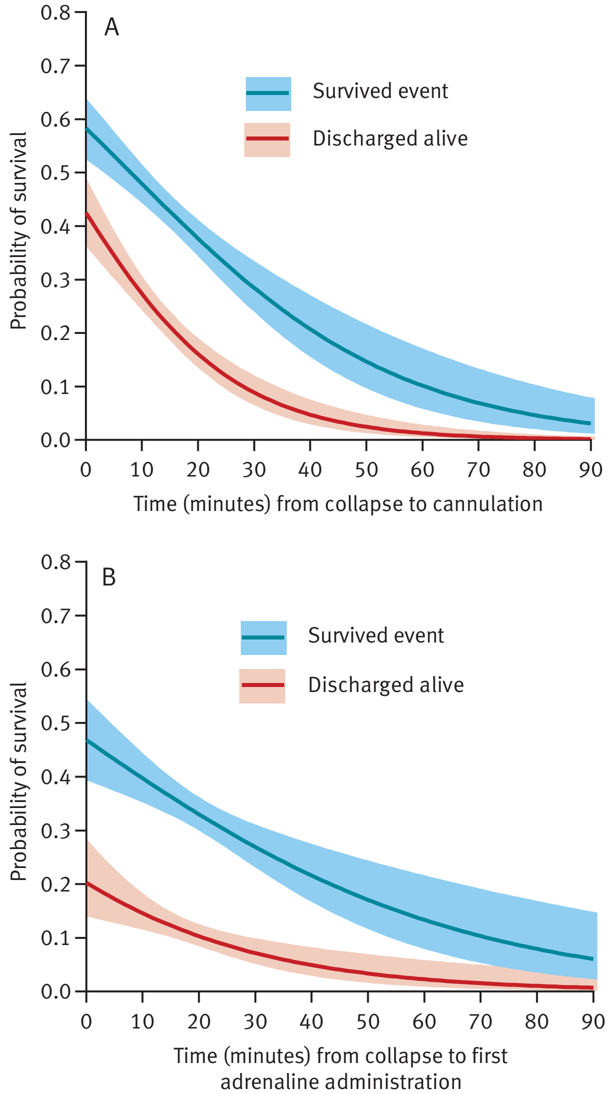

Figure 17. Fitted curves and the associated 95% confidence intervals (shaded areas) showing the probability of survival as a function of time from collapse to cannulation (A) and to first adrenaline administration (B). Predictions were based on univariate logistic regression models. The curves for 30-day survival almost overlap with those for discharged alive, and therefore are not shown.

6. Temperatures, heatwaves and OHCA risk

Increased frequency and intensity of extreme high temperatures, in particular heatwaves, has been observed in Australia and many parts of the world. OHCA is among the health conditions that are compounded by extreme temperatures. A number of studies have investigated the association of temperatures and the risk of cardiovascular diseases; however only a few on OHCA, and none in Australia. Quantifying the exposure-response association between temperatures and OHCA risk is essential for the development of mitigation strategies.

A statistical model was developed to investigate the association of temperatures and the risk of OHCA occurrence. Input data were OHCA daily counts and daily average temperatures for Brisbane over a 13-year period between January 2007 and December 2019. Figure 18 shows a graphical overview of daily average temperatures during the study period. The model adjusted for the following potential confounding factors: daily maximum temperatures, relative humidity, long-term temporal trends and seasonality, and day of the week.

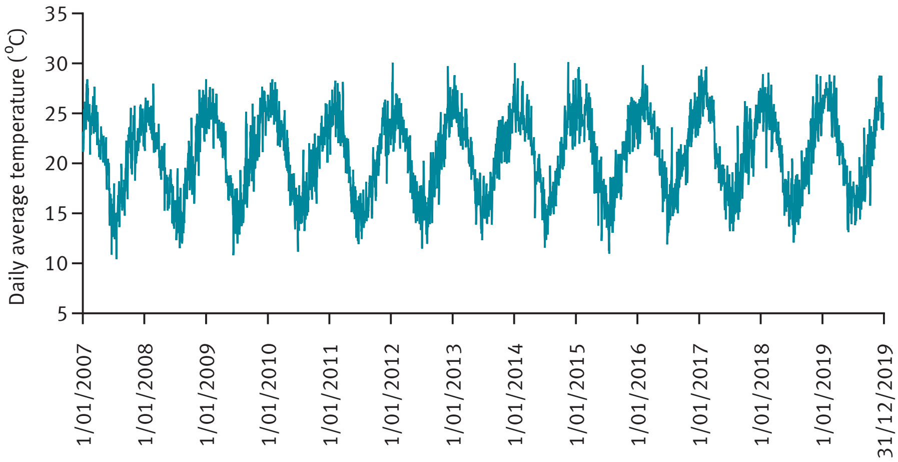

Figure 18. Time series plotting of daily average temperatures across the study period.

The overall effect of temperatures on the risk of OHCA occurrence was presented as the relative risk (RR) of OHCA associated with temperatures (as a continuous variable) compared to the reference temperature, which was chosen to be the median value of daily average temperatures of the whole study period (21.2°C).

The effect of heatwaves on OHCA risk was also examined. To date, there remains a lack of universal definitions for heatwaves. For consistency with previous studies that analysed Brisbane weather data,[11-13] heatwaves were defined as daily mean temperatures at or above a heat threshold for at least two consecutive days. A range of heat thresholds were considered, and included: 90th, 95th, 98th and 99th percentile of the yearly temperature distribution across the study period.[11-13]

The overall effect of temperatures is shown in Figure 19. The risk of OHCA generally increased when temperatures were below or above the reference temperature (21.2°C), with the greatest increase observed when temperatures were above 27°C. Figure 20 displays the effect of heatwaves on OHCA risk. Heatwaves significantly increased OHCA risk across the operational definitions. When a threshold of 95th percentile of yearly temperature distribution was used to define heatwaves, OHCA risk increased 1.23 times (95% confidence interval 1.01-1.50). When the heat threshold for defining heatwaves increased to 99th percentile, the relative risk increased to 1.45 (1.08-1.94).

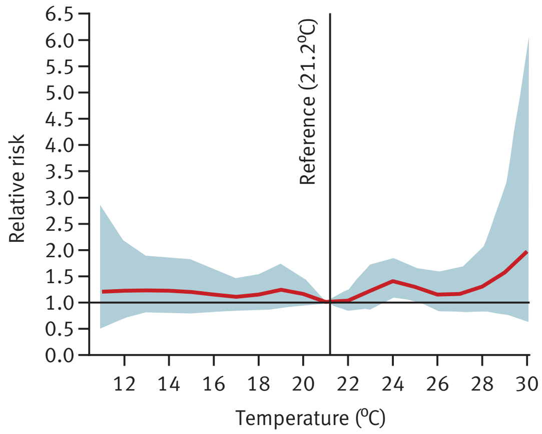

Figure 19. Overall effect of temperatures on OHCA risk. Data points above/below one, as demonstrated by the horizontal line, represent an increased/reduced OHCA risk relative to the reference temperature.

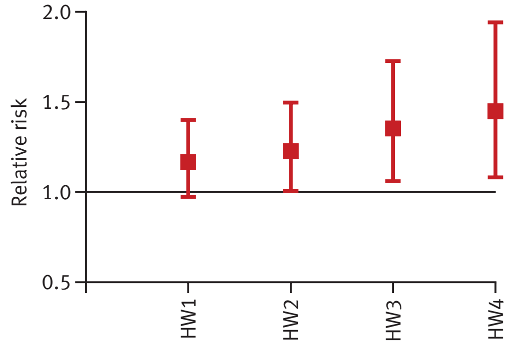

Figure 20. Effect of heatwaves on OHCA risk. Several heatwave definitions were considered: HW1, daily mean temperatures at or above 90th percentile of the yearly temperature distribution for at least two consecutive days; HW2, daily mean temperatures at or above 95th percentile of the yearly temperature distribution for at least two consecutive days; HW3, daily mean temperatures at or above 98th percentile of the yearly temperature distribution for at least two consecutive days; HW4, daily mean temperatures at or above 99th percentile of the yearly temperature distribution for at least two consecutive days.

To date, there is a lack of Australian data on temperatures and OHCA risk to which our results may be compared, however international studies conform with our findings. A study in Paris (France) found that heatwaves were associated with a 2.5 time increase in OHCA risk.[14] In another study in South Korea, Kang *et al.*[15] reported that heatwaves, defined as temperatures above the 98th percentile for at least two consecutive days, increased the risk of OHCA by 14%.

The exact mechanism underlying the association between temperatures and increased OHCA risk remains unknown, although several physiological mechanisms have been proposed to explain such association. Heat-induced disorders of thermoregulatory mechanisms have been proposed to explain heat-related OHCA. Exposure to heat can cause dehydration, leading to hydro-electrolytic disorders and potentially a state of myocardial hyperexcitability.[14] Sweating in response to exposure to high temperatures also increases skin blood flow and volume depletion, resulting in diminished cardiac preload and afterload.[16] Additionally, elevated heart rate and cardiac contractility as a result of heat can increase myocardial oxygen consumption.[15] Heat may also cause mental stress, which in turn increases OHCA risk.[17] It is thought that low temperatures stimulate thermoreceptors in the skin, thereby activating the sympathetic nervous system and consequently raising systemic catecholamine levels, which in turn induces vasoconstriction, increases heart rate and raises blood pressure.[18] Cold temperatures have also been shown to trigger biochemical responses by increasing blood cell counts, plasma cholesterol, C-reactive protein, plasma fibrinogen concentration and platelet viscosity - all of which compound the risk of an acute cardiovascular event and a sudden cardiovascular collapse through increased cardiac workload and reduced ischaemic threshold.[18-20]

7. Conclusions

This report demonstrates the outstanding quality of prehospital care delivered to OHCA patients by QAS paramedics. Our survival outcomes compare favourably with other ambulance jurisdictions nationally and internationally. In addition, this report provides a novel investigation into the association between ambient temperatures, heatwaves and OHCA risk. In the time of increasing frequency and intensity of extreme temperatures, and increasing demand for emergency ambulance services, such findings are valuable to inform the development of evidence-based mitigation strategies aimed at minimising temperature-related OHCA burden, and subsequently reducing avoidable increase in ambulance demand.

8. Acknowledgements

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

9. Publications using QAS OHCA data

List of recent peer-reviewed publications that used the QAS OHCA database, in chronological order.

- Schultz BV *et al*. Prehospital study of survival outcomes from out-of-hospital cardiac arrest in ST-elevation myocardial infarction in Queensland, Australia (the PRAISE study). *Eur Heart J Acute Cardiovasc Care*. 2020 (in press).
- Doan TN *et al*. Insights into the epidemiology of cardiopulmonary resuscitation-induced consciousness in out-of-hospital cardiac arrest. *Emerg Med Australas*. 2020 (in press).
- Doan *et al*. Surviving out-of-hospital cardiac arrest: The important role of bystander interventions. *Australas Emerg Care*. 2020; **23**: 47-54.
- Pemberton K *et al*. Epidemiology of pre-hospital outcomes of out-of-hospital cardiac arrest in Queensland, Australia. *Emerg Med Australas*. 2019; **31**: 821-29.
- Pemberton K *et al*. Pre-hospital outcomes of adult out-of-hospital cardiac arrest of presumed cardiac aetiology in Queensland, Australia (2002-2014): Trends over time. *Emerg Med Australas*. 2019; **31**: 813-20.
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- Beck B *et al*. Regional variation in the characteristics, incidence and outcomes of out-of-hospital cardiac arrest in Australia and New Zealand: Results from the Aus-ROC Epistry. *Resuscitation*. 2018; **126**: 49-57.
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Queensland Ambulance Service

Out of hospital cardiac arrest in Queensland
2019 annual report

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