

Inter-hospital trends of post-resuscitation interventions and outcomes of out-of-hospital cardiac arrest in Singapore

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ABSTRACT

Introduction: Hospital-based resuscitation interventions, such as therapeutic temperature management (TTM), emergency percutaneous coronary intervention (PCI) and extracorporeal membrane oxygenation (ECMO) can improve outcomes in out-of-hospital cardiac arrest (OHCA). We investigated post-resuscitation interventions and hospital characteristics on OHCA outcomes across public hospitals in Singapore over a 9-year period.

Methods: This was a prospective cohort study of all OHCA cases that presented to 6 hospitals in Singapore from 2010 to 2018. Data were extracted from the Pan-Asian Resuscitation Outcomes Study Clinical Research Network (PAROS CRN) registry. We excluded patients younger than 18 years or were dead on arrival at the emergency department. The outcomes were 30-day survival post-arrest, survival to admission, and neurological outcome.

Results: The study analysed 17,735 cases. There was an increasing rate of provision of TTM, emergency PCI and ECMO ($P < 0.001$) in hospitals, and a positive trend of survival outcomes ($P < 0.001$). Relative to hospital F, hospitals B and C had lower provision rates of TTM ($\leq 5.2\%$). ECMO rate was consistently $< 1\%$ in all hospitals except hospital F. Hospitals A, B, C, E had $< 6.5\%$ rates of provision of emergency PCI. Relative to hospital F, OHCA cases from hospitals A, B and C had lower odds of 30-day survival (adjusted odds ratio [aOR] < 1 ; $P < 0.05$ for hospitals A–C) and lower odds of good neurological outcomes (aOR < 1 ; $P < 0.05$ for hospitals A–C). OHCA cases from academic hospitals had higher odds ratio (OR) of 30-day survival (OR 1.3, 95% CI 1.1–1.5) than cases from hospitals without an academic status.

Conclusion: Post-resuscitation interventions for OHCA increased across all hospitals in Singapore from 2010 to 2018, correlating with survival rates. The academic status of hospitals was associated with improved survival.

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CLINICAL IMPACT

What is New

- This is the first study to the best of our knowledge to describe trends in post-resuscitation interventions and out-of-hospital cardiac arrest (OHCA) outcomes across public hospitals in Singapore over a 9-year period.
- Post-resuscitation interventions for OHCA increased across public hospitals, correlating with survival rates.
- OHCA cases from academic hospitals reported higher 30-day survival (odds ratio 1.3, 95% confidence interval 1.1–1.5).

Clinical Implications

- Findings of the present study may guide policies for OHCA management in future.

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) have notoriously been a medical issue with high morbidity and mortality.¹ It is a multifaceted problem with a multitude of aetiologies,² and as such various factors influence the outcome of OHCA patients.

The management of OHCA can generally be outlined by the “Chain of Survival”, a framework that includes pre-hospital and hospital-based management for increasing survival from sudden cardiac arrest.³ Each step in the chain is crucial in optimising survival.⁴ Non-modifiable pre-hospital factors that affect outcomes include age and sex.⁵ Modifiable pre-hospital factors that are well-established to affect survival outcomes include cause of arrest, ambulance response timings, presence of bystander cardiopulmonary resuscitation (CPR) and pre-hospital defibrillation.^{6–8} In Singapore, there have been efforts to improve countrywide pre-hospital management in recent years.⁹ The rates of pre-hospital CPR and return of spontaneous circulation have improved greatly.¹⁰

The fifth link—post-resuscitation care—in the Chain of Survival is largely based in hospitals and includes advanced treatments such as therapeutic temperature management (TTM),¹¹ extracorporeal membrane oxygenation (ECMO)^{12,13} and percutaneous coronary intervention (PCI).^{14–16} There are advocates for TTM and ECMO to be commenced as early as possible in OHCA management, even in emergency department (ED) settings where appropriate.^{17,18} Recently, there has

been an international interest in hospital management of OHCA patients in cardiac arrest centres, similar to the concept of management of stroke patients in acute stroke units.¹⁹ Studies from Denmark,²⁰ the US,²¹ Britain²² and Australia²³ suggest significantly better survival to hospital discharge with a cardiac arrest centre model. Such centres are defined as institutions that have the following facilities available round-the-clock²⁴: (1) intensive care, including mechanical ventilation and TTM; (2) acute cardiac care including PCI; (3) radiology service with computed tomography availability; and (4) delayed, multimodality and standardised neuroprognostication.

Hospital characteristics such as number of beds, years in operation, and teaching status are also known to affect survival outcomes.²⁵ In the context of Singapore, Tan et al.²⁶ showed stark differences in survival outcomes among government hospitals and suggested that academic status and hospital bed number correlated with better survival to discharge. An academic hospital is defined by the presence of a medical school directly affiliated to it. Apart from the aforementioned study in 2019, there is a paucity of local studies that focus on the quality of hospital-based interventions in OHCA. The current study aimed to glean insights into hospital-based factors associated with better OHCA survival outcomes in Singapore. We aimed to investigate trends in post-resuscitation interventions and OHCA outcomes across public hospitals in Singapore over a 9-year period. We hypothesised that inter-hospital differences in intervention rates (of TTM, ECMO and PCI) and hospital characteristics correlate with differences in survival outcomes.

METHODS

This was a prospective, nationwide, multicentre cohort study of consecutive OHCA cases presenting to Singapore government restructured hospitals from 2010 to 2018. Data were extracted from the Singapore cohort of the Pan-Asian Resuscitation Outcomes Study Clinical Research Network (PAROS CRN) registry, an international registry of OHCA in the Asia-Pacific region.²⁷ The registry included all OHCA cases that were either conveyed by emergency medical services (EMS) or had presented to EDs. The registry excluded patients who were immediately pronounced dead, for whom resuscitation was not attempted; or were associated with decapitation, rigor mortis, dependent lividity or existing “do not attempt resuscitation” orders. We further excluded patients who were younger than 18 years, found to be dead on arrival, and non-EMS cases.

We reviewed pre-hospital characteristics such as age, sex, presence of bystander CPR, pre-hospital defibrillation, cause of arrest, and ambulance response timings to look for trends over the years and between hospitals.

Data were collected from ambulance case reports and discharge summaries from wards, EDs and intensive care units (ICUs). The primary outcome was 30-day survival, defined as either discharged alive or remained alive in hospital on the 30th day post-arrest, whichever occurred first. Secondary outcomes included survival to hospital admission and survival with favourable neurological outcome, defined as Glasgow-Pittsburgh Cerebral Performance Categories (CPC) score ≤ 2 at either hospital discharge, or on the 30th day post-arrest if patient remained in hospital for longer than 30 days. Patients who were transferred to the nearest hospital for any intervention would be tallied under the hospital that they were first conveyed to.

Study setting

Singapore is a Southeast Asian country with a population of 5,905,527. As of the year 2021, its population density is 8,358 people per km², with a median age of 42.4 years.²⁸ Pre-hospital EMS is provided by the Singapore Civil Defence Force (SCDF), a uniformed government agency that operates a publicly funded fire-fighting, rescue and emergency medical service. As of 2018, it has 65 ambulances at its disposal.²⁹ Paramedics are trained in basic life support, 12-lead electrocardiography, automated external defibrillator usage, and adrenaline administration. SCDF operates through a centralised phone dispatch, with a tiered system after a phone triage. In scenarios of OHCA, SCDF conveys patients to a public hospital that is nearest to the incident location. In 2018, SCDF responded to 82% of life-threatening cases within 8 minutes.³⁰

In 2010, there were 6 adult acute restructured hospitals in Singapore (labelled Hospitals A-F in the current study), equipped with 6,686 beds with an occupancy rate of 343,332 (78.5%).³¹ There were 7 private hospitals in Singapore; however, they did not receive OHCA cases from EMS or handle post-OHCA patients. There was also a paediatric restructured hospital that did not manage adult OHCA patients. By 2018, an additional government restructured hospital was in operation, but it was excluded from the current study as it had limited temporal data. All hospitals had the capacity to offer TTM, whereas only 5 of the 6 hospitals (B-F) provided 24-hour emergency PCI services. Hospital F was the

only hospital with ECMO capability on-site, but all the other hospitals were able to transfer patients there for ECMO. All hospitals involved had readily available intensive care, computed tomography services with radiological interpretation, and multidisciplinary management for neuroprognostication. The current study was approved by the SingHealth Centralised Institutional Review Board (CIRB 2013/604/C and 2018/2937) and Domain Specific Review Board (C/10/545 and 2013/00929).

Statistical analysis

Characteristics of OHCA cases over consecutive calendar years were presented as mean (standard deviation) for continuous data and as count (%) for categorical data. For each hospital and for all hospitals combined, the yearly trends of hospital interventions and survival outcomes were explored graphically and tested for a linear trend by Mantel-Haenszel test. Similarly, OHCA characteristics of cases were summarised for each hospital and tabulated for comparison purpose.

Logistic regression was used to investigate the effect of hospital, time (in years), and interaction of time and hospital on the survival outcomes, with adjustment for pre-hospital factors. If the interaction time was not significant, it was removed from the regression model. The logistic regression was then repeated with adjustment for pre-hospital factors known to influence survival, namely, age, sex, witnessed arrest, bystander CPR, first arrest rhythm, pre-hospital defibrillation and cause of arrest. Response time was not adjusted for as SCDF conveys patients to the nearest hospitals independent of pre-hospital diagnosis. For the odds ratio (OR) of survival outcome from logistic regression, hospitals were compared against Hospital F, the oldest and largest restructured hospital in Singapore.

We attempted to explain inter-hospital differences in 30-day survival by examining hospital characteristics reported to be influential in the literature.²⁵ Hospital characteristics investigated were 24-hour access to PCI, academic status of hospitals, OHCA patient volume >4,000 cases a year, and years in operation (>20). The effect of each hospital characteristic on 30-day survival was analysed with univariate logistic regression.

Lastly, in the subgroup of OHCA who survived to hospital admission, the effect of each hospital intervention on 30-day survival was analysed by univariate logistic regression. All analyses were performed with SPSS Statistics software version 26.0 (IBM Corp, Armonk, US), where $P < 0.05$ was considered as statistically significant.

RESULTS

Description of patient characteristics

A total of 18,359 cases were extracted from the PAROS CRN registry. Of these, 17,735 cases qualified for analysis (Fig. 1). From year 2010 to 2018, there was an increase of 4.6 years in the mean age of patients with OHCA, while the proportion who were of male sex remained stable (Table 1). Bystander CPR increased throughout the years from 225 (21.6%) to 1,683 (61.6%) cases. The proportion of witnessed arrest remained stable, as did defibrillation prior to ED and the cause of arrest. There was no significant difference in major pre-hospital patient characteristics (age, sex, first arrest rhythm, cause of arrest and bystander CPR) between hospitals (Supplementary Table S1 in online Supplementary Material).

Graphical exploratory analysis of hospital-based interventions over the years by hospitals

There was a growing provision of hospital-based interventions (Fig. 2A). Hospitals B and C showed lower provision rates of TTM (number of patients with TTM employed out of the total number of OHCA cases per hospital) across all years ($\leq 5.2\%$) compared to other hospitals. All hospitals except F had an ECMO rate of

$<1\%$ over the study period 2010–2018. Hospitals A, B, C and E had $\leq 6.5\%$ yearly rates of emergency PCI; however, hospital E had a steady increase in emergency PCI provision rate from 2% to an estimated 6.1% over the years studied.

Graphical exploratory analysis of survival outcomes over the years by hospitals

There was a significant positive trend ($P<0.001$) for all 3 outcomes over the years (Fig. 2B). Hospitals A, B and C had rates below 25% over the years for survival to admission (Fig. 2B, P value not significant for linear trend). Hospital E had low rates of yearly survival to admission (below 25%) but rates improved linearly over the years ($P<0.001$).

Although hospitals B, C, D and E had a linear positive trend in 30-day survival (B: $P=0.015$; C: $P=0.045$; D: $P<0.001$; E: $P<0.001$; Fig. 2B), hospitals A, B and C had lower rates of 30-day survival (all below 7.1% for any year) compared to the other hospitals.

Hospitals A, B and C had lower rates of good neurological outcome (below 4.2% for any year). A linear positive trend in good CPC was reflected in hospitals B, D and E (B: $P=0.015$; D: $P<0.001$; E: $P<0.001$).

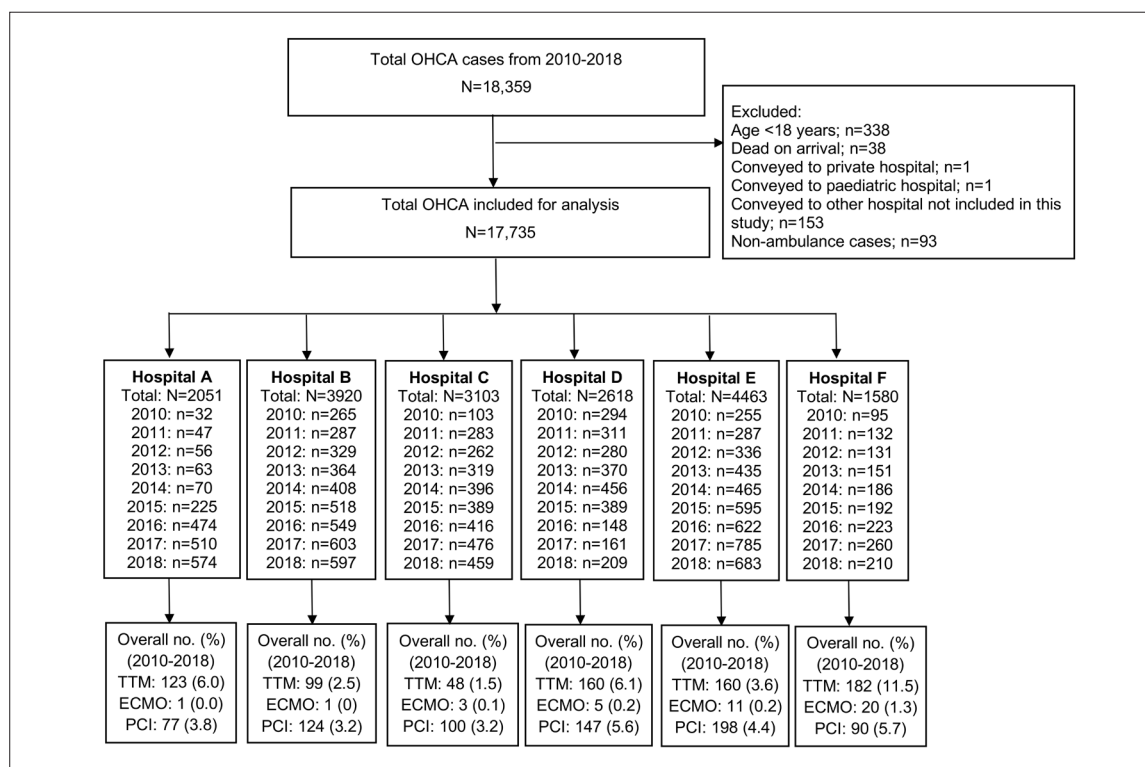


Fig. 1. Patient flowchart by hospital and outcomes

ECMO: extracorporeal membrane oxygenation; PCI: percutaneous coronary intervention; OHCA: out-of-hospital cardiac arrest; TTM: therapeutic temperature management

Logistic regression assessing effect of each hospital and time on survival outcomes

For any given hospital, the odds of any survival outcome increased over the years as seen in Model 2 (Table 2; $P < 0.05$ for all outcomes). For each additional year, adjusted odds ratio (aOR) was 1.04 for survival to admission, 1.12 for 30-day survival, and 1.16 for CPC 1 or 2.

However, at any given year, hospitals A, B and C when compared to F had lower odds of survival to discharge (Model 2). Compared to hospital F, the 3 hospitals decreased in odds of approximately 25–35% (aOR 0.67–0.76; $P < 0.05$ for A, B and C), and had lower 30-day survival with decreased odds of approximately 30–40% (aOR 0.61–0.68; $P < 0.05$ for A, B and C). These hospitals had lower odds of good neurological outcome with decreased odds of 30–35% (aOR 0.65–0.71; $P < 0.05$ for A, B and C).

Logistic regression assessing effect of hospital characteristics on 30-day survival

Hospitals D, E and F with academic status had 30% higher odds of 30-day survival (Table 3) as compared to hospitals A, B and C without academic status. The OR was 1.3 (95% confidence interval [CI] 1.1–1.5).

At the hospital level, 24-hour access to PCI did not confer a higher OR for 30-day survival (0.97, 95% CI 0.78–1.20). Academic status of hospitals was also found to be the only significant hospital characteristic that affected 30-day survival.

Logistic regression assessing effect of hospital interventions on 30-day survival in cohort of patients who survived to hospital admission

Among patients who survived to admission, those who underwent TTM and PCI show improved 30-day survival where ORs were 1.96 (95% CI 1.64–2.34) and 3.95 (95% CI 3.31–4.71), respectively (Table 4).

DISCUSSION

The present study of OHCA over a 9-year period reinforces current observational evidence in the literature that there is a difference in the provision of interventions and OHCA outcomes between hospitals.³² Our primary outcome, 30-day survival, had a similar maximum rate of 14.2% when compared with Møller et al.³³ (13.8%). However, there was a vastly different minimum survival rate in our study (0%) as compared to their study (8.5%) which could be attributed to their selection of patients with only cardiac causes of OHCA.

Table 1. Characteristics of out-of-hospital cardiac arrest cases in Singapore over a 9-year period from 2010 to 2018

Characteristics	2010 n=1044	2011 n=1347	2012 n=1394	2013 n=1702	2014 n=1984	2015 n=2308	2016 n=2432	2017 n=2795	2018 n=2732
Age, mean (SD), years	64.4 (16.2)	64.7 (16.0)	65.6 (16.7)	67.0 (16.4)	67.0 (16.6)	66.7 (16.4)	67.5 (16.9)	68.9 (16.6)	69.0 (17.1)
Male sex, no. (%)	677 (64.8)	935 (67.9)	916 (68.1)	1106 (65.1)	1279 (64.6)	1505 (65.3)	1549 (63.8)	1743 (62.5)	1857 (64.4)
Witnessed cardiac arrest									
Bystander, no. (%)	382 (36.6)	93 (51.6)	18 (45.0)	797 (46.9)	977 (49.4)	1130 (49.0)	1129 (46.5)	1388 (49.7)	1080 (39.5)
EMS/private ambulance, no. (%)	78 (7.5)	112 (8.3)	119 (8.5)	137 (8.1)	154 (7.8)	214 (9.3)	246 (10.1)	254 (9.1)	385 (10.4)
Bystander CPR, no. (%)	225 (21.6)	291 (21.6)	460 (33.0)	727 (42.8)	1002 (50.6)	1247 (54.1)	1379 (56.8)	1679 (60.2)	1683 (61.6)
Pre-hospital defibrillation, no. (%)	239 (22.9)	322 (23.9)	364 (26.1)	420 (24.7)	558 (28.2)	642 (27.9)	632 (26.0)	649 (23.3)	646 (23.6)
Cause of arrest									
Presumed cardiac, no. (%)	769 (73.7)	1053 (78.2)	994 (71.3)	1159 (68.1)	1367 (69.0)	1537 (66.6)	1653 (68.0)	1807 (64.7)	1887 (69.1)
Respiratory, no. (%)	97 (9.3)	74 (5.5)	116 (8.3)	89 (5.2)	81 (4.1)	99 (4.3)	96 (3.9)	87 (3.1)	104 (3.8)
Trauma, no. (%)	28 (2.7)	45 (3.3)	32 (2.3)	53 (3.1)	56 (2.8)	96 (4.2)	96 (3.9)	96 (3.4)	91 (3.3)
Initial shockable rhythm, no. (%)	200 (22.2)	249 (18.5)	280 (20.0)	299 (17.5)	345 (17.4)	377 (16.3)	428 (17.6)	419 (15.0)	436 (15.9)

CPR: cardiopulmonary resuscitation; EMS: emergency medical services; SD: standard deviation

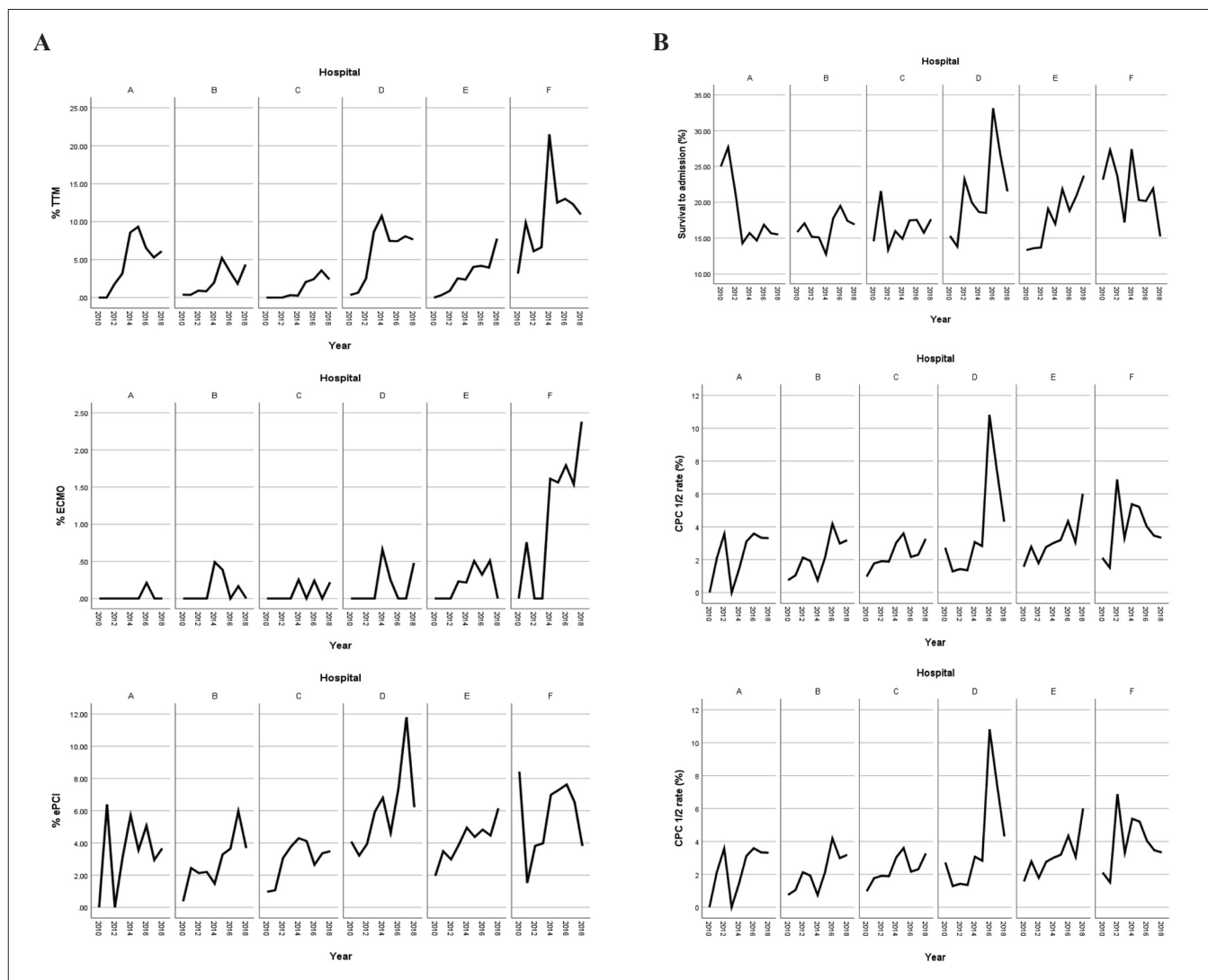


Fig. 2. (A) Inter-hospital temporal trends of hospital-based interventions. (B) Inter-hospital temporal trends in survival outcomes
CPC: cerebral performance category; ECMO: extracorporeal membrane oxygenation; PCI: percutaneous coronary intervention; TTM: therapeutic temperature management

The data showed an encouraging trend towards improving provision of hospital-based interventions across all hospitals in Singapore. This correlated with the improvement in survival for patients with OHCA. Patients who received TTM or PCI were associated with better outcomes. Although our data showed no significant improved survival in patients who underwent ECMO, the number of cases that received ECMO was minimal ($n=45$, across 9 years).

In terms of hospital characteristics, only academic status of hospitals showed a significant correlation with better 30-day survival, whereas 24-hour access to PCI, years in operation, number of beds, and OHCA patient volume were not significant factors. It should be noted that patients who had been transferred to the nearest

hospital for any intervention would be tallied under the hospital they were first conveyed to.

Academic hospitals overseas have been reported to have a lower mortality rate from its medical and surgical interventions.³⁴ Academic hospitals were more likely to utilise contemporary technologies.³⁵ Hospitals without an academic status might have been less likely to offer the same level of guideline-directed care.³⁶ ED care in academic hospitals was associated with more effective CPR and earlier PCI commencement, which could have contributed to improved survival.³⁷ However, our study did not examine the quality of resuscitative efforts in ED to discern if quality had any effect on survival outcomes.

As opposed to the landmark Singapore study in 2019,²⁶ our data did not find that bed capacity was a significant

Table 2. Unadjusted and adjusted survival outcomes for out-of-hospital cardiac arrest by hospital

Survival to admission	Model 1 Adjusted OR ^a (95% CI)	Model 2 Adjusted OR ^b (95% CI)
Year	1.03 (1.01–1.05)	1.04 (1.03–1.06)
Hospital A	0.68 (0.58–0.81)	0.67 (0.56–0.81)
Hospital B	0.73 (0.63–0.85)	0.76 (0.65–0.89)
Hospital C	0.73 (0.63–0.85)	0.72 (0.61–0.85)
Hospital D	0.94 (0.80–1.10)	0.90 (0.76–1.06)
Hospital E	0.86 (0.75–0.99)	0.92 (0.78–1.07)
Hospital F	Reference	
30-day survival		
Year	1.09 (1.06–1.13)	1.12 (1.08–1.16)
Hospital A	0.66 (0.49–0.88)	0.67 (0.49–0.93)
Hospital B	0.59 (0.45–0.76)	0.68 (0.51–0.91)
Hospital C	0.62 (0.47–0.81)	0.61 (0.45–0.82)
Hospital D	0.85 (0.65–1.11)	0.82 (0.61–1.11)
Hospital E	0.79 (0.62–1.01)	0.90 (0.68–1.117)
Hospital F	Reference	
CPC scores 1 or 2		
Year	1.13 (1.09–1.18)	1.16 (1.11–1.22)
Hospital A	0.65 (0.46–0.93)	0.68 (0.45–1.01)
Hospital B	0.58 (0.42–0.80)	0.71 (0.50–1.02)
Hospital C	0.61 (0.44–0.86)	0.65 (0.45–0.94)
Hospital D	0.90 (0.64–1.26)	0.88 (0.61–1.28)
Hospital E	0.84 (0.63–1.14)	1.01 (0.72–1.41)
Hospital F	Reference	

CI: confidence interval; CPC: cerebral performance category; OR: odds ratio

^a Adjusted for year, hospital

^b Adjusted for year, hospital, age, sex, cause of arrest (cardiac/respiratory/traumatic/others), witnessed arrest, bystander cardiopulmonary resuscitation, first arrest rhythm (shockable/unshockable) and pre-hospital defibrillation

factor associated with better survival to discharge. However, the data showed that OHCA patient volumes correlated inversely with survival outcomes, in contrast to other studies.³⁸ This could imply that hospital volume and capacity have a complex relationship that includes an optimal level of function, beyond which quality may be compromised.

A 24-hour PCI access is considered an important criterion for cardiac arrest centres.²⁴ However, our study

Table 3. Association between hospital characteristics and 30-day survival for out-of-hospital cardiac arrest

Hospital characteristic	No. of hospitals	Hospitals	With hospital characteristics ^a		Without hospital characteristics ^b		Unadjusted OR ^c (95% CI)
			No. of OHCA cases	30-day survival, no. (%)	No. of OHCA cases	30-day survival, no. (%)	
24h PCI capability	5	B, C, D, E, F	15684	735 (4.7)	2051	99 (4.8)	0.97 (0.78–1.20)
Years in operation (>20 years)	4	B, D, E, F	12581	610 (4.8)	5154	224 (4.3)	1.12 (0.96–1.31)
Academic status	3	D, E, F	8661	460 (5.3)	9074	374 (4.1)	1.30 (1.13–1.50)
Bed number (≥1,000 beds)	4	B, D, E, F	12581	610 (4.8)	5154	224 (4.3)	1.12 (0.96–1.31)
OHCA patient volume (>40 patients/month)	3	A, B, E	10434	479 (4.6)	7031	355 (4.9)	0.94 (0.82–1.08)

CI: confidence interval; OHCA: out-of-hospital cardiac arrest; OR: odds ratio; PCI: percutaneous coronary intervention

^a OHCA cases sent to hospitals with the hospital characteristic indicated in that row

^b OHCA cases sent to hospitals without the hospital characteristic indicated in that row

^c Odds ratio is reported for odds of 30-day survival for group with hospital characteristics versus the reference group without respective hospital characteristics

Table 4. Association between interventions and 30-day survival for out-of-hospital cardiac arrest in the cohort of patients who survived to hospital admission

Hospital intervention type	With intervention	Without intervention	30-day survival, no. (%)		Unadjusted OR ^b (95% CI)
	No. of cases ^a	No. of cases ^a	In group with intervention	In group without intervention	
TTM	718	2503	263 (36.6)	571 (22.8)	1.96 (1.64–2.34)
ECMO	25	3196	5 (20)	829 (25.9)	0.71 (0.27–1.91)
PCI	732	2489	355 (48.5)	479 (19.2)	3.95 (3.31–4.71)

CI: confidence interval; ECMO: extracorporeal membrane oxygenation; PCI: percutaneous coronary intervention; OR: odds ratio; TTM: therapeutic temperature management

^a Out of the number of patients that survived to admission

^b Not corrected for pre-hospital factors

suggested that 24-hour PCI alone did not confer improved survival. This may be because 1 hospital in our study did not have 24-hour PCI service, making it difficult to ascertain significance. Although a sizable proportion of the study population had a labelled “presumed cardiac cause” of arrest (66.6–78.2% from year 2010 to 2018 [Table 1]), the data did not specify if the causes were structural, arrhythmic, or ischaemic. Therefore, we were unable to determine which cases in the study qualified for PCI. It has been shown that for patients who were successfully resuscitated post-cardiac arrest without an ST-segment elevation myocardial infarction, emergency angiography did not have better outcomes than delayed angiography.³⁹ Furthermore, post-resuscitation care is a complex, multidisciplinary effort not dependent on a single therapy. Due to the limitations of our data, we were unable to quantify other aspects of post-resuscitation care, such as quality of intensive care, compliance with post-resuscitation bundles, availability of neuroprognostication, rehabilitation, and other essential elements of care.

Given the strong correlation of survival with academic status of hospitals, the study suggests that patients with OHCA might benefit from EMS conveyance to academic hospitals with a focus on providing excellent, multidisciplinary, post-resuscitation care. However, a change in pre-hospital transport policies faces logistical challenges such as increased travel and turnaround time for ambulances; overcrowding of receiving hospitals; and resultant increased demand of ICU capacity.

The data reflected OHCA outcomes of Singapore hospitals over a period. While it may not be clear as to which factors directly influenced these trends, the data offer an opportunity for Singapore hospitals to review their practices and operations. There is much work to be

done before OHCA management can be perfected within our hospitals. Further inquiry into cases of suboptimal OHCA management should be conducted in the pursuit of quality improvement, where information should also be interpreted with data on quality of ED resuscitation and door-to-intervention time.

Limitations

The current study has several limitations. Despite correcting for confounding pre-hospital factors, certain factors were not accounted for. Data on CPR quality in the pre-hospital and ED setting were not available in this study. Other factors such as renal function and comorbidities were also not available. Given the geographically determined catchment area for each hospital, there could be differences in socioeconomic factors (such as income, ethnicity, age, etc.) in each region. This could have introduced bias into the demographics of patients presenting to each hospital.

We were limited by a lack of data on many other individual patient characteristics (e.g. comorbidities, baseline functioning, prognosis and prior preferences). Without in-depth comprehension of the patient population at hand, we were unable to interpret the data optimally in an appropriate context. Clinically, the holistic view of each patient may be very different, and individual physician decision-making affects a patient’s eligibility for each intervention. In practice, patients deemed too ill to benefit from an intervention may not be selected.⁴⁰ Hence, the observed superior survival rate of patients who received interventions may have been inflated.

Hospital-based factors such as treatment policy changes over time. Infrastructure limitations and workforce changes could have influenced intervention trends within each hospital.

CONCLUSION

Post-resuscitation interventions for OHCA increased across all hospitals in Singapore over a 9-year period, correlating with survival rates. Only academic status of hospitals was associated with improved survival. The findings of this study may have policy implications for the management of OHCA in future. Future research involving simulation modelling may study how different pre-hospital transport policies impact OHCA outcomes.

Disclosure

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Group information

The Singapore PAROS investigators are listed in Appendix of the Supplementary Material in the online version of this article.

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