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ORIGINAL RESEARCH

Cost-effectiveness analysis of an ambulance service-operated specialised cardiac vehicle with mobile extracorporeal cardiopulmonary resuscitation capacity for out-of-hospital cardiac arrests in Queensland, Australia

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Abstract

Objective: Extracorporeal CPR (E-CPR) has been primarily limited to the in-hospital setting. A few systems around the world have implemented pre-hospital mobile E-CPR in the form of a dedicated cardiac vehicle fitted with specialised equipment and clinicians required for the performance of E-CPR on-scene. However, evidence of the outcomes and cost-effectiveness of mobile E-CPR remain to be established. We evaluated the cost-effectiveness of a hypothetical mobile E-CPR vehicle operated by Queensland Ambulance Service in the state of Queensland, Australia.

Methods: We adapted our published mathematical model to estimate the cost-effectiveness of pre-hospital mobile E-CPR relative to current practice. In the model, a specialised cardiac vehicle with mobile E-CPR capability is deployed to selected OHCA patients, with eligible candidates receiving pre-hospital E-CPR in-field and rapid transport to the closest appropriate centre for in-hospital E-CPR. For comparison, non-candidates receive standard ACLS from a conventional ambulance response. Cost-effectiveness was expressed as Australian dollars ($, 2021 value) per quality-adjusted life year (QALY) gained.

Results: Pre-hospital mobile E-CPR improves outcomes compared to current practice at a cost of $27 323 per QALY gained. The cost-effectiveness of pre-hospital mobile E-CPR is sensitive to the assumption around the number of patients who are the targets of the vehicle, with higher patient volume resulting in improved cost-effectiveness.

Conclusions: Pre-hospital E-CPR may be cost-effective. Successful implementation of a pre-hospital E-CPR programme requires substantial planning, training, logistics and operational adjustments.

Key words: *cost-effectiveness, extracorporeal cardiopulmonary resuscitation, mobile extracorporeal membrane oxygenation device, out-of-hospital cardiac arrest.*

Key findings

- Pre-hospital mobile extracorporeal cardiopulmonary resuscitation (E-CPR) improves outcomes compared to conventional CPR for refractory out-of-hospital cardiac arrest at a cost of $27 323 per quality-adjusted life year gained.
- The cost-effectiveness of pre-hospital mobile E-CPR is sensitive to the assumption around the number of patients who are the targets of the vehicle.

Introduction

Approximately one-third of out-of-hospital cardiac arrest (OHCA) patients present with an initial shockable rhythm (VF or VT).[1] While VF/VT arrests generally have a good prognosis with early defibrillation, approximately 25% of these patients are resistant to defibrillation.[1] These patients are called refractory VF/VT and have a poor prognosis.

International guidelines recommend that extracorporeal CPR (E-CPR) can be used as a rescue resuscitative therapy for selected refractory VF/VT arrest patients for whom the suspected cause of the arrest is potentially reversible (weak recommendation, very low certainty of evidence).[2] E-CPR uses an extracorporeal membrane oxygenation device (ECMO) to provide mechanical haemodynamic and oxygenation support while the underlying cause of the arrest is being treated. Limited evidence with low level of certainty suggests that E-CPR may improve outcomes in carefully

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selected out-of-hospital refractory VF/VT patients compared to conventional CPR (C-CPR).[3–6]

E-CPR is resource-intensive, requiring a multidisciplinary, specially trained team. Despite its high cost and limited evidence of effectiveness, the adoption of E-CPR has increased rapidly.[7] However, E-CPR treatment has primarily been limited to the in-hospital setting. Data on the cost-effectiveness of E-CPR are scarce despite the rapid adoption of this technology. Our study[8] and a limited number of other studies in Japan,[9] Canada,[10] the USA,[11] the Netherlands[12] and Australia[13] found that in-hospital E-CPR for refractory cardiac arrest is cost-effective compared to C-CPR.

A handful of systems around the world have implemented pre-hospital mobile E-CPR programmes. Examples include Paris (France), Twin Cities (the USA), Albuquerque (the USA) and Los Angeles (the USA). A feasibility study in metropolitan Melbourne (Victoria, Australia) found that pre-hospital E-CPR for refractory OHCA appeared to be feasible in this jurisdiction.[14]

Mobile E-CPR is often in the form of a specialised cardiac vehicle fitted with equipment necessary for the performance of E-CPR on-scene. By bringing E-CPR capacity directly to the patient in the field, mobile E-CPR theoretically may help shorten the time to commencement of E-CPR treatment and increase the number of patients who may benefit from this treatment.[15] Nevertheless, data on the outcomes and cost-effectiveness of mobile E-CPR remain to be established. The present study aimed to evaluate the cost-effectiveness of a hypothetical specialised cardiac vehicle with mobile E-CPR capability operated by Queensland Ambulance Service (QAS) in the state of Queensland, Australia.

Methods

Setting

With a land area of 1.7 million square kilometres, Queensland is Australia's second largest state and home to more than 5.4 million people. There is a spatial concentration of population on the east coast, especially southeast areas of the state. Spatial distribution of OHCA cases reflects those patterns of population distribution (Fig. S1).

The QAS is a single, state-wide, government-funded emergency ambulance service that serves all of Queensland. It is a primarily paramedic-staffed emergency ambulance service. For OHCA, the QAS uses a two-tiered response model that consists of advanced care paramedics (ACPs) and critical care paramedics (CCPs). ACPs are trained to provide ACLS, including airway management, respiratory procedures, cardiac management, drug and fluid administration, and the administration of basic and advanced pharmacological agents. CCPs are skilled in all ACP procedures, as well as more advanced interventions and administration of additional drugs. Both ACPs and CCPs are authorised to carry and administer antiarrhythmic medications for refractory cardiac arrest, with amiodarone being the sole agent used within the QAS. Detailed clinical scope of practice of ACPs and CCPs can be found on the QAS website.[16] The QAS response to OHCA typically involves concurrent deployment of ACPs and CCPs (where available).

In some metropolitan areas, QAS also has a third tier called 'high-acuity response units' (HARU). HARU officers are primarily CCPs and occasionally medical officers, that in addition to standard CCP scope of practice, perform procedures such as general anaesthesia via rapid sequence induction, small bore transtracheal ventilation, surgical cricothyrotomy, transfusion of packed red blood cells and other blood products, point-of-care US, finger thoracostomy and resuscitative thoracotomy.

OHCA database

The QAS OHCA database is a state-wide, population-based database that prospectively collects data from all consecutive OHCA patients who are attended by QAS paramedics in Queensland. The database contains patient's clinical characteristics and procedural data relating to pre-hospital treatment of cardiac arrest. The database is linked with the ED Data Collection, the Queensland Hospital Admitted Patient Data Collection and the Death Registrations from the Registry of Births, Deaths and Marriages, for survival data. Detailed description of the QAS OHCA database can be found in our previous publications.[17]

QAS current approach to pre-hospital management of potential E-CPR candidates

Under current QAS guidelines, refractory VF/VT OHCA patients who are potentially eligible for E-CPR receive standard ACLS from paramedics and are rapidly transported to the closest E-CPR centre for in-hospital E-CPR, with prior notification to the E-CPR team. In Queensland, there are currently four hospitals that offer E-CPR service, including the Royal Brisbane and Women's Hospital, The Prince Charles Hospital, The Princess Alexandra Hospital and Gold Coast University Hospital. Figure S2 shows geographic locations of these hospitals.

Pre-hospital E-CPR model

The QAS is considering a specialised cardiac vehicle with mobile E-CPR capability, with evaluation of the cost-effectiveness of this model of E-CPR delivery to inform decision-making. The vehicle is to be stationed at the QAS headquarters (Brisbane, Queensland; refer to Fig. 1), and deployed immediately to all OHCA that meet the following criteria, as identified through the Triple Zero call taking process:

- Patient aged ≤65 years;
- Independent living without significant comorbidities;
- Immediate bystander CPR;
- Non-traumatic arrest and
- Within 45-min radius from the QAS headquarters. This would allow a minimum of 15 min for cannulation on scene arrival to facilitate ECMO circuit establishment within 60 min of the arrest.[18,19]

Retrospective analysis of QAS OHCA data indicates that, on average, one patient per day, or 365 patients per year, meet the

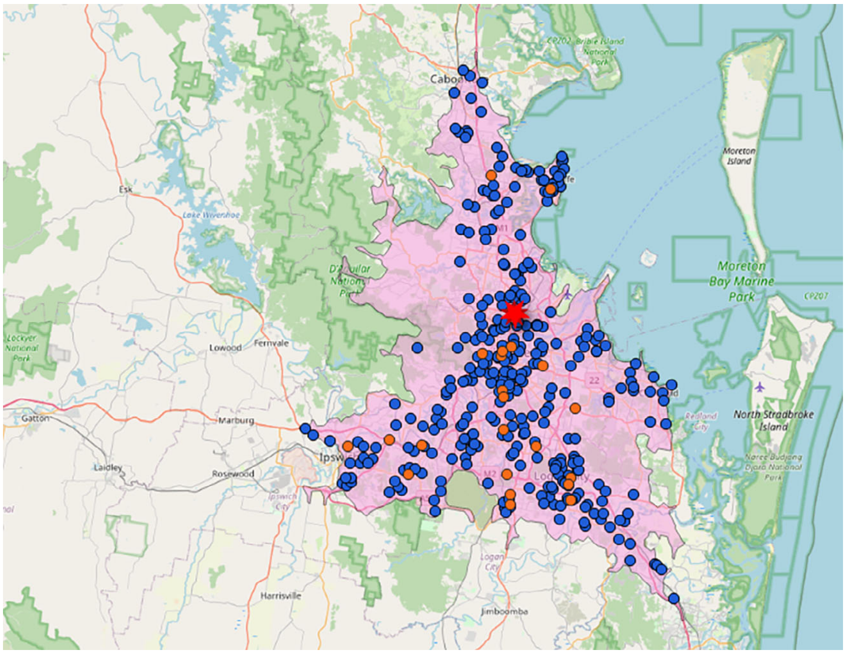

Figure 1. *Map of the 45-min radius (pink area) from the QAS headquarters (red star), of the 365 patients (per year) who are targets of the specialised cardiac vehicle (blue and orange circles), and of the 24 patients (per year) who are potential E-CPR targets (orange circles). All cases (blue + orange circles) meet the following criteria: 65 years or younger, independent living, immediate bystander CPR, non-traumatic and within 45-min radius from the QAS headquarters (red star) (total 365 cases/year). These patients are targets of the specialised cardiac vehicle. The orange cases (total 24/year) meet the following additional criteria: bystander-witnessed, initial rhythm VF/VT and no return of spontaneous circulation after three shocks. They are E-CPR candidates. E-CPR, extracorporeal CPR; QAS, Queensland Ambulance Service.*

aforementioned criteria, and are targets for the cardiac specialised vehicle (Fig. 1).

Furthermore, upon arrival at the patient, ambulance clinicians will determine that the patient is a candidate for E-CPR if they meet the following additional criteria:

- Bystander-witnessed;
- Initial cardiac rhythm VF/VT and
- No return of spontaneous circulation after three shocks.

If the patient is E-CPR eligible, pre-hospital E-CPR will be initiated; otherwise, standard ACLS. QAS OHCA data indicate that, on average, two patients a month, or 24 patients a year, are potential E-CPR candidates (Fig. 1).

Specialised cardiac vehicle with E-CPR capability

The specialised cardiac vehicle is to be equipped with medical equipment necessary for the performance of standard ACLS and E-CPR in the field. It is to be staffed around-the-clock with the following ambulance clinicians: one HARU medical officer, one HARU CCP, one clinical nurse and one ambulance technician. Table 1 shows cost estimates for such a vehicle.

Cost-effectiveness model

We compared a hypothetical scenario to current practice. In the scenario, a specialised cardiac vehicle with mobile E-CPR capability is deployed to eligible patients (see previous section for criteria) with E-CPR candidates receiving pre-hospital E-CPR and non-candidates receiving standard ACLS. Under current practice, a conventional ambulance is deployed to those patients, with E-CPR candidates transported rapidly to the closest E-CPR centre for in-hospital E-CPR and non-candidates receiving standard ACLS. We defined incremental cost-effectiveness ratios (ICERs) as additional cost per quality-adjusted life year (QALY) gained from the scenario relative to current practice.

We adapted our previous model that investigated the cost-effectiveness of in-hospital E-CPR for refractory OHCA patients.[8] It is a mathematical model (Fig. 2) that simulates the journey of OHCA patients from pre-hospital to in-hospital to after discharge, and estimates downstream costs and health outcomes (QALYs). The analysis is conducted from the perspective of the Australian healthcare system. Epidemiological input values for the model were derived from the QAS OHCA database and our previous publication, and are presented in Table S1.[8] The cost of the vehicle is presented in Table 1, and all other cost inputs are presented in Table S1. Cost inputs were presented in Australian dollar ($) 2021 values.

A lifetime horizon was used, divided into four periods: acute period from the cardiac arrest event to hospital discharge; short-term (within 3 months after hospital discharge); medium-term (3 months after discharge to 10 years) and long-term (after 10 years). While undergoing E-CPR, patients had a probability of developing significant complications associated with the procedure and, as a consequence, experienced additional risk of death and incurred additional costs.[10]

Patients are discharged into one of the four cerebral performance category (CPC) scores (CPC-1, CPC-2, CPC-3 and CPC-4) or death.[4] Changes (improvement or worsening) of CPC scores within the first 3 months after discharge were allowed, as per our previous study.[8] The probabilities of changes in CPC scores within the first 3 months after discharge were assumed to be the same for E-CPR and standard ACLS patients. Patients were assumed to stay in their same CPC score after 3 months from discharge.[3,25] During each year of the medium- and long-term periods, patients are either alive and stay in the same CPC score or die. The

TABLE 1. *Cost estimates of a specialised cardiac vehicle with mobile E-CPR capability (all costs are in Australian dollar, 2021 values)*

	Upfront cost	Per patient cost	Assumption	Source
Purchase and set-up	$2.6 million	$1018	7 years vehicle lifespan, 7 × 365 eligible patients during 7-year period	Minnesota Mobile Resuscitation Consortium[20]
HARU medical officer		$520	Queensland Health medical officer classification L10 plus 28% penalty rates. Annual salary ($148 341 × 1.28)/365 patients per year	Queensland Government Department of Health[21]
HARU CCP		$391	QAS AE33/2 level plus 28% penalty rate. Annual salary ($111 532 × 1.28)/365 patients per year	Queensland Ambulance Service[22]
Clinical nurse		$356	Queensland Health Nursing stream 6.3 level plus 28% penalty rate. Annual salary ($101 469 × 1.28)/365 patients per year	Queensland Government Department of Health[23]
Ambulance technician		$222	QAS AG12 level plus 28% penalty rate. Annual salary ($63 293 × 1.28)/365 patients per year	Queensland Ambulance Service[22]
ECMO circuit		$6650		Boyd and Lyle-Edrosolo[24]
Non-wage operational cost (fuel, insurance, maintenance)		$27	$10 000 per year/365 patients per year	Assumed

CCP, critical care paramedic; ECMO, extracorporeal membrane oxygenation; HARU, high acuity response unit; QAS, Queensland Ambulance Service.

probability of death specific to each CPC score for the medium-term period (from 3 months after discharge until 10 years) was derived from the literature that followed up OHCA patients for 10 years following the index event.[26] For the long-term period (after 10 years), we assumed no excess mortality (i.e. OHCA had no effect on survival after 10 years), and used age and sex-specific annual probability of death from the Australian Life Tables (Table S2).[27] We did not consider destination therapies after E-CPR (e.g. long-term ventricular assist device, heart transplant), nor did we consider organ donation. For patients who are the target of the mobile E-CPR vehicle but upon scene assessment found to be ineligible for E-CPR, and therefore receive standard ACLS, we assumed that our modelled paramedic-physician ambulance response model increases survival to hospital admission by 10%–15% compared to our existing paramedic-staffed ambulance response model.[28]

Uncertainty and sensitivity analysis

Uncertainty analysis was performed with Monte Carlo simulation (10 000 iterations) to randomly sample parameters from their distributions. We reported 95% uncertainty ranges around projected point estimates (median). Univariate sensitivity analysis was also carried out to understand the key ICER drivers. The variables that were considered in the univariate sensitivity analysis were: annual number of OHCA cases that the specialised cardiac vehicle is deployed to; annual number of OHCA patients who are eligible for E-CPR; upfront cost of the specialised cardiac vehicle with mobile E-CPR capability; personnel of the specialised cardiac vehicle employed on a part-time basis; and effect of paramedic-physician ambulance response model on survival to hospital admission. The present study was approved by the Children's Health Queensland Human Research Ethics Committee (approval number REC/21/QCHQ/85522). Patient consent was waived by the ethics committee.

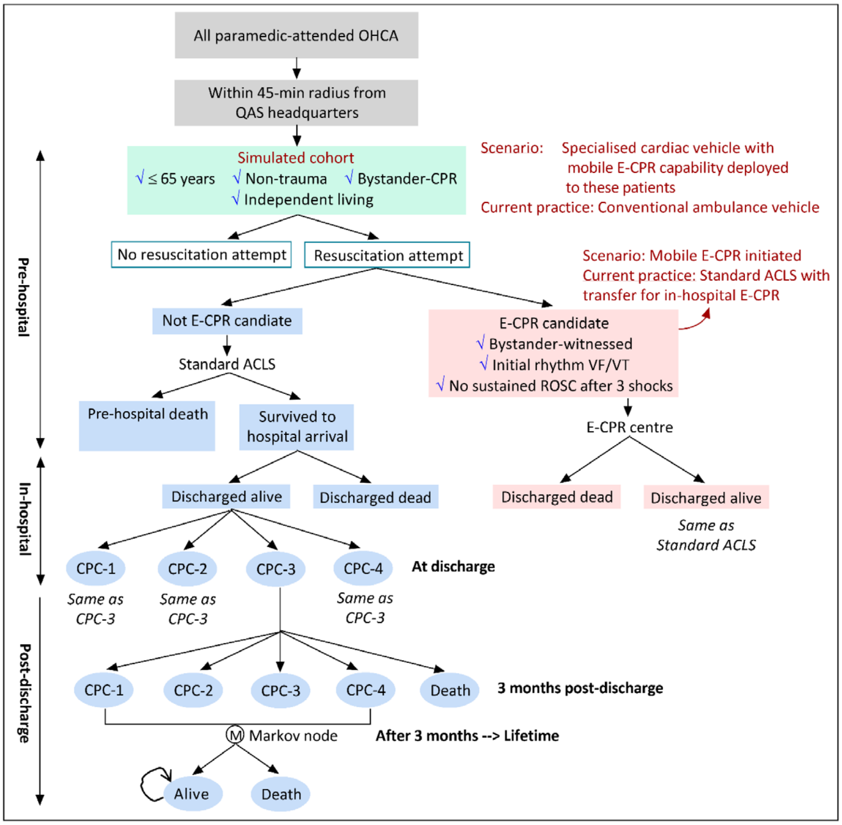

Figure 2. *Model diagram. CPC, cerebral performance category; E-CPR, extracorporeal CPR; OHCA, out-of-hospital cardiac arrest; QAS, Queensland Ambulance Service; ROSC, return of spontaneous circulation.*

Results

Table 2 and Figure 3 show the estimated cost and effectiveness of the specialised cardiac vehicle with mobile E-CPR capability. It improves outcomes compared to current practice at a cost of $27 323 per QALY gained (i.e. ICER).

The sensitivity of the cost-effectiveness of the specialised cardiac vehicle with mobile E-CPR capability to changes in model's input values is shown in Figure 4. The cost-effectiveness of the vehicle is most sensitive to the assumption around the survival benefit of the paramedic-physician ambulance response model, and the annual number of patients who are the targets of the vehicle. More patients attended to by the specialised cardiac vehicle (i.e. more utilisation) result in improved cost-effectiveness.

Discussion

This is the first cost-effectiveness analysis of pre-hospital E-CPR compared to in-hospital E-CPR for eligible OHCA. We estimated the ICER of pre-hospital E-CPR to be $27 323 per QALY gained, which is below current accepted willingness-to-pay thresholds internationally (Table S3).[9,10,25]

We based our cost estimates for the mobile E-CPR vehicle on data reported by the Minnesota Mobile Resuscitation Consortium.[20] Since the vehicle has not actually been implemented in Queensland, and there are unknowns regarding the vehicle configurations and organisation setup, there are still uncertainties around these estimates. Nevertheless, the sensitivity analysis shows that the results are not sensitive to changes in cost estimates for the vehicle. We assumed that personnel for the vehicle will be employed on a full-time basis. In practice, when integrating the vehicle into routine practice there might be scope for some resource sharing. This in turn would improve the cost-effectiveness of pre-hospital E-CPR. Given very low patient volume, efficient staffing design is important to ensure best utilisation of their time.

We assumed deployment of the mobile E-CPR vehicle at time of initial emergency call, consistent with what is done in a number of current trials (NCT04620070) and services.[29] This will inevitably lead to a number of 'false call outs' when

TABLE 2. *Estimated cost and effectiveness*

	Cost ($) per patient over lifetime	QALYs per patient over lifetime	ICER ($/QALY gained)
Scenario†	14 969 (14 093 – 15 880)	0.96 (0.84–1.09)	27 323 (20 823 – 37 719)
Current practice‡	12 375 (11 565 – 13 235)	0.86 (0.76–0.98)	

†Specialised cardiac vehicle with mobile E-CPR capability is deployed to eligible patients with E-CPR candidates receiving pre-hospital E-CPR and non-candidates receiving standard ACLS. ‡Conventional ambulance is deployed to those patients, with E-CPR candidates transported rapidly to the closest E-CPR centre for in-hospital E-CPR and non-candidates receiving standard ACLS. E-CPR, extracorporeal CPR; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life year.

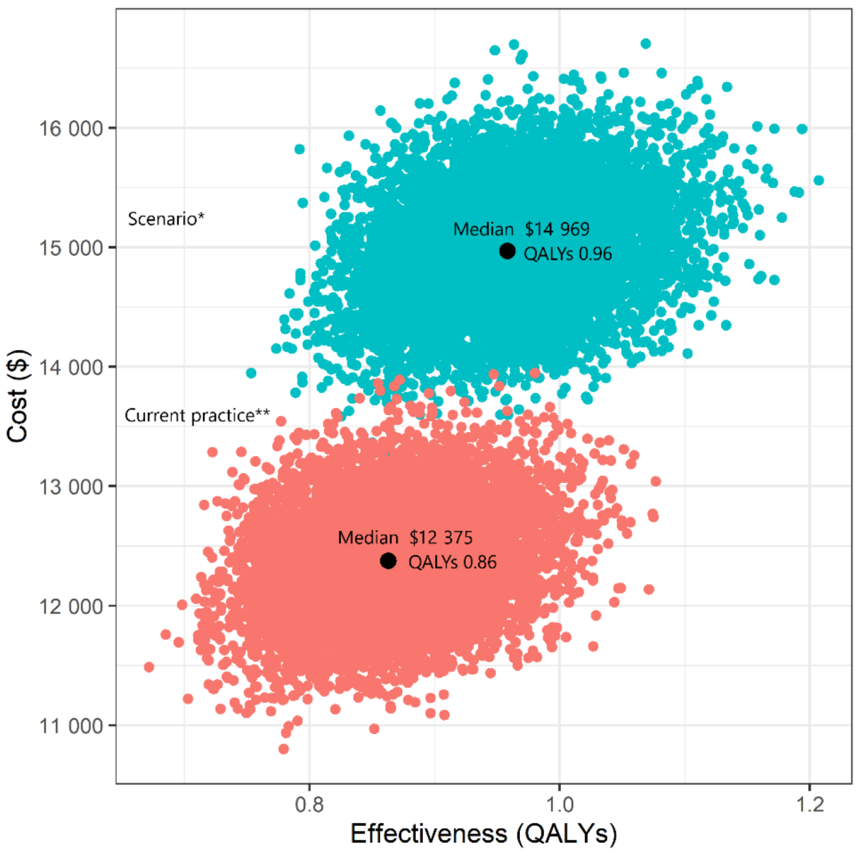

Figure 3. *Graphical presentation of the estimated cost and effectiveness. *Specialised cardiac vehicle with mobile E-CPR capability is deployed to eligible patients with E-CPR candidates receiving pre-hospital E-CPR and non-candidates receiving standard ACLS. **Conventional ambulance is deployed to those patients, with E-CPR candidates transported rapidly to the closest E-CPR centre for in-hospital E-CPR and non-candidates receiving standard ACLS. E-CPR, extracorporeal CPR; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life year.*

some patients are found not to be eligible for pre-hospital E-CPR upon scene assessment. Nevertheless, patients who are subsequently deemed not suitable for pre-hospital E-CPR are still likely to benefit from receiving specialised cardiac team response. An alternative model of waiting for a conventional ambulance to attend the arrest before activation of the pre-hospital E-CPR team would reduce 'false call outs' but also reduce the number of patients that may benefit from E-CPR. In a feasibility study in metropolitan Melbourne (Victoria, Australia), Richardson *et al.*[14] highlighted the rarity of OHCA eligible for E-CPR, reporting that 1.4% of potential cardiac arrest emergency calls would be eligible for pre-hospital E-CPR or 2.8% if considering only confirmed arrests. A balancing act between maximising the benefit of pre-hospital E-CPR and minimising wasted time and resources is required and should be tested in trials.

E-CPR is high-risk, complex and resource-intensive; and pre-hospital E-CPR is even more so. Successful implementation of a mobile E-CPR programme is multifaceted, entailing more than favourable pre-implementation assessment and purchasing the necessary hardware. The operational model for pre-hospital E-CPR would require substantial planning, training and coordination between the QAS and hospitals. Successful implementation of such a programme also requires institutional commitment from all relevant stakeholders including ambulance service, receiving hospital, governmental officials and the broader healthcare system.

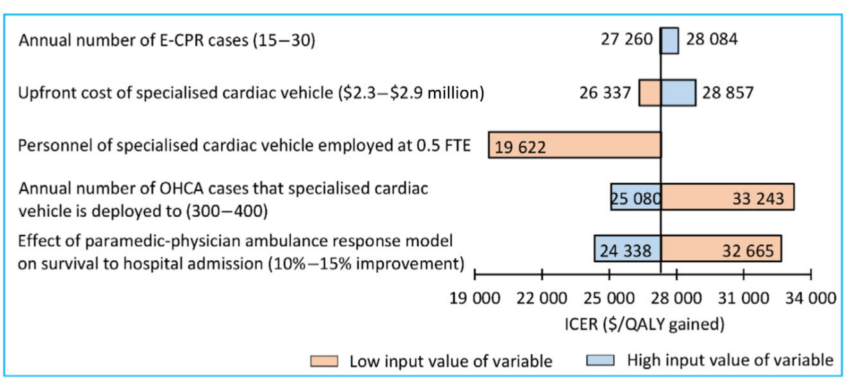

Figure 4. *Sensitivity analysis. E-CPR, extracorporeal CPR; FTE, full-time equivalent; ICER, incremental cost-effectiveness ratio; OHCA, out-of-hospital cardiac arrest; QALY, quality-adjusted life year.*

Limitations

The present study is subject to a number of limitations. It was conducted from a health system perspective, and therefore did not incorporate indirect costs such as loss of productivity. Cost of destination therapies after E-CPR (e.g. long-term ventricular assist device, heart transplant) was not considered. We did not consider the potential gain in organ donation as an outcome associated with E-CPR. The inclusion of organ donation would further improve the cost-effectiveness of E-CPR. Like other studies in this area, we did not incorporate costs associated with E-CPR training and maintenance due to the lack of data. We used our OHCA data, supplemented with relevant published data, to parameterise our model. Therefore, our results may not be generalisable to settings in which practices and costs are very different from ours and from those we used.

Conclusions

Pre-hospital E-CPR has ICER that is well below common accepted willingness-to-pay thresholds. Despite its potential advantages, pre-hospital E-CPR poses significant implementation challenges. Local factors within the healthcare system need to be considered to determine the feasibility of implementing an effective pre-hospital E-CPR programme.

Competing interests

None declared.

Data availability statement

The data that support the findings of the present study are available in the supplementary material of this article.

References

1. Queensland Ambulance Service. *Out-of-Hospital Cardiac Arrest Database*. Brisbane, Australia: Queensland Ambulance Service; 2023.
2. Panchal AR, Bartos JA, Cabañas JG *et al*. Part 3: adult basic and advanced life support: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2020; **142**: S366–468.
3. Yannopoulos D, Bartos J, Raveendran G *et al*. Advanced reperfusion strategies for patients with out-of-hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single centre, open-label, randomised controlled trial. *Lancet* 2020; **396**: 1807–16.
4. Kim SJ, Jung JS, Park JH, Park JS, Hong YS, Lee SW. An optimal transition time to extracorporeal cardiopulmonary resuscitation for predicting good neurological outcome in patients with out-of-hospital cardiac arrest: a propensity-matched study. *Crit. Care* 2014; **18**: 535.
5. Sakamoto T, Morimura N, Nagao K *et al*. Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with out-of-hospital cardiac arrest: a prospective observational study. *Resuscitation* 2014; **85**: 762–8.
6. Maekawa K, Tanno K, Hase M, Mori K, Asai Y. Extracorporeal cardiopulmonary resuscitation for patients with out-of-hospital cardiac arrest of cardiac origin: a propensity-matched study and predictor analysis. *Crit. Care Med*. 2013; **41**: 1186–96.
7. Richardson ASC, Schmidt M, Bailey M, Pellegrino VA, Rycus PT, Pilcher DV. ECMO cardio-pulmonary resuscitation (ECPR), trends in survival from an international multicentre cohort study over 12-years. *Resuscitation* 2017; **112**: 34–40.
8. Doan TN, Rashford S, Pincus J, Bosley E. Cost-effectiveness of extracorporeal cardiopulmonary resuscitation for refractory out-of-hospital cardiac arrest: a modelling study. *Resusc. Plus* 2022; **12**: 100309.
9. Kawashima T, Uehara H, Miyagi N *et al*. Impact of first documented rhythm on cost-effectiveness of extracorporeal cardiopulmonary resuscitation. *Resuscitation* 2019; **140**: 74–80.
10. Ontario Health (Quality). Extracorporeal membrane oxygenation for cardiac indications in adults: a health technology assessment. *Ont. Health Technol. Assess. Ser*. 2020; **20**: 1–121.
11. Bharmal MI, Venturini JM, Chua RFM *et al*. Cost-utility of extracorporeal cardiopulmonary resuscitation in patients with cardiac arrest. *Resuscitation* 2019; **136**: 126–30.
12. Gravesteijn BY, Schluep M, Voormolen DC *et al*. Cost-effectiveness of extracorporeal cardiopulmonary resuscitation after in-hospital cardiac arrest: a Markov decision model. *Resuscitation* 2019; **143**: 150–7.
13. Dennis M, Zmudzki F, Burns B *et al*. Cost effectiveness and quality of life analysis of extracorporeal cardiopulmonary resuscitation (ECPR) for refractory cardiac arrest. *Resuscitation* 2019; **139**: 49–56.
14. Richardson SAC, Anderson D, Burrell AJC *et al*. Pre-hospital ECPR in an Australian metropolitan setting: a single-arm feasibility assessment – the CPR, pre-hospital ECPR and early reperfusion (CHEER3) study. *Scand. J. Trauma Resusc. Emerg. Med*. 2023; **31**: 100.
15. Song C, Dennis M, Burns B *et al*. Improving access to extracorporeal membrane oxygenation for out of hospital cardiac arrest: pre-hospital ECPR and alternate delivery strategies. *Scand. J. Trauma Resusc. Emerg. Med*. 2022; **30**: 77.
16. Queensland Ambulance Service. *Clinical Scope of Practice*. (version January 2023). Brisbane, Australia: Queensland Ambulance Service, 2024. [Cited 8 February 2024] Available from URL: https://www.ambulance.qld.gov.au/docs/clinical/csop.pdf
17. Doan TN, Adams L, Schultz BV *et al*. Insights into the epidemiology of cardiopulmonary resuscitation-induced consciousness in out-of-hospital cardiac arrest. *Emerg. Med. Australas*. 2020; **32**: 769–76.
18. Jones D, Daglish FM, Tanner BM, Wilkie FJM. A review of pre-hospital extracorporeal cardiopulmonary resuscitation and its potential application in the north east of England. *Int. J. Emerg. Med*. 2024; **17**: 7.
19. Vos IA, Deuring E, Kwant M *et al*. What is the potential benefit of pre-hospital extracorporeal cardiopulmonary resuscitation for patients with an out-of-hospital cardiac arrest? A predictive modelling study. *Resuscitation* 2023; **189**: 109825.
20. The Minnesota Daily. *UMN Rolls out New Medical Truck to Better Help Cardiac Arrest Patients*. Minneapolis, MN: The Minnesota Daily, 2024. [Cited 8 February 2024] Available from URL: https://mndaily.com/265941/news/umn-rolls-out-new-medical-truck-to-better-help-cardiac-arrest-patients/#:~:text=site%20Submit%20Search-,UMN%20rolls%20out%20new%20medical%20truck%20to%20better%20help%20cardiac,to%20refractory%20cardiac%20arrest%20patients.&text=University%20of%20Minnesota's%20new%20Mobile%20Resuscitation%20Consortium%20truck
21. Queensland Government Department of Health. *Wage Rates – Medical Stream*. [Cited 8 February 2024] Available from URL: https://www.health.qld.gov.au/hrpolicies/wage-rates/medical#allowances

22. Queensland Ambulance Service. *Operational Wage Rates*. [Cited 8 February 2024] Available from URL: https://qldambulance.sharepoint.com/sites/intranet/hr/wages/Documents/QAS%20Operational%20Wage%20Rates.pdf#search=wage%20rate
23. Queensland Government Department of Health. *Wage Rates – Nursing Stream*. [Cited 8 February 2024] Brisbane, Australia: Queensland Government Departmentof Health, Available from URL: https://www.health.qld.gov.au/hrpolicies/wage-rates/nursing
24. Boyd DL, Lyle-Edrosolo G. Implementing nurse extracorporeal membrane oxygenation specialists to maintain a sustainable program. *Nurse Lead*. 2023; **21**: 239–43.
25. Matsuoka Y, Goto R, Atsumi T *et al*. Cost-effectiveness of extracorporeal cardiopulmonary resuscitation for out-of-hospital cardiac arrest: a multi-centre prospective cohort study. *Resuscitation* 2020; **157**: 32–8.
26. Chocron R, Fahrenbruch C, Yin L *et al*. Association between functional status at hospital discharge and long-term survival after out-of-hospital-cardiac-arrest. *Resuscitation* 2021; **164**: 30–7.
27. Australian Bureau of Statistics. *Life Tables (2020)*. Canberra, Australia: Australian Bureau of Statistics, 2024. [Cited 8 February 2024] Available from URL: https://www.abs.gov.au/statistics/people/population/life-tables/latest-release
28. Sato N, Matsuyama T, Akazawa K, Nakazawa K, Hirose Y. Benefits of adding a physician-staffed ambulance to bystander-witnessed out-of-hospital cardiac arrest: a community-based, observational study in Niigata, Japan. *BMJ Open* 2019; **9**: e032967.
29. Marinaro J, Guliani S, Dettmer T, Pruett K, Dixon D, Braude D. Out-of-hospital extracorporeal membrane oxygenation cannulation for refractory ventricular fibrillation: a case report. *J. Am. Coll. Emerg. Physicians Open* 2020; **1**: 153–7.

Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Figure S1. Spatial distribution of population (left) and out-of-hospital cardiac arrest (OHCA) cases (right), showing concentration of population and OHCA cases on the east coast, especially southeast areas of the state. Darker colours mean higher population density (left) and higher OHCA cases (right).

Figure S2. Queensland map with locations of the E-CPR centres. E-CPR, extracorporeal cardiopulmonary resuscitation; GCUH, Gold Coast University Hospital; PAH, The Princess Alexandra Hospital; QAS, Queensland Ambulance Service; RBWH, Royal Brisbane and Women's Hospital; TPCH, The Prince Charles Hospital.

Table S1. Model inputs.

Table S2. Age and sex-specific background mortality.

Table S3. Current accepted willingness-to-pay (WTP) thresholds internationally.