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Clinical paper

Association between direct transport to a cardiac arrest centre and survival following out-of-hospital cardiac arrest: A propensity-matched Aotearoa New Zealand study

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Abstract

Background and Objectives: Direct transport to a cardiac arrest centre following out-of-hospital cardiac arrest may be associated with higher survival. However, there is limited evidence available to support this within the New Zealand context. This study used a propensity score-matched cohort to investigate whether direct transport to a cardiac arrest centre improved survival in New Zealand.

Methods: A retrospective cohort study was conducted using the Aotearoa New Zealand Paramedic Care Collection (ANZPaCC) database for adults treated for out-of-hospital cardiac arrest of presumed cardiac aetiology between 1 July 2018 to 30 June 2023. Propensity score-matched analysis was used to investigate survival at 30-days post-event according to the receiving hospital being a cardiac arrest centre versus a non-cardiac arrest centre.

Results: There were 2,297 OHCA patients included. Propensity matching resulted in 554 matched pairs ($n = 1108$). Thirty-day survival in propensity score-matched patients transported directly to a cardiac arrest centre (56%) versus a non-cardiac arrest centre (45%) was not significantly different (adjusted Odds Ratio 0.78 95%CI 0.54, 1.13, $p = 0.19$). Shockable presenting rhythm, bystander CPR, and presence of STEMI were associated with a higher odds of 30 day survival ($p < 0.05$). Māori or Pacific Peoples ethnicity and older age were associated with lower survival ($p < 0.05$).

Conclusions: This study found no statistically significant difference in outcomes for OHCA patients transferred to a cardiac arrest compared to a non-cardiac arrest centre. However, the odds ratio of 0.78, equivalent to a 22% decrease in 30-day mortality, is consistent with benefit associated with management by a cardiac arrest centre. Further research in larger cohorts with detailed information on known outcome predictors, or large randomised clinical trials are needed.

Keywords: Out of hospital, Cardiac arrest, Resuscitation, Cardiac arrest centre, Paramedic, EMS, New Zealand, Aotearoa

Introduction

A recent systematic review and meta-analysis of observational studies revealed that, in non-traumatic out-of-hospital cardiac arrests (OHCA), centralisation of care through direct transport to a cardiac arrest centre is associated with higher survival and improved neurological outcomes [1]. Cardiac arrest centres may contribute to improved outcomes due to the availability of key services such as percutaneous coronary intervention (PCI) and targeted temperature management [2]. In addition, higher patient volumes and increased exposure of clinicians using specialist skills may provide better levels of overall care [2]. The International Liaison Committee on Resuscitation (ILCOR) currently suggests that adult non-traumatic OHCA patients should be cared for in cardiac arrest centres [3]. However, the evidence for this recommendation is limited. We, have previously demonstrated higher thirty-day survival in OHCA patients directly transported to facilities with PCI capability in Aotearoa New Zealand (Aotearoa, Māori-language name for New Zealand) [4]. Recently, direct transport to cardiac arrest centres has been challenged by a

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randomised superiority trial in the United Kingdom that showed no survival benefit for patients cared for in a cardiac arrest centre [5]. Notably, this trial excluded patients with ST-elevation myocardial infarction (STEMI) on the post-resuscitation 12-lead, as there is strong evidence for increased survival in patients with cardiac arrest and STEMI who receive early invasive interventions [6,7]. Any survival benefit of direct transport to a cardiac arrest centre has not been investigated in the Aotearoa New Zealand setting. We used a propensity score-matched cohort to investigate whether direct transport to a cardiac arrest centre was associated with improved survival in Aotearoa New Zealand. Propensity scoring was used to adjust for an imbalance in prognostic factors according to destination.

Methods

Study design

This was a retrospective cohort study investigating the association between survival and direct transport to a cardiac arrest centre in Aotearoa New Zealand over a 5-year period from 1 July 2018 to 30 June 2023. This was a national study covering a population of 5.1 million and a land area of 264,920 square kilometres [8,9].

Aotearoa New Zealand, Paramedic Care Collection (ANZPaCC)

ANZPaCC contains all routinely collected clinical data for all patients attended by road EMS (Emergency Medical Services; excluding air transport) in Aotearoa New Zealand. In addition, ANZPaCC is linked to data elements such as mortality and ethnicity from Manatū Hauora (Ministry of Health) records. The full details of data variables contained within these datasets are described in the ambulance care standard and the Manatū Hauora data dictionaries [10,11].

Inclusion and exclusion criteria

All adult patients (≥15 years old) who had an OHCA with presumed cardiac aetiology (inclusive of those with STEMI), where resuscitation was attempted by EMS, and who were transported directly to either a cardiac arrest centre or a non-cardiac arrest centre were included. There are currently no credentialing criteria for a cardiac arrest centre in New Zealand. The definition of cardiac arrest centre was derived from the capabilities outlined in previous literature, and NZ hospitals were assigned as either a cardiac arrest centre or non-cardiac arrest centre for the purpose of the study. A cardiac arrest centre was defined as a hospital that could provide all the following services: tracheal intubation and ventilation, haemodynamic support and monitoring, assessment of the underlying cause of arrest with on-site diagnostics, 24-hour invasive reperfusion capability, temperature control, and neuroprognostication (Appendix A). All Aotearoa New Zealand cardiac arrest centres receive greater than 25 OHCA patients annually. A non-cardiac arrest centre was defined as all other hospitals that did not have all of the above services and that had no invasive cardiac reperfusion capabilities. Four hospitals were excluded that had the capabilities of the cardiac arrest centres but only during certain times of the day (Appendix A).

Geographic areas

A meshblock is the smallest population unit for which statistical data is collected and processed by Statistics NZ [12]. A meshblock is defined by a discrete number of people living within a cohesive geographic area; the area can vary in size from part of a city block to a large area of rural land. The 2018 meshblock of the incident location was used to determine rurality (urban or rural) coded as per the Geographic Classification for Health (GCH2018) [13].

Demographic and clinical variables

Demographic and clinical variables included sex, age, ethnicity, location, rurality, socioeconomic deprivation based on the patient address, witnessed status, initial rhythm, bystander CPR, community defibrillation, minutes to scene, transport time, EMS 12-lead indication of STEMI, the year during which the event occurred, ROSC on handover and survival to thirty days.

This study allocated a single ethnicity per individual based on a prioritisation hierarchy according to Manatū Hauora [14]. Ethnicities analysed were: Māori (the indigenous population of New Zealand), Pacific Peoples (people predominantly from South Pacific Islands including Samoa, Cook Islands, Tonga and Niue), and Non-Māori/Non-Pacific (predominantly New Zealand European). The Missing Data ethnicity category included 'don't know', 'refused to answer', 'response unidentifiable', and 'not stated'.

The deprivation index is a socioeconomic measure scoring from 1 to 10, with decile 10 areas being the 10% most deprived [15]. The deprivation index takes several factors into account, including income, employment, overcrowding, and education. Deprivation was determined from the 2018 meshblock of the patient's residential address. Scores were up-grouped into quintiles.

Statistical analysis

Variables were described as totals and percentages of total numbers. A Pearson Chi-Squared test was used to compare nominal values. Continuous variables (age, time to scene and transport time) were compared using the Mann–Whitney U Test. A binary logistic regression was used to predict the propensity score for admission to a cardiac arrest centre. Prognostic factors were chosen based on standard Utstein variables, and those that were statistically significant were included in the final propensity score matching [16]. Using a greedy algorithm and nearest neighbour matching with a fixed caliper of a tenth of the standard deviation of the propensity score, a one-to-one matching was performed. Adjusted odds ratios (aORs) and 95% confidence intervals (95% CIs) were calculated from multivariable logistic regression models from the propensity matched cohort. Data analysis was performed using SPSS v29. A p-value <0.05 was considered statistically significant.

Results

Between 1 July 2018 and 30 June 2023, there were 2,297 adult patients with OHCA of presumed cardiac aetiology that met the study inclusion criteria and were transported to either a cardiac arrest centre (n = 1,397, 61%) or a non-cardiac arrest centre (n = 900, 39%) (Fig. 1). Prior to propensity matching, there were significant differences in the demographics and clinical variables for patients directly transported to a cardiac arrest centre (Supplementary Table S1).

Odds of direct transport to a cardiac arrest centre vs a non-cardiac arrest centre in the initial OHCA cohort

The odds of transport to a cardiac arrest centre were significantly associated with patient and clinical characteristics (Table 1). Age, ethnicity, rurality, deprivation, EMS time to scene and presence of a STEMI were significantly associated with either increased or

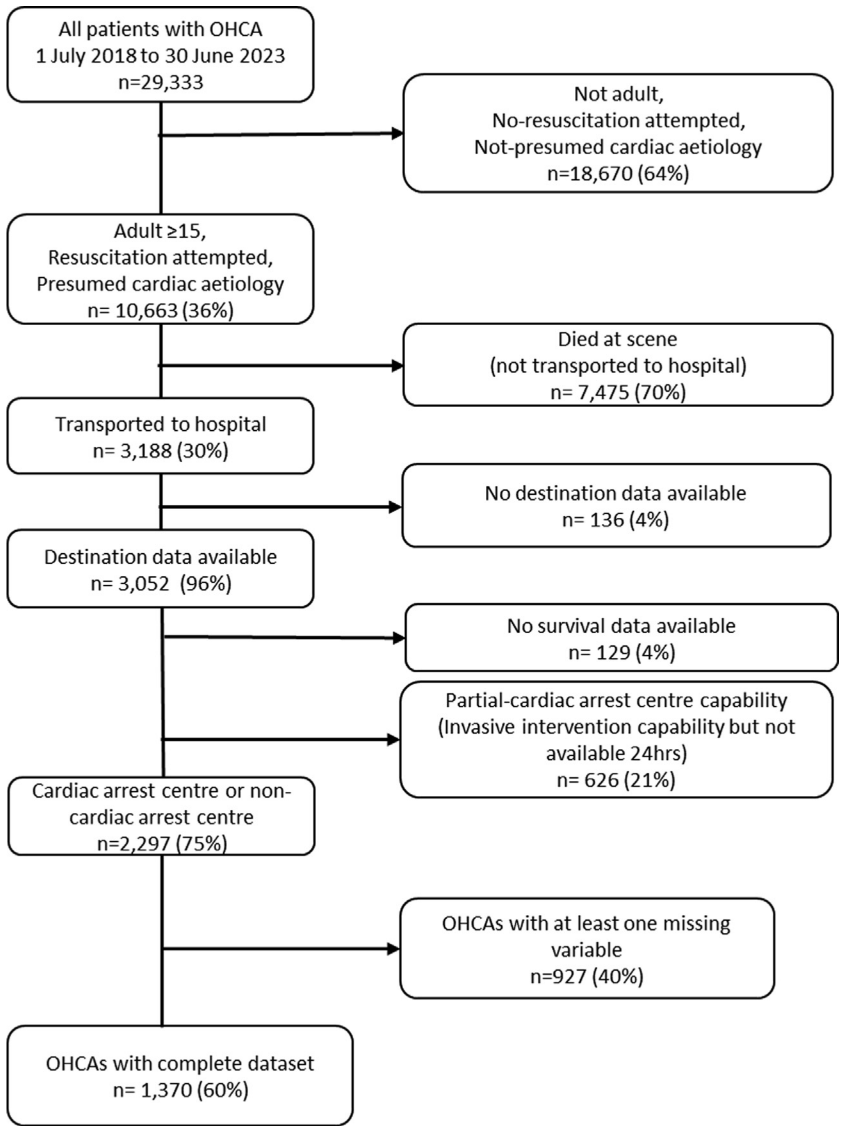

Fig. 1 –

Table 1 – Multivariable logistic regression adjusted odds of admission to a cardiac arrest centre versus a non-cardiac arrest centre in the initial OHCA cohort.

Effect		aOR*	95% CI	p-value
Age in years	Age In Years	0.98	(0.97, 0.99)	<0.001
Ethnicity	Non-Māori Non-Pacific (ref)	1.0		<0.001
	Māori	0.48	(0.33, 0.69)	
	Pacific Peoples	3.31	(1.71, 6.4)	
Rurality	Rural (ref)	1.0		<0.001
	Urban	3.20	(2.08, 4.92)	
Socioeconomic deprivation - patient home address	Quintile 1 (ref)	1.0		<0.001
	Quintile 2	1.01	(0.59, 1.7)	
	Quintile 3	0.86	(0.5, 1.46)	
	Quintile 4	0.67	(0.41, 1.11)	
	Quintile 5	0.32	(0.19, 0.52)	
EMS Time to scene (min)	Time to scene	1.07	(1.03,1.12)	<0.001
12-Lead indication of a STEMI	No-STEMI (ref)	1.0		<0.001
	STEMI	2.23	(1.49,3.35)	

EMS: Emergency medical service, **ROSC**: Return of spontaneous circulation, **CPR**: Cardiopulmonary resuscitation, **STEMI**: ST-elevation myocardial infarction.
[*] Adjusted odds ratio, adjusted for all variables. Data in the table is only shown for significant variables, $p < 0.05$.

decreased odds of being transported directly to a cardiac arrest centre (Table 1).

Higher odds of transport to a cardiac arrest centre were associated with Pacific Peoples ethnicity (aOR 3.31 95%CI (1.71, 6.4), $p < 0.001$), OHCA event location in an urban setting (aOR 3.20 95%CI (2.08, 4.92), $p < 0.001$), having a longer response time (aOR 1.07 95%CI (1.03, 1.12), $p < 0.001$), and having a prehospital 12-lead indication of STEMI (aOR 2.23 95%CI (1.49,3.35), $p < 0.001$) (Table 1).

Lower odds of transport to a cardiac arrest centre were associated with increasing age in years (aOR 0.98 95%CI (0.9, 0.99), $p < 0.001$), Māori ethnicity (aOR 0.48 95%CI (0.33, 0.69), $p < 0.001$), and with patient's home address located in the most socioeconomically deprived quintile (aOR 0.32 95%CI (0.19, 0.52), $p < 0.001$) (Table 1).

Propensity score-matched cohort

Propensity matching was conducted based on the above characteristics found to be statistically significant (Table 1). Propensity matching limited the data to 1108 records, producing two matching groups, one group of 554 patients who went to a cardiac arrest centre, and another group of 554 who did not. There were no significant differences between these two matching groups in terms of age, ethnicity, rurality, deprivation, time to scene and presence of STEMI (See Table 2).

Multivariable logistic regression for the propensity score-matched cohort for thirty day survival indicated higher odds of survival for usual Utstein variables including shockable presenting rhythm (aOR 4.23 95%CI (2.71, 6.62), $p < 0.001$), and the performance of CPR prior to EMS arrival (aOR 2.00 95%CI (1.15, 3.47), $p = 0.01$). The presence of a pre-hospital STEMI was also associated with higher odds of survival (aOR 1.74 95%CI (1.01, 3.01), $p = 0.05$) (Table 3).

Lower odds of survival in the propensity matched cohort were associated with being older (aOR 0.95 95% CI (0.94, 0.96), $p < 0.001$), being of Māori (aOR 0.36 95% CI (0.22, 0.57), $p < 0.001$) or Pacific Peoples (aOR 0.18, 95% CI (0.06, 0.55), $p < 0.001$) ethnicity, and where the OHCA was unwitnessed (aOR 0.45 95% CI (0.31, 0.66), $p < 0.001$) (Table 3).

Unadjusted logistic regression indicated lower odds of survival in those OHCA patients taken to a non-cardiac arrest centre (uOR 0.65 95% CI (0.51, 0.83), $p < 0.001$). However, this was not significant in the adjusted logistic regression, indicating no significant difference in thirty-day survival in patients transported to a non-cardiac arrest centre (aOR 0.78, 95% CI (0.54, 1.13), $p = 0.19$) compared to a cardiac arrest centre (Table 4).

Discussion

This study demonstrates that following propensity matching, with an odds ratio of 0.78, there appears to be potential for around a 22% decrease in 30-day mortality associated with a cardiac arrest centre. However, this current study may be limited in power to establish statistical significance. Whilst not an aim of this study, the findings also demonstrated clear differences in access to cardiac arrest centres by age, ethnicity, rurality, deprivation, and presence of a STEMI. Additionally, there were confronting differences in survival by demographic factors in Aotearoa New Zealand. Specifically, our minoritised ethnic groups — Māori and Pacific Peoples — had significantly lower survival from out-of-hospital cardiac arrest than non-Māori/non-Pacific peoples.

Although underpowered, this study is indicative of a possible survival benefit for cardiac arrest centres and is aligned with recent international literature reviews and meta-analysis that indicate a survival benefit for transport to a cardiac arrest centre [1,17,18]. The Yeo et al and Yeung et al studies were nuanced in that the survival benefit was noted to be more pronounced or only associated with the presence of a shockable rhythm, or only until discharge but not to 30-days [1,17]. The Lipe et al review indicated a survival benefit for both discharge and to 30-days but no sub-group analysis of shockable rhythm was undertaken [18]. Our current findings are also consistent with our previous results, where we demonstrated that direct transport to PCI capable hospitals following OHCA is associated with a survival benefit [4].

In our study, we defined cardiac arrest centres as providing: tracheal intubation and ventilation, haemodynamic support and monitoring, assessment of the underlying cause of arrest with on-site diagnostics, 24-hour invasive reperfusion capability, temperature control, and neuroprognostication regardless of volume of annual OHCA cases (Appendix A). In Aotearoa New Zealand there is no credentialling process for what constitutes a cardiac arrest centre. This differs from other countries such as Germany, which initiated the process of certification in 2018 with recent results indicating survival was similar between certified and non-certified centres [19,20]. However, the likelihood of favourable neurological outcome was higher after cardiac arrest centre certification [19,20].

One of the criteria often utilised to define a cardiac arrest centre is the number of cases admitted to the hospitals annually [21]. It may be that a higher frequency of annual cases is associated with survival in addition to PCI capability, as Schober *et al.* demonstrated an association between direct transport to hospitals with greater than of 100 OHCA admissions annually and survival [21]. Notably in our study, only two out of the five cardiac arrest centre hospitals receive greater than 100 OHCA cases annually, with the remaining three hospitals each receiving less than sixty cases per year. In a similar propensity-matched observational study from the UK, centres with 24/7 PCI capability had a larger impact on survival than OHCA volume [22]. However, in the more recent randomised trial from the UK that excluded patients with STEMI indicated no survival benefit for cardiac arrest centres, five out of the seven designated cardiac arrest centres received more than 100 cases annually (with the remaining two receiving more than eighty and sixty, respectively) [5].

Our study was limited to cases with a presumed cardiac cause. Cases were presumed to be of cardiac aetiology by the treating EMS staff unless there was an obvious other cause, such as trauma. This was similar to both our previous Aotearoa New Zealand study and observational studies in the UK and Australia [4,22,23]. Although our study included only patients with presumed cardiac cause there were key differences, in particular the previous Aotearoa New Zealand study was not propensity matched and, therefore, subject to increased selection bias [4]. The Australian study only included those patients who were admitted to a PCI capable hospital and compared those who arrived directly versus indirectly; it did not include patients who remained within non-PCI capable hospitals or died prior to transfer [22]. The UK observational study that used a similar propensity matched cohort to this study differed materially on the population that was admitted to hospital, with less than 50% of patients having return of spontaneous circulation (ROSC) on arrival at hospital, and less than 13% surviving to discharge, whereas in our study, we had greater than 85% of patients with ROSC on arrival and more than 45% survival to thirty days [22]. This indicates that in Aotearoa

Table 2 – Distribution of variables between cardiac arrest centres and non-cardiac arrest centres after propensity score matching.

		Cardiac arrest centre n, %		Non-cardiac arrest centre n, %		Total n, %		[a] P-value
Total		554		554		1108		
Sex	Female	138	24.9%	169	30.5%	307	27.7%	0.04
	Male	416	75.1%	385	69.5%	801	72.3%	
Age in years (median, (IQR))	Age in years	66 (57, 75)		67 (56, 75)		66 (56, 75)		0.23
Ethnicity	Non-Māori/Non-Pacific	418	75.5%	400	72.2%	818	73.8%	0.43
	Māori	118	21.3%	131	23.6%	249	22.5%	
	Pacific Peoples	18	3.2%	23	4.2%	41	3.7%	
Location	[b] Healthcare Facility	23	4.2%	9	1.6%	32	2.9%	0.02
	Home	351	63.4%	381	68.8%	732	66.1%	
	Other	180	32.5%	164	29.6%	344	31.0%	
Rural/Urban – incident location	Rural	136	24.5%	147	26.5%	283	25.5%	0.45
	Urban	418	75.5%	407	73.5%	825	74.5%	
Socioeconomic deprivation - patient home address	Quintile 1	87	15.7%	67	12.1%	154	13.9%	0.32
	Quintile 2	78	14.1%	75	13.5%	153	13.8%	
	Quintile 3	95	17.1%	89	16.1%	184	16.6%	
	Quintile 4	128	23.1%	132	23.8%	260	23.5%	
	Quintile 5	166	30.0%	191	34.5%	357	32.2%	
Witnessed	Bystander	324	58.5%	325	58.7%	649	58.6%	0.18
	EMS	167	30.1%	148	26.7%	315	28.4%	
	Not witnessed	63	11.4%	81	14.6%	144	13.0%	
Initial Rhythm	Non-shockable	156	28.2%	185	33.4%	341	30.8%	0.06
	Shockable	398	71.8%	369	66.6%	767	69.2%	
Bystander CPR (excludes EAS witnessed)	NO	56	14.5%	57	14.0%	113	14.2%	0.86
	YES	331	85.5%	349	86.0%	680	85.8%	
Community defibrillation	Community	72	13.0%	58	10.5%	130	11.7%	0.02
	Fire service/first response	58	10.5%	36	6.5%	94	8.5%	
	No defibrillation prior	424	76.5%	460	83.0%	884	79.8%	
EMS Time to scene (min) (median, (IQR)	Time to scene	6 (4, 9)		5 (4, 8)		6 (4, 9)		0.11
Transport time (min) (median, (IQR)	Transport time	17 (11, 31)		13 (8,27)		15 (9, 29)		<0.001
EMS 12-Lead	No STEMI	451	81.4%	465	83.9%	916	82.7%	0.27
	STEMI	103	18.6%	89	16.1%	192	17.3%	
Year	1 July 2019 to 30 June 2020	154	27.8%	150	27.1%	304	27.4%	0.11
	1 July 2020 to 30 June 2021	121	21.8%	145	26.2%	266	24.0%	
	1 July 2021 to 30 June 2022	134	24.2%	144	26.0%	278	25.1%	
	1 July 2022 to 30 June 2023	145	26.2%	115	20.8%	260	23.5%	
ROSC on handover	No	33	6.0%	65	11.7%	98	8.8%	0.001
	Yes	521	94.0%	489	88.3%	1010	91.2%	
30-Day Mortality	Died	245	44.2%	304	54.9%	549	49.5%	<0.001
	Survived	309	55.8%	250	45.1%	559	50.5%	

EMS: Emergency medical service, **ROSC**: Return of spontaneous circulation, **CPR**: Cardiopulmonary resuscitation, **STEMI**: ST-elevation myocardial infarction.

[a] $p < 0.05$ is significant; $\chi 2$ test for nominal values; Mann–Whitney U-test for continuous values.

[b] A healthcare facility refers to non-hospital treatment localities such as a general practice clinic.

New Zealand, EMS may have differing criteria for transporting patients from the scene to hospital than in other jurisdictions. Notably, our inclusion criteria also differed from a recent German study that included all cardiac arrest patients and Danish study that included all cardiac arrest patients except those with STEMI, with the German study indicating improved functional neurological outcome and the Danish study demonstrating improved survival [20,24].

Contrasting results to the Danish study were recently reported in a UK randomised trial that also excluded patients with STEMI, which demonstrated no survival benefit for direct transport to cardiac arrest centres in non-STEMI patients [5]. This suggests that country-specific analysis is warranted and that potentially there may be differing outcomes for sub-populations of OHCA patients, namely those with STEMI. Our study was inclusive of patients with STEMI and these patients had higher odds of survival following propensity matching. It could be that the patients with STEMI in our study may have had additional factors that were unable to be investigated that may have led to higher survival, such as early fibrinolysis, perhaps they were also more likely to have had shorter no-flow time than other patients in the cohort. Given the existing evidence for patients with STEMI it is likely that the balance of evidence supports direct transport of these patients to cardiac arrest centres [6,7]. Inclusion of all patients transported to hospital in this study — regardless of the presence of STEMI —serves as an initial first step in reviewing

Table 3 – Multivariable logistic regression adjusted odds ratios and 95% confidence intervals of survival to thirty days for OHCA patients after propensity score matching.

Effect		*aOR	95% CI	p-value
Age in years	Age In Years	0.95	(0.94, 0.96)	<0.001
Ethnicity	Non-Māori/Non-Pacific (ref)	1.0		<0.001
	Māori	0.36	(0.22, 0.57)	
	Pacific Peoples	0.18	(0.06, 0.55)	
Arrest witnessed	Bystander (ref)	1.0	-	<0.001
	EAS	1.16	(0.88, 1.52)	
	NO	0.45	(0.31, 0.66)	
Initial Rhythm	Non-shockable (ref)	1.0	-	<0.001
	Shockable	4.23	(2.71, 6.62)	
Bystander CPR	NO (ref)	1.0	-	0.01
(excludes EAS witnessed)	YES	2.00	(1.15, 3.47)	
EMS 12-Lead	No STEMI (ref)	1.0	-	0.05
	STEMI	1.74	(1.01, 3.01)	

EMS: Emergency medical service, **CPR**: Cardiopulmonary resuscitation, **STEMI**: ST-elevation myocardial infarction.
* Adjusted odds ratio, adjusted for all variables. Data in the table is only shown for significant variables, $p < 0.05$.

Table 4 – Univariable and multivariable logistic regression for odds of thirty-day survival according to transport to a cardiac arrest centre after propensity score matching.

Effect	uOR	95% CI	p-value	*aOR	95% CI	p-value
Cardiac arrest centre (ref)	1.0	-		1.0	-	
Non-cardiac arrest centre	0.65	(0.51, 0.83)	<0.001	0.78	(0.54, 1.13)	0.19

* Adjusted odds ratio, adjusted for all variables.

the New Zealand context. However, it is pertinent that future studies undertake subsequent analyses of patients without STEMI.

In our study, the length of transport time to both cardiac arrest centres (17 minutes) and non-cardiac arrest centres (13 minutes), though statistically significant, are both relatively short. Therefore, the impact of distance/time to hospital could not be investigated with this study. Bypassing the closest hospital, as in favour of a more distant cardiac arrest centre is a particular interest to EMS with previous studies indicating that increasing transport distance may impact survival [25,26]. A Taiwanese retrospective observational study also investigated whether transport times greater or less than 8 min impacted on the potential survival benefit of a cardiac arrest centre; this study demonstrated that regardless of transport time there was a survival benefit but only for patients presenting in a shockable rhythm but not a non-shockable [27]. Moreover, there are wider implications that need to be considered when transporting a patient outside of their home area, in particular the social, financial, and cultural impacts on a family's wellbeing [28,29].

The association between ethnicity and rates of direct transport to cardiac arrest centres might, in-part, be reflective of the urban/rural distinction, with Aotearoa New Zealand cardiac arrest centres being in central urban areas. In 2018, most Pacific Peoples resided in the highly urbanised Auckland region of Aotearoa New Zealand [30]. A higher proportion of Māori (25%) compared to non-Māori(18%) live in rural areas and almost a third of residents in New Zealand's most remote areas are of Māori ethnicity [31].

Following propensity matching, stark differences in survival outcomes for both Pacific Peoples and Māori remained, indicating that regardless of differing access to a cardiac arrest centre, other factors are impacting survival in these populations. There are well documented inequities in outcomes for Māori and Pacific Peoples that reflect differences in overall access to both primary preventive care and definitive care, quality of healthcare, socioeconomic disparity and unacceptable racism of our health system [32].

Limitations

This study was an observational study and therefore faces the risks of bias and confounding which are inherent in studies of this nature. We sought to reduce this risk through including measured confounders recommended by Utstein in our modelling but it remains possible that unmeasured confounders may have influenced the study findings. Whilst several scores have been developed to assess prognosis at hospital arrival (e.g. the CRASS Score [33], MIRACLE-2 score [34] there is a paucity of scores which enable accurate prediction of outcomes that that have been validated for application at the scene of a cardiac arrest when making the decision which patients to transport to hospital. Further limitations include the small number of patients in the study following propensity matching may have reduced the ability for the study to detect a statistical difference according to hospital destination. This study excluded patients that were directly transported to hospitals with partial cardiac arrest centre capabilities regardless of whether they were subsequently transferred to a cardiac arrest centre. The specific treatments and interventions received by patients who went to cardiac arrest centres, were not part of this study and these may have varied by patient.

Four hospitals were excluded from the study as they had the capabilities of the cardiac arrest centres but only during certain times of the day; it was not possible to align times of ambulance transport and hospital arrival to determine if, at the time of arrival, the hospital would have had cardiac arrest centre capability or not. As there is currently no destination policy within the New Zealand context directing post-cardiac arrest patients to a cardiac arrest centre, almost all patients are transported to the closest hospital. Consideration could have been given to the possibility of only evaluating rural patients who are without immediate access to a cardiac arrest centre, but there would be limited comparators as almost all rural patients would be taken to a nearby non-cardiac arrest centre.

Conclusions

With an odds ratio of 0.78, there appears to be potential for around a 22% decrease in 30-day mortality associated with a cardiac arrest centre; however, this was not statistically significant. Further research is required with a larger cohort to determine a treatment effect. Nevertheless, our data revealed notable disparities in survival rates among ethnic groups, with Māori and Pacific Peoples experiencing significantly lower survival rates compared to their non-Māori/non-Pacific counterparts. Ensuring equitable care and outcomes for minoritised populations is a crucial priority for future research.

Ethics approval

This study has been approved by the Northern B Health and Disability Ethics Committee. Reference: Aotearoa New Zealand, Paramedic Care Collection (ANZPaCC), 2022 FULL 13415.

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CRediT authorship contribution statement

Bridget Dicker: Writing – review & editing, Writing – original draft, Conceptualization, Data curation, Formal analysis, Methodology. **Nick Garrett:** Methodology, Formal analysis, Conceptualization, Writing – review & editing. **Graham Howie:** Conceptualization, Writing – original draft, Writing – review & editing. **Aroha Brett:** Formal analysis, Writing – review & editing. **Tony Scott:** Formal analysis, Writing – review & editing. **Ralph Stewart:** Formal analysis, Methodology, Writing – review & editing. **Gavin D. Perkins:** Writing – review & editing, Methodology, Investigation, Formal analysis, Conceptualization. **Tony Smith:** Formal analysis, Writing – review & editing. **Elena Garcia:** Writing – review & editing. **Verity F. Todd:** Methodology, Investigation, Formal analysis, Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: [GDP is Editor in Chief of Resuscitation Plus and supported by NIHR ARC West Midlands. BD - Is a Co-guest editor for Resuscitation Plus. BD, EG, AB and T-Smith are employees of Hato Hone St John. Other authors, declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.].

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Appendix A. Hospitals according to cardiac arrest centre* designation used in this analysis

Hospital Name	Hospital Level
Auckland City Hospital	Cardiac arrest centre
Christchurch Hospital	Cardiac arrest centre
Dunedin Hospital	Cardiac arrest centre
Waikato Hospital	Cardiac arrest centre
Wellington Hospital	Cardiac arrest centre
Middlemore Hospital	Partial-cardiac arrest centre capability - excluded from study
Nelson Hospital	Partial-cardiac arrest centre capability - excluded from study
North Shore Hospital	Partial-cardiac arrest centre capability - excluded from study
Tauranga Hospital	Partial-cardiac arrest centre capability - excluded from study
Palmerston North Hospital	Non-cardiac arrest centre
Ashburton Hospital	Non-cardiac arrest centre
Bay of Islands Hospital	Non-cardiac arrest centre
Buller Health	Non-cardiac arrest centre
Dargaville Hospital	Non-cardiac arrest centre
Dunstan Hospital	Non-cardiac arrest centre
Gisborne Hospital	Non-cardiac arrest centre
Gore Hospital	Non-cardiac arrest centre
Hawera Hospital	Non-cardiac arrest centre
Hawkes Bay Hospital	Non-cardiac arrest centre
Horowhenua Hospital	Non-cardiac arrest centre
Hutt Hospital	Non-cardiac arrest centre
Kaitaia Hospital	Non-cardiac arrest centre
Southland Hospital	Non-cardiac arrest centre
Lakes District Hospital	Non-cardiac arrest centre
Whangarei Hospital	Non-cardiac arrest centre
Oamaru Hospital	Non-cardiac arrest centre
Rotorua Hospital	Non-cardiac arrest centre
Starship Child & Family Unit	Non-cardiac arrest centre
Taranaki Base Hospital	Non-cardiac arrest centre
Taumarunui Community Hospital	Non-cardiac arrest centre
Taupo Hospital	Non-cardiac arrest centre
Te Kuiti Hospital	Non-cardiac arrest centre
Te Nikau Grey Hospital	Non-cardiac arrest centre
Timaru Hospital	Non-cardiac arrest centre
Tokoroa Hospital	Non-cardiac arrest centre
Wairarapa Hospital	Non-cardiac arrest centre
Wairau Hospital	Non-cardiac arrest centre
Wairoa Hospital & Health Centre	Non-cardiac arrest centre
Whakatane Hospital	Non-cardiac arrest centre
Whanganui Hospital	Non-cardiac arrest centre

*A cardiac arrest centre was defined as a hospital that could provide all the following services: tracheal intubation and ventilation, haemodynamic support and monitoring, assessment of the underlying cause of arrest with on-site diagnostics, 24-hour invasive reperfusion capability, temperature control, and neuroprognostication.

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100625.

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