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Short paper

Positive association between ambulance double-crewing and OHCA outcomes: A New Zealand observational study

Bridget Dicker[a,b,*], *Kevin Govender*[a], *Graham Howie*[a,b], *Andy Swain*[a,c], *Verity F. Todd*[a,b]

[a] *Paramedicine Department, Auckland University of Technology, Auckland, New Zealand*
[b] *Clinical Audit and Research, St John New Zealand, Auckland, New Zealand*
[c] *Wellington Free Ambulance, Wellington, New Zealand*

Abstract

Background and objectives: New Zealand emergency medical service (EMS) crewing configurations generally place one (single) or two (double) crew on each responding ambulance unit. Recent studies demonstrated that double-crewing was associated with improved survival from out-of-hospital cardiac arrest (OHCA), therefore single-crewed ambulances have been phased out. We aimed to determine the association between this crewing policy change and OHCA outcomes in New Zealand.

Methods: This is a retrospective observational study using data from the St John OHCA Registry on patients treated during two dierent time periods: the Pre-Period (1 October 2013–30 June 2015), when single-crewed ambulances were in use by EMS, and the Post-Period (1 July 2016–30 June 2018) when single-crewed ambulances were being phased out. Geographic areas identified as having low levels of double crewing during the Pre-Period were selected for investigation. The outcome of survival to thirty-days post-OHCA was investigated using logistic regression analysis.

Results: The proportion of double-crewed ambulances arriving at OHCA events increased in the Post-Period (81.8%) compared to the Pre-Period (67.5%) ($p \leq 0.001$). Response times decreased by two minutes (Pre-Period: median 8 min, IQR [6–11], Post-Period: median 6 min, IQR [4–9]; $p \leq 0.001$). Thirty-day survival was significantly improved in the Post-Period (OR 1.63, 95%CI (1.04–2.55), $p = 0.03$).

Conclusions: An association between improved OHCA survival following increased responses by double-crewed ambulances was demonstrated. This study suggests that improvements in resourcing are associated with improved OHCA outcomes.

Keywords: Resuscitation, Crew configuration, Double crewing, Survival, ROSC, EMS, New Zealand, OHCA, Cardiac Arrest, Out-of-Hospital, Pre-Hospital, Paramedic, Ambulance

Introduction

In New Zealand, EMS respond to around 4,000 out-of-hospital cardiac arrests annually.[1] A resuscitation is attempted in around half of OHCA events attended, but only 15% of patients survive to 30-days.[1] Modifiable EMS-related factors correlated with survival include shortened response intervals and optimised crew configurations.[2–4] On New Zealand ambulances, crew configurations may be single- or double-crewed.[5,6] However, in 2017 we demonstrated that OHCA survival improved when a double-crewed ambulance was first on scene.[6] Given this disparity in outcomes, St John EMS invested in extra staff resourcing in areas with single-crewed responses. This study aimed to determine whether those improvements in ambulance resourcing were associated with increased Return of Spontaneous Circulation (ROSC) sustained to hospital handover and 30-day survival.

* Corresponding author.
E-mail address: bridget.dicker@stjohn.org.nz (B. Dicker).

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Methods

Study design

This was a retrospective observational study of specific geographic areas during two distinct time periods: the Pre-Period from 1 October 2013 to 30 June 2015 (pre-improvements in crew resourcing), and the Post-Period from 1 July 2016 to 30 June 2018 (post-improvements in crew resourcing).

Setting

St John is the largest EMS in New Zealand. It attends 90% of New Zealanders, covers 97% of the country, and treats almost 500,000 patients every year.[7] In reported OHCAs, the computer aided dispatch system activates a two-tiered response which dispatches the closest unit, regardless of the crew configuration and level of expertise.[1] The second unit is concurrently dispatched, consisting, wherever possible, of crew at the level of a paramedic or an intensive care paramedic.[1] It is not uncommon for the first arriving unit to be single-crewed, particularly in rural areas. Treatment of OHCA patients is initiated according to the scope of practice of the first arriving crew and guided throughout by established clinical practice protocols.[8,9]

The St John OHCA registry

The St John OHCA Registry and the data variables held within the registry are described elsewhere.[1] Ethnicity and mortality data are derived through the New Zealand National Health Index (NHI).[10]

Location data

Geographic areas of New Zealand are designated as meshblocks.[11] A meshblock is the minimal unit of geography and census data. They are defined by both physical and social features - for example, a meshblock optimally contains only 30–50 dwellings, and may vary in size from part of a city block to large areas of rural land. Each meshblock borders on another to form a contiguous network covering all New Zealand. The location of each OHCA was mapped to a specific meshblock determined via an automated ambulance vehicle location system, accurate to within 100 metres.

Geographically defined low-resourced cohorts

For the purposes of this study, a cohort of meshblocks was identified as low-resourced. The low-resourced cohort was defined by either: 1) meshblocks where >10% of OHCA events were attended by a single-crewed ambulance during the Pre-Period, or 2) meshblocks where St John had invested extra staff resourcing. As a comparative cohort, highly-resourced meshblocks were identified, defined as having < 5% of OHCA events attended by a single-crewed ambulance in both the Pre- and Post-Periods (Table S1).

Inclusion and exclusion criteria

OHCA registry data included all events that occurred during the Pre- or Post-Periods where a resuscitation attempt was made. Events occurring within a geographically mapped meshblock were eligible for inclusion into the study. OHCAs that were initially attended by non-transporting emergency vehicles (e.g. Fire trucks) were excluded from the study, as were those where more than two or an unknown number of ambulance staff arrived as the first. Events were included regardless of patient age, aetiology, or occurrence of the OHCA in the presence of EMS. (Fig. 1).

Statistics

OHCA characteristics and patient demographics are presented as frequencies and percentages, stratified by the Pre-Period and Post-Period. Differences between the two periods were tested using Pearson Chi-Square test and the z-test for column proportions to compare nominal values. The Mann-Whitney-U test was used to compare continuous variables. Binary logistic models investigated outcome differences in ROSC sustained to handover at hospital and survival to thirty-days. Data are presented as odds ratios (OR) with 95% confidence intervals (95% CI). All variables used as covariates for the adjusted model are listed within the tables. Missing data was handled by pairwise, case available analysis. Analysis was completed only on the data points present within a given variable and missing data points were excluded. This meant the denominator value for a given variable changed, but rarely by more than 1–2 percent. Data analysis was performed using IBM SPSS (v. 27.0). A p-value < 0.05 was considered statistically significant.

Ethics

This study was approved by the New Zealand Health and Disabilities Ethics Committee (No. 19/NTB/187/AM01).

Results

During the study periods, St John attended 8,113 OHCAs where a resuscitation was attempted. After exclusions a total of 5,603 OHCA events remained. Of these, 1,158 events occurred in a low-resourced area and 972 events in the highly-resourced comparator group area (Figs. 1 and S1).

EMS crew and response characteristics

There was a significant difference in the number of double-crewed ambulances that were first to arrive to OHCA events between the Pre-Period (67.5%, n = 365) and the Post-Period (81.8%, n = 505) (p < 0.001). Response times were significantly quicker in the Post-Period in both low- and high-resourced areas, with a median response interval time of 6 minutes compared to 8 minutes in the Pre-Period (Tables 1 and S2).

Population and OHCA characteristics

Population demographics were similar across both study periods (Table 1). There was no significant difference in the proportion of patients attended for both sex and ethnicity. However, small differences did exist between age groups (Table 1). In the Pre-Period, a higher proportion of patients over 65 years old were attended compared to the Post-Period (57.2% vs. 51.0%, p = 0.04). A slightly higher proportion of patients in the Post-Period cohort were in the 45–64 year old age group (34.7% vs. 26.8% in the Pre-Period, p = 0.042) (Table 1). There were no significant differences in the proportion of OHCA characteristics between both periods regarding aetiology, presenting rhythm, witnessed status, bystander CPR, or community defibrillation (p > 0.05).

ROSC and Thirty-day survival

There was a significantly higher proportion of patients with ROSC on arrival at hospital in the Post-Period (32.9% vs. 26.2%, p = 0.01) (Table 1). Following adjusted logistic regression, the increase in ROSC between the periods was not significant (OR 1.08, 95% CI (0.79–1.48), p = 0.63) (Table 2).

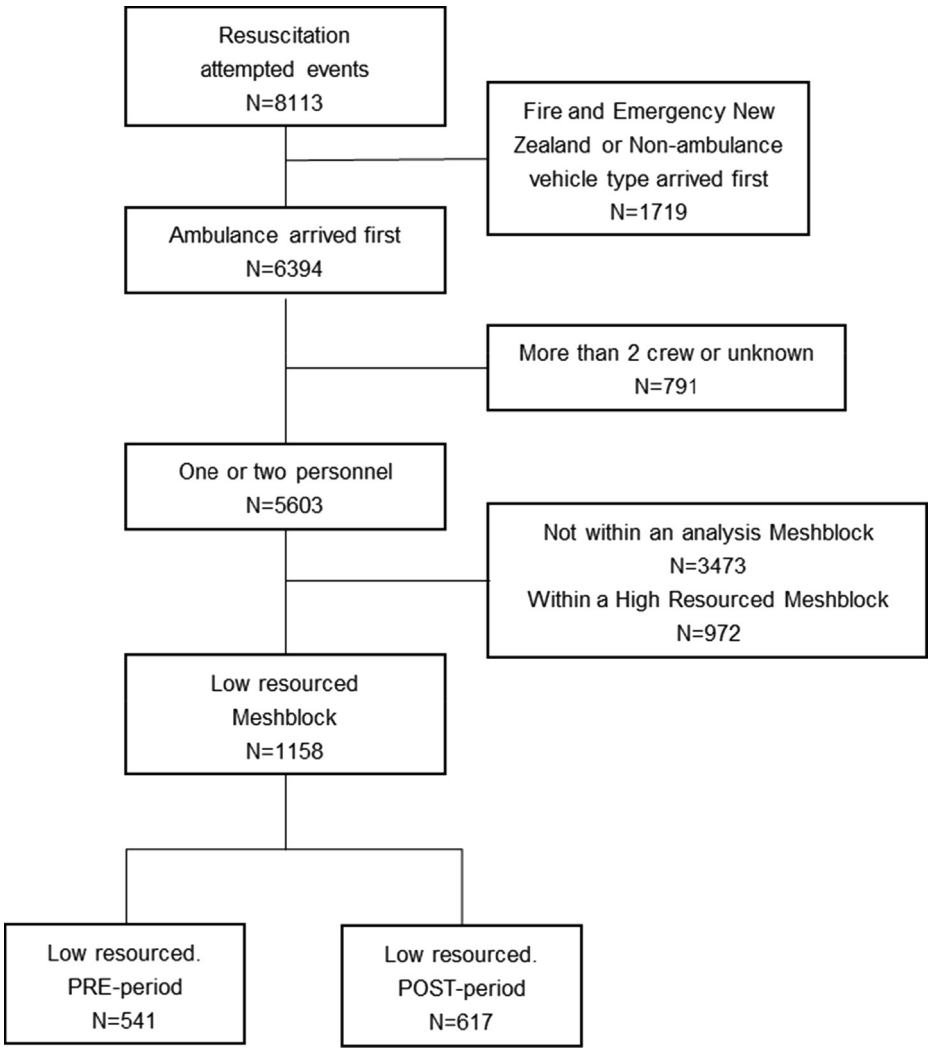

Fig. 1 – Inclusion criteria low resourced meshblocks.

Of the 1,158 total OHCA patients attended, 163 (14.1%) survived to 30 days after the OHCA event. There was a greater proportion of patients who had survived to 30 days in the Post-Period (n = 103, 16.8%), compared to the Pre-Period (n = 60, 11.1%) (p = 0.01). This increase in survival to 30 days remained significant following adjusted logistic regression (OR 1.63, 95 %CI (1.04–2.55), p = 0.03) (Table 2). No significant differences in 30-day survival were observed during the same Pre- and Post-Periods for geographic areas that were highly resourced (OR 1.12, 95 %CI (0.73–1.73), p = 0.61) (Tables S2 and S3).

Discussion

This was a retrospective observational study of specific geographic areas of New Zealand which, until additional resourcing was provided, had low levels of double-crewed responses to OHCA events. St John invested extra staff resourcing into these areas predominantly in response to our previous study that demonstrated poorer survival outcomes with single-crewed ambulances.[6] Between the Pre- and Post-periods, more than 300 additional ambulance staff were employed in these areas. Correspondingly, rates of double-crewed responses to OHCA events increased from 67.5% to 81.8%.

This increase in double-crewed responses appears to have had a positive influence on OHCA survival to 30 days, which increased from 11.1% to 16.8%. To determine whether this increase in survival could be due to other factors that may have occurred between the Pre- and Post-Periods, we also looked at highly-resourced geographic areas with high levels of double-crewing. The same training, clinical procedures, and operational systems were utilised across both low- and highly-resourced geographic areas throughout the study periods. In those areas with consistently high levels of double-crewing there was no significant improvement in survival between the two time periods.

It could be speculated that the improvement in survival was due to the improvement in response times identified in the Post-Period. However, this two-minute decrease in response time was also found in the highly-resourced areas, but with no corresponding increase in survival. (Tables S2 and S3). Moreover, it is unlikely that a two minute improvement in response times would markedly improve sur-

Table 1 – Descriptive analysis of OHCA events in low-resourced areas during the periods pre- and post- additional resourcing to increase double-crewing on ambulances.

		Total (n = 1158)		Pre-Period (n = 541)		Post-Period (n = 617)		P value
		n	%	n	%	n	%	
Crew number	1	288	24.9%	176	32.5%	112	18.2%	*<0.001
	2	870	75.1%	365	67.5%	505	81.8%	
Age	<15	35	3.1%	18	3.4%	17	2.9%	*0.04
	15–44	134	12.0%	66	12.6%	68	11.4%	
	45–64	346	31.0%	140	26.8%	206	34.7%	
	65plus	602	53.9%	299	57.2%	303	51.0%	
Sex	Female	379	32.8%	181	33.5%	198	32.3%	0.68
	Male	775	67.2%	360	66.5%	415	67.7%	
Ethnicity	Māori	349	36.5%	143	36.1%	206	36.9%	0.81
	Non-Māori	606	63.5%	253	63.9%	353	63.1%	
Aetiology	Non-cardiac	275	23.7%	126	23.3%	149	24.1%	0.73
	Presumed cardiac	883	76.3%	415	76.7%	468	75.9%	
Shockable Rhythm (VT, VF)[$]	Yes	393	33.9%	171	31.6%	222	36.0%	0.12
Witnessed	EMS	184	15.9%	85	15.7%	99	16.0%	0.13
	No	407	35.1%	175	32.3%	232	37.6%	
	Yes	567	49.0%	281	51.9%	286	46.4%	
Bystander CPR	Yes	676	58.6%	301	56.2%	375	60.8%	0.11
Community Defibrillation	Yes	43	3.7%	14	2.6%	29	4.7%	0.06
Response time	Median (IQR)	7 (5–10)		8 (6–11)		6 (4–9)		*<0.001
Location	Home	831	71.8%	380	70.4%	451	73.1%	0.30
	Other	326	28.2%	160	29.6%	166	26.9%	
Rurality	Urban	746	65.3%	349	65.4%	397	65.2%	0.95
	Rural	397	34.7%	185	34.6%	212	34.8%	
ROSC on handover at hospital	Yes	345	29.8%	142	26.2%	203	32.9%	*0.01
30-Day Survival	Yes	163	14.1%	60	11.1%	103	16.8%	*0.01

[*] P < 0.05 is significant; $\chi 2$ test for nominal values; Mann-Whitney U-test for continuous values. CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation [#]Missing values were less than 1% for all variables, except for ethnicity which was missing in 17.5% of cases.
[$] Shockable rhythm includes Ventricular Tachycardia (VT) and Ventricular Fibrillation (VF), a non-shockable rhythm includes Pulseless Electrical Activity (PEA) and Asystole.

Table 2 – Survival outcomes (ROSC and 30-day survival) in low-resourced areas during the periods pre- and post-additional resourcing to increase double-crewing on ambulances.

Survival Outcome	Cohort	Unadjusted Odds Ratio (95% CI)	Unadjusted Odds Ratio Significance	Adjusted[#] Odds Ratio (95% CI)	Adjusted[#] Odds Ratio Significance
ROSC on handover at hospital	Pre-Period (reference)	1.00	*0.01	1.00	0.63
	Post-Period	1.38 (1.07–1.78)		1.08 (0.79–1.48)	
30-Day Survival	Pre-Period (reference)	1.00	*0.01	1.00	*0.03
	Post-Period	1.62 (1.15–2.27)		1.63 (1.04–2.55)	

[#] Adjusted for Crew number, Age, Sex, Ethnicity, Aetiology, Witnessed, Bystander CPR, Community Defib, Shockable Rhythm, Location, Rurality.
*p-value $\leq$ 0.05 is considered significant.

vival, given the ambulance arrival time for both periods still falls outside the optimal response window of 3–5 minutes, where a significant difference in survival is most likely.[12]

It may be that in a single-crewed response a lone responder is unable to perform sufficiently high quality CPR, a known predictor of survival.[13,14] A single responder would be expected to multi-task, performing chest compressions, ventilations, interacting with bystanders and family, attaching defibrillation pads and administering defibrillation. Whereas, with double-crewing, one of the responders can perform continuous high-quality chest compressions. Fatigue may also impact on the quality of chest compressions delivered in the setting of a single-crewed response with chest compression rate and depth being known to wane over time.[15,16]

Limitations

This was a retrospective study using observational data therefore conclusions regarding causation associated with increased survival cannot be drawn.

Conclusions

This study suggests that the investment of extra EMS staff in previously low-resourced areas to increase double-crewed responses is associated with improved OHCA survival in those communities.

CRediT authorship contribution statement

Bridget Dicker: Conceptualization, Methodology, Investigation, Data curation, Writing – original draft, Writing – review & editing, Supervision. **Kevin Govender:** Methodology, Writing – review & editing, Project administration. **Graham Howie:** Writing – review & editing. **Andy Swain:** Writing – review & editing. **Verity F. Todd:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Declaration of Competing Interest

The 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. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2021.100187.

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