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Prehospital advanced versus basic life support: A cohort study comparing survival to hospital for major trauma patients in New Zealand

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ABSTRACT

Objective: To examine the relationship between prehospital Advanced Life Support (ALS) and survival to hospital for major trauma patients in New Zealand and explore its implications for Emergency Medical Service (EMS) practice.

Methods: A mixed-methods explanatory design was used. Data on major trauma patients attended by road EMS (December 2016–November 2018) was analysed. A multivariable model with propensity scores estimated the odds of survival for patients receiving Advanced versus Basic Life Support (BLS). Semi-structured interviews conducted with EMS stakeholders were analysed using thematic analysis.

Results: Among 1118 patients, 661 (59 %) received ALS. Only 52 (5 %) did not survive to hospital. Multivariable modeling estimated ALS recipients had 1.5 times higher odds of survival than BLS-only recipients (OR 1.49, 95 % CI 0.66–3.35). Interviews with five EMS clinical leaders highlighted two likely influences: clinical judgment and evidence use. Despite imprecise quantitative findings, stakeholders supported ALS based on clinical judgment.

Conclusions: A tension between population-level results and provision of care based on clinical judgement exists. Quantitative analysis found no evidence that ALS offers a survival benefit, although considerable uncertainty exists, whereas stakeholders perceive ALS has clinical and equity benefits. Future research should assess equity, disability, and quality of life outcomes of ALS.

Introduction

Injury is responsible for approximately 8 % of deaths globally, with unintentional injury alone contributing 3.2 million deaths annually [1]. In New Zealand (population 5 million), there were 13,982 serious non-fatal hospitalised injuries in 2022, and 2323 injury-related fatalities in 2019 [2]. Emergency medical services (EMS) provide on-scene prehospital care to major trauma patients [3, 4]. A 2020 analysis of those who did not survive to hospital following injury in New Zealand estimated 40 % had survivable or potentially survivable injuries [5]; suggesting opportunities exist to improve the chances of survival following major trauma in the EMS setting.

Advanced Life Support (ALS), often involving invasive interventions such as Rapid Sequence Intubation (RSI) for emergency airways management, are considered by EMS providers to improve survival in major trauma patients over and above Basic Life Support (BLS) interventions [6]. Multiple systematic reviews and meta-analyses have examined the relationship between prehospital ALS and mortality for trauma patients [6–14]. Heterogeneity among studies and issues with confounding have made it difficult for these studies to provide clear evidence [22]. For example, three meta-analyses found that ALS is unlikely to provide a survival benefit compared with BLS in trauma patients [6–8]. Therefore, questions remain regarding the survival benefit of ALS, compared to BLS, delivered by EMS in the prehospital setting for major trauma patients.

Both ALS and BLS are performed by EMS on major trauma patients in New Zealand [15]; however, there are no published evaluations of mortality outcomes for patients receiving prehospital ALS in New

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Zealand. This study sought to answer whether ALS delivered by EMS in the prehospital setting improves survival to hospital using a national cohort of EMS-attended major trauma patients and additionally explores the potential implications of this for EMS practice in New Zealand.

Methods

Study design

A mixed methods sequential explanatory design (QUAN→qual) was utilised. Phase One involved undertaking statistical analysis of a cohort of major trauma patients to understand the relationship between ALS and survival to hospital compared to BLS. Phase Two explored the potential implications of the quantitative findings for EMS practice in New Zealand.

Phase One: quantitative

This phase drew on a subset of data selected from a retrospectively designed prospective cohort study. The full study protocol is published elsewhere [16]. In brief the wider study comprised major trauma patients (injury severity score [ISS] of >12 or death following injury) aged 15–84 years attended by one of New Zealand's two road EMS providers Hato Hone St John and Wellington Free Ambulance, and captured in the New Zealand Trauma Registry, between 1 December 2016 and 30 November 2018. [18]. We only included patients that received either ALS or BLS and who had EMS staff on scene that could perform ALS. Patients were excluded if the incident location was a healthcare facility, if there was no electronic patient report form, or if patients had not received a relevant ALS or BLS intervention: prehospital interventions were included regardless of outcome.

The Ministry of Health's National Health Index database was used to obtain patients' age, sex, and ethnicity. Ethnicity was prioritised into Māori and non-Māori following Ethnicity Data Protocols [17]. Rurality of the injury incident location was obtained using the 2018 Geographical Classification for Health categorised into two urban, (U1 [most urban] or U2), and three rural categories (R1, R2, or R3 [most rural]) [18].

Injury characteristics of patients including ISS for those who survived to hospital were obtained from the New Zealand Trauma Registry [16]; for those who did not survive to hospital these were coded by a trained ISS coder using pathology information obtained from the National Coronial Information System [19].

Electronic patient report forms (ePRF) from EMS providers supplied patient-level vital measurements including the Glasgow Coma Scale, heart rate and systolic blood pressure. Clinical shock, calculated from patient vital signs, was defined as having an initial or final EMS recorded shock index (heart rate divided by systolic blood pressure) of ≥ 1.4 [20]. Individual patient Charlson Comorbidity Index values obtained using a 5-year lookback was provided by the Health Quality and Safety Commission.

EMS provided treatment and pathway variables such as triage status, prehospital time, and helicopter involvement were obtained from ePRFs. The clinical status of each patient on scene, assessed by EMS personnel, was categorised as: immediate, potential, or unlikely/no threat-to-life. The prehospital activation interval was defined as time from EMS call centre pick up to ambulance dispatch.

The treatment provided was obtained from ePRF data. Life support treatment delivered on scene, based on the framework of Gomes [21] and clinical EMS review, was dichotomised into:

- BLS: laryngeal mask airway, oropharyngeal airway, cardiopulmonary resuscitation, oxygen, tourniquet, pelvic wrap/binding/sling/slip, adrenaline (topical, intramuscular, intranasal, nebulised)
- ALS: intubation, RSI, chest decompression, adrenaline (infusion, bolus, or intravenous for arrest), atropine, sodium chloride, or combined administration of calcium chloride and sodium bicarbonate

The outcome of interest, survival to first hospital, was selected because it is the closest patient-level outcome to EMS care received [22].

To compare characteristics of patients receiving ALS and BLS, Chi-square and Wilcoxon-Rank Sum tests were used for descriptive analyses. To derive the propensity score weightings logistic regression was used with ALS as the outcome; explanatory variables were selected based on a priori relationships with the outcome, prior measurement before treatment allocation, or relevance to both outcome and treatment (Table 1). In the next stage of the analysis, crude odds of survival to hospital for ALS versus BLS patients were estimated via logistic regression then adjusted using propensity score weights. The final analytical model was extended using variables relating to timepoints after treatment likely to be predictive of survival. Statistical analysis was conducted using Stata SE, Version 17 [23].

Phase Two: qualitative

Semi-structured interviews were conducted with clinical leaders, covering medical and paramedicine, as well as urban and rural service provision perspectives, from five key stakeholder providers identified from New Zealand's EMS ambulance and trauma sector. Open questions relating to the provider's definition of ALS, the provision of ALS, and the

Table 1
Measures used in analyses.

Variable	Form	Modelling	
		Propensity	Analytical
Age	Continuous	Y	
Sex	Binary (Male/Female)	Y	
Ethnicity	Binary (Māori/non-Māori)	Y	
Respiratory rate	Two binary variables (≤9 breaths per minute, yes/no & ≥30 breaths per minute, yes/no)	Y	
Heart rate	Two binary variables (<60 beats per minute, yes/no & >130 beats per minute, yes/no)	Y	
Systolic blood pressure	Binary (<90 mmHg, yes/no)	Y	
Glasgow Coma Score	Continuous	Y	
Life threatening event	Binary (yes/no)	Y	
Traumatic Brain Injury	Binary (yes/no)	Y	
Dominant injury type	Binary (penetrating injury yes/no)	Y	
Mechanism of injury	Two binary variables (fall, yes/no & transport, yes/no)	Y	
Rurality of injury incident	Continuous (five level Geographical Classification for Health)	Y	
Computer Aided Discharge triage	Binary (highest priority - suspected cardiac or respiratory arrest, yes/no)	Y	
Clinical status on scene	Binary (immediate threat to life yes/no)	Y	
Time from emergency call to EMS arrival on-scene	Binary (>12 min, yes/no)	Y	
ISS	Continuous		Y
Helicopter involvement	Binary (yes/no)		Y
Exposure of interest			
Life support	Binary (ALS, BLS)	Y	Y
Outcome of interest			
Survival to hospital	Binary (yes/no)	Y	Y

potential implications of the findings from Phase One for EMS practice in New Zealand were asked of each interviewee. Informed consent was obtained prior to the interview commencing. Interviews occurred online and were recorded, transcribed verbatim, and imported into NVivo for analysis. Thematic analysis was undertaken following a general inductive approach to summarise the data and generate key themes [24]. Respondent validation was used to increase rigour and credibility [25].

Ethical approval

Ethical approval for the parent study was obtained from the New Zealand Health and Disability Ethics Committee Northern (reference 18NTB142). Approval to access the datasets required was obtained from the New Zealand Trauma Registry Data Governance Group, National Coronial Information System (reference NZ013), Ministry of Health, and from Hato Hone St John and Wellington Free Ambulance. Individual consent was waived.

Results

Phase 1 Quantitative results

The study population comprised 3333 trauma patients. A total of 2215 patients did not meet the inclusion criteria (Fig. 1) leaving a final cohort of 1118 eligible major trauma patients. Of the 1118 patients, 661 (59 %) received at least one ALS intervention, with the remaining 457 (41 %) receiving BLS only.

Sociodemographic characteristics

The cohort was predominantly male (72 %) with approximately one in five patients aged between 15 and 24 years (Table 2). A quarter of patients identified as Indigenous Māori. A higher proportion of patients who identified as Māori received ALS compared to non-Māori patients (65 % compared with 56 %, p = 0.03).

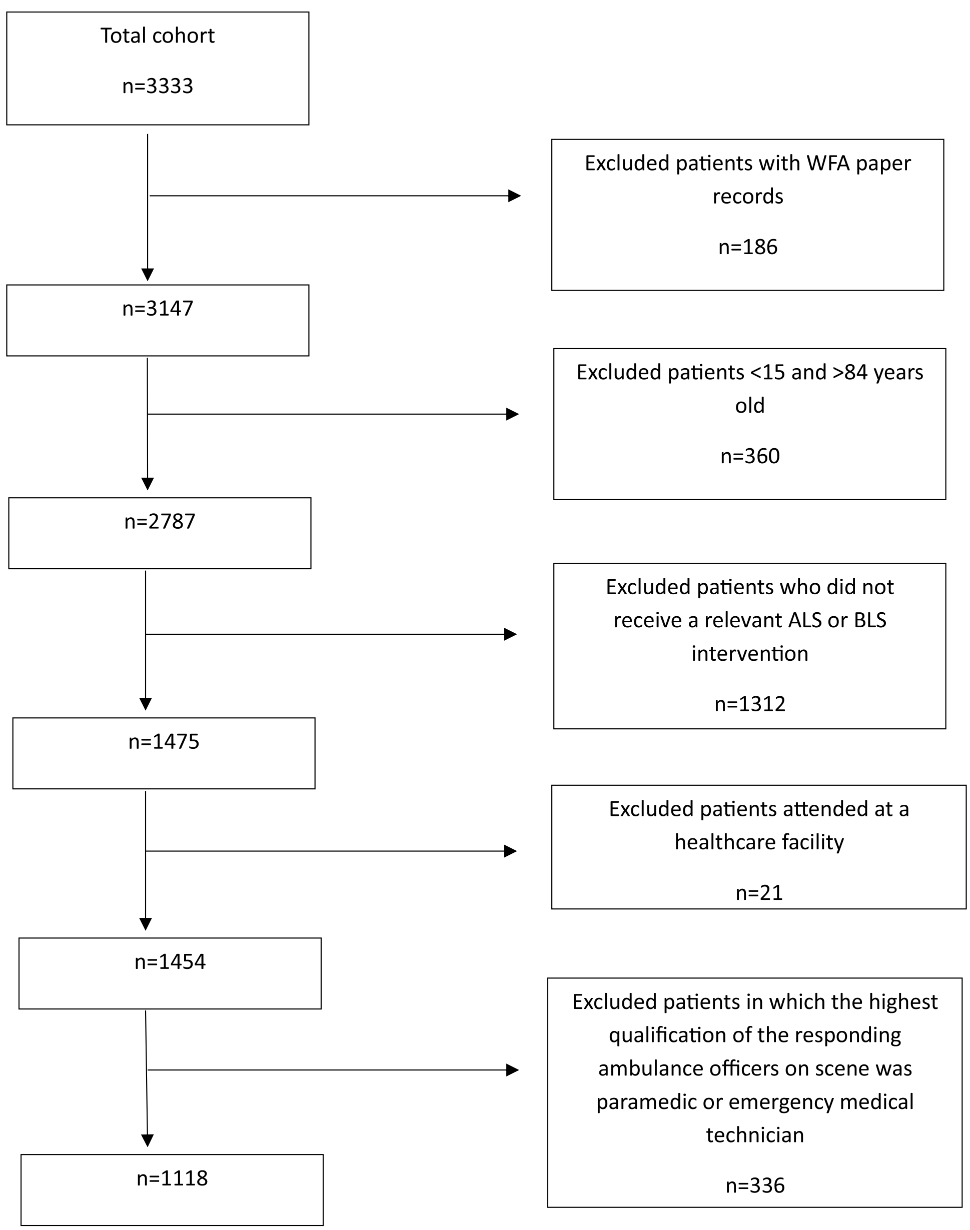

Fig. 1. Selection of the study cohort.

Table 2
Sociodemographic and injury characteristics of patients stratified by prehospital care received.

Demographic and health characteristics	All patients (n = 1118)		Treatment level				
			BLS (n = 457)		ALS (n = 661)		Chi² p-value
	n	col %	n	row %	n	row %	
Sex							
Female	316	28.3	126	39.9	190	60.1	0.7
Male	802	71.7	331	41.3	471	58.7	
Age							
15–24	229	20.5	84	36.7	145	63.3	0.2
25–34	198	17.7	72	36.4	126	63.6	
35–44	135	12.1	58	43.0	77	57.0	
45–54	202	18.1	80	39.6	122	60.4	
55–64	168	15.0	75	44.6	93	55.4	
65–74	93	8.3	42	45.2	51	54.8	
75–84	93	8.3	46	49.5	47	50.5	
Ethnicity (prioritised)							
Māori	274	24.5	97	35.4	177	64.6	0.03
Non-Māori	842	75.4	360	42.8	482	57.2	
Missing	2						
ISS group							
ISS< 25 (survivable)	680	61.0	318	46.8	362	53.2	< 0.001
ISS 25–49 (potentially survivable)	369	33.1	122	33.1	247	66.9	
ISS ≥ 50 (non-survivable)	66	5.9	15	22.7	51	77.3	
Missing	3						
Traumatic brain injury							
No	839	75.0	363	43.3	476	56.7	0.005
Yes	279	25.0	94	33.7	185	66.3	
Penetrating injury							
No	1010	96.2	418	41.4	592	58.6	< 0.001
Yes	56	5.3	25	44.6	31	55.4	
Missing	52						
Mechanism of injury							
Transport: Motor Vehicle Traffic	665	59.5	246	37.0	419	63.0	0.003
Transport: other	137	12.3	59	43.1	78	56.9	
Fall	151	13.5	82	54.3	69	45.7	
Cut/Pierce	42	3.8	16	38.1	26	61.9	
Firearm	18	1.6	6	33.3	12	66.7	
Natural/ Environmental	9	0.8	4	44.4	5	55.6	
Struck by or against	50	4.5	18	36.0	32	64.0	
Other	40	3.6	21	52.5	19	47.5	
Unspecified/Not recorded	6	0.5	5	83.3	1	16.7	
Location of injury							
Aged care facility	3	0.3	2	66.7	1	33.3	0.1
Farm	58	5.2	26	44.8	32	55.2	
Footpath	23	2.1	14	60.9	9	39.1	
Home	170	15.2	78	45.9	92	54.1	
Public (Other)	112	10.0	48	42.9	64	57.1	
Road	662	59.2	249	37.6	413	62.4	
Workplace	55	4.9	26	47.3	29	52.7	
Other	35	3.1	14	40.0	21	60.0	
Rurality of injury incident							
U1 (most urban)	477	42.9	219	45.9	258	54.1	0.1
U2	188	16.9	73	38.8	115	61.2	
R1	253	22.7	93	36.8	160	63.2	
R2	139	12.5	50	36.0	89	64.0	
R3 (most rural)	56	5.0	20	35.7	36	64.3	
Missing	5						

Injury characteristics

A total of 61 % of patients had a survivable injury (ISS<25) (Table 2). One quarter of patients sustained a traumatic brain injury (TBI). Penetrating injuries were uncommon (5 %). Motor vehicle traffic-related injuries were common, accounting for 60 % of incidents, most occurred on the road (59 %) and in urban areas (60 %). The proportion of patients receiving ALS increased with increasing injury severity (from 53 % in the ISS<25 category to 77 % in the ISS≥50), was higher for those with a TBI and (66 % compared with 57 %, $p = 0.005$) was lower for those with penetrating injuries (55 % compared with 59 %, $p < 0.001$). Except for injuries due to falls, for all other mechanisms of injury, a higher proportion of patients received ALS.

Patient status

Vital signs, indicating clinical concern such as the presence of clinical shock, differed between the patients receiving ALS and BLS (Table 3). Of the patients who experienced clinical shock, 91 % received ALS compared with 9 % who received BLS only. A total of 70 % of patients who had a poor level of consciousness (Glasgow Coma Score ≤8) received ALS.

EMS pathways

Only 6 % of major trauma patients were assigned the highest priority in Computer Aided Dispatch triage indicating a suspected cardiac or respiratory failure, while 45 % were triaged as having an “immediate” threat to life clinical status on-scene (Table 3). Helicopter EMS were involved in 68 % of cases. A higher proportion of patients receiving ALS was observed for those with a high priority Computer Aided Discharge triaged (77 % compared with 58 %, $p = 0.002$), those with a ‘immediate threat to life’ clinical status on scene (70 % compared with 51 %, $p < 0.001$) and those attended by helicopter EMS, (67 % compared with 56 %, $p < 0.001$). The mean activation interval was similar for ALS and BLS patients.

Outcome

Almost all of the cohort (95 %, n = 1066) survived to hospital. Of 52 patients who died prior to arrival at hospital, 73 % (n = 38) received ALS compared with 27 % (n = 14) receiving BLS only ($p = 0.04$). A higher proportion of patients who survived to hospital received ALS than BLS only (58 % compared with 42 %, $p = 0.04$).

Modelling ALS effect

The crude odds ratio (OR) estimated the odds of survival for patients receiving ALS as 0.6 times that of patients receiving BLS only (OR 0.60, 95 % CI 0.32, 1.13) (Table 4).

Following adjustment for ISS, helicopter involvement, and the propensity weights, the odds of survival for patients who received ALS were 1.5 times higher than those receiving BLS only (OR 1.49, 95 % CI 0.66, 3.35). The wide confidence interval indicates there is considerable

Table 3
Patient status on-scene and emergency medical services pathway characteristics of patients stratified by prehospital care received.

Patient vital status and EMS pathway characteristics	All patients (n = 1118)		Treatment level				
			BLS (n = 457)		ALS (n = 661)		Chi^2 p-value
	n	col %	n	row %	n	row %	
Charlson comorbidity index[a]							
0	925	82.7	380	41.1	545	58.9	0.1
1–2	97	8.7	41	42.3	56	57.7	
≥ 3	37	3.3	19	51.4	18	48.7	
Respiratory rate (breaths per minute)[a]							
≤ 9	65	5.8	14	21.5	51	78.4	0.001
10–29	842	75.3	364	43.2	478	56.8	
≥ 30	206	18.4	75	36.4	131	63.6	
Heart rate (beats per minute)[a]							
< 60	102	9.2	36	35.3	66	64.7	0.001
60–130	934	84.1	400	42.8	534	57.2	
> 130	74	6.7	16	21.6	58	78.4	
Systolic blood pressure (mmHg)[a]							
< 90	100	8.9	19	19.0	81	81.0	< 0.001
≥ 90	945	84.5	405	42.9	540	57.1	
Clinical shock[b]							
No	1005	95.0	430	42.8	575	57.2	< 0.001
Yes	53	5.0	5	9.4	48	90.6	
Glasgow Coma Scale score							
≤ 8	289	25.9	88	30.5	201	69.6	< 0.001
> 8	829	74.2	369	44.5	460	55.5	
Highest discharge triage (purple)							
Yes	69	6.2	16	23.2	53	76.8	0.002
No	1049	93.8	441	42.0	608	58.0	
Clinical status at scene							
Immediate threat to life	498	44.5	151	30.3	347	69.7	< 0.001
Other	620	55.5	306	49.4	314	50.6	
Single EMS crew attendance							
No	1116	50	456	20.4	660	29.6	0.8
Yes	2	50.0	1	25.0	1	25.0	
Helicopter EMS involvement							
No	750	67.1	334	44.5	416	55.5	< 0.001
Yes	368	32.9	123	33.4	245	66.6	
	mean	**median**	**mean**	**median**	**mean**	**median**	
Activation interval[c]	5.52	3.57	5.29	3.55	5.68	3.58	0.8

Key
[a] using initial EMS measurements: 59 missing Charlson comorbidity index, 5 missing respiratory rate, 8 missing heart rate, 73 missing systolic blood pressure, 60 missing clinical shock, 21 missing life threatening event
[b] Clinical shock was defined as having an initial or final EMS recorded shock index (heart rate divided by systolic blood pressure) of ≥ 1.4
[c] Time from ambulance call centre phone pick up to time ambulance was dispatched in minutes

Table 4
Odds of survival to first hospital for patients who receive ALS compared with patients receiving BLS following major trauma.

	Count (n)	Odds Ratio (OR)	95 % Confidence Interval (95 % CI)
Crude	1059	0.60	(0.32, 1.13)
Propensity score adjusted	1059	1.56	(0.82, 2.98)
Final adjusted model*	1059	1.49	(0.66, 3.35)

uncertainty with this estimate.

Phase Two: Qualitative results

Thematic analysis of the five interviews conducted with clinical leaders within the EMS ambulance and trauma care sector generated two overarching themes: clinical judgement and the role of evidence. These each had sub-themes, that are directly relevant to the clinical interpretation of the quantitative study findings (Table 5) and are now described in more detail.

Theme 1: Clinical judgement

The provision of ALS was noted as relying on the clinical judgement of EMS clinicians on scene and is informed by training, experience, and scope of practice in conjunction with evidence-informed guidelines to inform decision making on scene. The varying amount of clinical *"leeway"* different EMS clinicians have on-scene was discussed with qualifications and level of training contributing to the scope of practice with those able to deliver interventions classified as ALS receiving more training. Aspects of *"clinical indication"* and *"patient trajectory"* were identified as important factors that inform the provision of ALS on-

Table 5
Selected quotes from qualitative interviews to support the themes.

Theme	Subthemes	Example quotations
Clinical judgement	Qualification level	"…the training of their intensive care, or Critical Care Paramedics is getting better and better. And so as long as they're properly trained, and they are getting sufficient refresher and practical experience, then I don't have any problem with them doing these things."
	Scope of practice	"…there's very little leeway for first responders and EMTs. But there's increasing leeway for Paramedics and a substantial amount of leeway for our Intensive Care Paramedics and our Critical Care Paramedics, on when they choose to do a particular intervention or not."
	Destination hospital choice	"…historically, and I'm talking more than 20 years ago, we pretty much, pretty much always just took patients to the closest hospital. But about 20 years ago, we made a change in that. And we said, you know, the closest hospital was not always the most appropriate hospital. And actually, sometimes you might even use the word often, particularly for major trauma, but also other conditions like stroke and heart attack, the patient actually does better if you take longer to get them to a definitive care hospital. And so, particularly for trauma, and in conjunction with national and regional networks, we spent a lot of time trying to develop a system that gets the patient to the right hospital. Ideally, the first time, whenever it's feasible and safe to do so."
	Decision making at call	"So for every determinant, and there are about 1800 of them. We have predefined in an ideal world, what we would dispatch to that scene. So for example, if we, if this is a determinant with a high rate of very badly injured people, then we will ask that an Intensive Care Paramedic is sent to the scene."
	Decision making on-scene	"…and then the decision is "Do we need to do something now? Because otherwise this patient is not going to survive to hospital. Or can we support the patient, keep them alive, and get them to hospital?"
The role of evidence	Evidence informed practice	"There are very few clinical decisions in medicine, I would, say, you know, there was the best randomised evidence for this, you can, you know, you can ever get, even for stuff we do commonly."
	Equity	"So when we talk about distance to hospital, this is one of the things I think drives inequitable care in New Zealand is, distance to an appropriate hospital or distance to a hospital because not all hospitals are created equal. Not all of them, let's say you've got a traumatic brain injury, if you don't have a neurosurgeon at the hospital that you're rushing to, and you've made that the deciding factor, or do they get a helicopter, or do they get a road ambulance, you've triaged that person out of getting the best possible care. Because it should be about where they're going to get the best possible care, and that should be part of the conversation, which it isn't. Probably outside the remit of what you're looking at, but I think that it should be from the outset. If we're thinking about gold standard, best interventions for patients, we should think about, clearly this person has got a brain injury, they need this, then they need to go to a hospital that can manage that with the best possible outcome."
	Comparison to other countries	"And you know, a hell of a lot of their major trauma is penetrating. A hell of a lot of their major trauma is less than 15 min to hospital. You know, you get major trauma in New York, you're in hospital in less than 15 min, you say, well, probably, unless, unless you're bleeding out of your carotid artery, there's kind of no intervention in 15 min, that's going to make a difference. It's really hard to compare, you know, to compare us with, you know, major trauma in New York, or, or Los Angeles or something like that. In fact, we're probably almost impossible to compare to be honest."

scene. These were described as how rapidly the patient was expected to deteriorate, if the intervention can be performed during transport, or if they were expected to remain stable to hospital. Factors other than clinical indication were also raised as informing provision of ALS on scene, including distance and time to hospital, trauma capability of hospital, and if a helicopter is to be involved with patient transport.

All interviewees felt on-scene clinical judgment in individual situations is the most important aspect in the provision of ALS, therefore it will continue to play an important role in the provision of ALS in the prehospital setting. Interviewees highlighted that connected to clinical judgement are the EMS pathways and processes that exist to guide decision making and the scope of practice of EMS clinicians on scene.

Theme 2: The role of evidence Some interviewees questioned the clinical importance of the quantitative findings. Many reasons for this interpretation were discussed. Interviewees commented that quantitative research within prehospital care is challenging because *"prehospital medicine is messy"*, often reliant on expert clinical opinion when quantitative EMS research produces uncertain estimates which *"include the null"* value. Interviewees stated that the provision of ALS still occurs to minimise sequelae and reduce long term morbidity despite the lack of strong quantitative evidence. Alternative arguments were offered by interviewees that survival to hospital is more indicative of how severe the injury was, rather than a reflection of the pre-hospital EMS care received. It should be noted here that ISS was included in the multivariable model to control for injury severity.

The challenges of comparing the New Zealand prehospital setting with other countries, such as issues of equity was noted by some. Inequities in accessing ALS in rural areas compared to urban areas in New Zealand was raised as a concern, as well as the level of trauma care available at different hospitals, such as the presence or absence of advanced trauma care or a neuroscience centre.

Most of the interviewees shared the view that the quantitative research findings support what is currently happening in the prehospital setting which is driven by clinical judgment on a case-by-case basis. Others mentioned the need to continue to "*strive for balance*" in the provision of ALS, the need for more research on prehospital EMS, and that there has already been a significant financial investment supporting changes in the New Zealand EMS environment towards upskilling EMS clinicians for the provision of ALS when indicated.

Discussion

This novel mixed methods study found a clear clinical position for the ongoing provision of ALS despite continued uncertainty regarding population level survival benefits of ALS compared to BLS for major trauma patients. The quantitative analysis provided no evidence of a statistically significant difference in survival benefit for ALS compared to BLS in the New Zealand context. Estimates within the 95 % confidence interval indicated that although survival rates could be three times higher for trauma patients receiving ALS, they could also be one third lower. In interpreting this finding, qualitative interviews with clinical EMS and trauma care leaders found in the presence of this equivocal quantitative evidence that ALS provision should continue to be based on clinical judgement for perceived clinical and equity benefits to individual patients beyond improved survival outcomes.

Similar to this study, previous research evaluating survival outcomes following ALS for trauma often have a point estimate indicating an ALS benefit with wide confidence intervals including the null value [26–28]. Most analyses comparing survival outcomes compare ALS and BLS providers, rather than the advanced and basic nature of the EMS interventions delivered to patients [29–32]. In this study, ALS and BLS were defined by interventions patients received in the EMS setting. The variation of EMS systems, geography, and type of trauma included (i.e. penetrating versus blunt) across studies makes it difficult to directly compare or generalise our findings with other studies from around the world.

This is the first published study we are aware of using a sequential mixed methods design to qualitatively examine the clinical interpretation of quantitative findings on the efficacy of ALS in EMS settings in New Zealand. This study's combined findings indicate that while the quantitative findings are uncertain, the qualitative findings indicate a clear clinical justification that individual patient survival may depend on ALS and that the benefits of ALS are believed to extend beyond just prevented mortality. At a population level, however, as major trauma only makes up a small caseload of the patients attended by EMS in New Zealand, there is an opportunity cost in having highly skilled EMS clinicians (i.e. Intensive or Critical Care Paramedics) across New Zealand whose high-acuity technical skills are only needed for a small proportion EMS attended events, such as life-threatening incidents including major trauma. This may also have implications on how often these highly skilled EMS clinicians perform ALS interventions on major trauma patients and how they can remain competent, and skilled.

Additional concerns were raised in qualitative interviews about the equitable provision of ALS to patients who may need it in rural areas without ALS trained EMS clinicians and the importance of the level of trauma care provided at the destination hospital. If the focus of an EMS system is on providing the highest level of EMS care at the individual patient level, and clinical judgement deems that the patient needs ALS, access to ALS-trained EMS clinicians or other medical practitioners in rural areas should be improved and maintained to ensure equitable outcomes for rurally located major trauma patients. Ensuring a patient receives the best possible trauma care means they receive appropriate prehospital care (based on the on-scene clinical judgement) and are subsequently rapidly transported to an appropriate destination hospital (based on the on-scene clinical judgement and destination hospital guidelines). Future analyses from this parent cohort will examine the role of rapid transportation to definitive hospital level care on survival following major trauma [5].

Challenges with results that provide no evidence of differences are also present in high quality randomised controlled trials (RCTs) in other areas of EMS research. For example, a recent trial estimated survival with a favourable functional outcome at six months following major trauma with prehospital administration of tranexamic acid (TXA) was uncertain with a risk ratio of 1.00 (95 % CI 0.90, 1.12) [33]. Despite no evidence of any clear benefit current EMS practice in New Zealand includes TXA which can be provided by EMS clinicians based on clinical judgement and TXA availability [15].

This study utilised a mixed methods sequential explanatory design which involved analysing quantitative cohort data, followed by semi-structured interviews to explore the quantitative findings from a clinical perspective allowing for a more comprehensive understanding than could be achieved by using either approach alone [34]. Engagement with key stakeholder providers in the EMS ambulance and trauma sector provided an opportunity to bridge the population level statistical findings with day-to-day EMS clinical practice in New Zealand. In the absence of randomisation to a treatment group, propensity scores enabled a comparison of survival outcomes between patients with similar characteristics with the intent of isolating the effect of ALS on survival to hospital compared to those receiving BLS [35].

The study is limited by several aspects. The sample size for this study was relatively small, missing data further reduced the sample size and mortality was rare (5 % of major trauma cases), contributing to the wide confidence intervals obtained. Although the use of propensity scores is advantageous in making the two treatment groups more comparable, it is limited to balancing only measured confounders thus unmeasured confounders may still be present, such as distance to care [36]. The availability of data from helicopter EMS providers was limited and information about interventions provided during the helicopter transfer was not available, potentially misclassifying those receiving ALS only during helicopter transfer. While senior clinical leaders were interviewed from each of the key stakeholder providers, conducting more interviews with individuals from each provider may have been beneficial in gaining more diverse opinions. This study focused only on survival to hospital, and other outcomes such as disability, quality of life or equity need further examination. The timeliness of these data may limit the generalisability to current practice.

In conclusion, this mixed method study sought to answer if ALS delivered by EMS in the prehospital setting improves survival to hospital and explored the implications of quantitative analyses for EMS practice in New Zealand, involving key EMS and trauma sector stakeholders. Findings were mixed, highlighting the tension between population-level evidence and provision of EMS care based on clinical judgment. While quantitative analysis found no evidence of survival benefits of prehospital ALS compared with BLS for major trauma patients, there was considerable uncertainty in the estimates obtained, whereas qualitative interviews with clinical leaders found clear clinical support for ongoing provision of ALS for its perceived individual equity and clinical benefits. Future research should assess ALS efficacy, considering equity of access and broader outcomes beyond survival, such as disability and quality of life.

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Declaration of Competing Interest

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