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Predicting 2-day mortality in the pre-hospital setting: A retrospective cohort study comparing the New Zealand Early Warning Score (NZEWS) and paramedic triage Status Codes

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Abstract

Objective: To investigate whether the New Zealand Early Warning Score (NZEWS) has greater diagnostic accuracy than current clinical triage Status Codes for predicting 2-day mortality in the Aotearoa New Zealand pre-hospital setting.
Methods: A retrospective cohort study used de-identified data from the Aotearoa New Zealand Paramedic Care Collection. Records from patients attended by the Hato Hone St John ambulance service between 1 July 2022 and 31 December 2022 were screened for eligibility. Included patients were adults ($\geq$15 years) transported to hospital with a complete set of initial vital signs and an initial clinical triage Status Code. NZEWS was applied retrospectively and compared with clinical triage Status Codes for predicting 2-day mortality using area under the receiver operating characteristic curve (AUROC), sensitivity, specificity, positive predictive value and negative predictive value. The optimal NZEWS threshold was identified using the best balance of sensitivity and specificity. Secondary analyses used Chi-square and Mann–Whitney *U* tests to describe demographic differences, while logistic regression examined associations between demographic and contextual factors and 2-day mortality.
Results: The study included 125,278 patients. Both NZEWS and clinical triage Status Codes were strongly associated with 2-day mortality. NZEWS demonstrated superior diagnostic accuracy (AUROC 0.80, 95% CI 0.79–0.81) compared with clinical triage Status Codes (AUROC 0.74, 95% CI 0.73–0.76; DeLong test: $Z = 9.66$, $p < 0.001$). The optimal NZEWS threshold for predicting 2-day mortality was lower than previously reported high-risk thresholds (score of 6), identifying more at-risk patients but increasing over-triage. Older age, Māori and Pacific ethnicity and rurality were independently associated with increased 2-day mortality.
Conclusion: NZEWS outperformed clinical triage Status Codes in predicting 2-day mortality, identifying more at-risk patients at the cost of increased over-triage. NZEWS may support earlier recognition of high-risk patients in the pre-hospital setting, although further research is needed to refine thresholds and guide implementation.

Keywords

early warning score, status codes, mortality, pre-hospital, out of hospital, paramedic, ambulance, emergency services, acuity, deterioration

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Introduction

Emergency Ambulance Service (EAS) personnel often represent the first point of contact for patients and play a vital role in recognising patients at risk of clinical deterioration.[1] Early identification of such patients improves patient outcomes and reduces mortality.[2] However, EAS personnel typically work in unpredictable environments and must make clinical decisions based on limited information and diagnostic tools. Aotearoa New Zealand (AoNZ) EAS operates by necessity with a high level of autonomy, and often without immediate clinical support.[3] Pre-hospital identification of patients at risk of clinical deterioration is complicated, with EAS personnel exhibiting a high level of subjectivity and a lack of consistency.[1] Several studies have reported that these patients are not reliably identified using current screening tools, with mortality risk in patients presenting with medical conditions as opposed to trauma appearing more likely to be underestimated.[4,5]

In the pre-hospital setting in AoNZ, EAS personnel currently categorise the severity of a pre-hospital patient's condition using clinical triage 'Status Codes' as defined in the Clinical Procedures and Guidelines (CPGs).[6] Patients are allocated one of five possible levels of triage (clinical status 0, 1, 2, 3 or 4) based on the attending EAS personnel's clinical judgement, and this informs patient priority, clinical support and transport to ongoing care.[7]

The use of early warning scores (EWS) has become established within the in-hospital setting.[8] EWS help identify clinical deterioration by tracking key physiological indicators such as respiratory rate, oxygen saturation, heart rate, blood pressure, temperature and level of consciousness. Acute changes in these indicators often occur before clinical deterioration.[2] The New Zealand EWS (NZEWS) was introduced into AoNZ hospitals in 2017 after it was recognised that there was a need for a consistent approach to the recognition and response to clinical deterioration.[9] Based on the National EWS (NEWS),[10] the NZEWS assigns a numerical weighting to the patient's vital signs, giving a composite score. This score, or a significant change in a single vital sign, is linked to predefined thresholds that initiate a clinical response.[10]

Although the application of EWS has become increasingly established in the pre-hospital setting, recent research has suggested that pre-hospital EWS does not perform as well as in-hospital EWS for predicting patient mortality.[8] Early mortality, such as 2-day mortality, most closely reflects deterioration from critical illness present during the pre-hospital phase, whereas later outcomes, such as in-hospital or 30-day mortality, may be influenced by inpatient management, comorbidities and end-of-life decisions.[2,11–13] It is not known whether the adoption of the NZEWS in the AoNZ pre-hospital setting would increase diagnostic accuracy for predicting 2-day mortality compared with the current practice of categorising patients by clinical triage Status Codes.

This study aims to investigate whether the NZEWS is more accurate for predicting 2-day mortality in the AoNZ pre-hospital setting than the current use of patient clinical triage Status Codes. Demographic and descriptive variables were collected and summarised; while not a primary focus, their associations with 2-day mortality are reported to provide contextual insight and inform future research directions.

Methods

Study design

This retrospective observational cohort study compared the initial clinical triage Status Code allocated on scene by the attending EAS personnel with the NZEWS score calculated from the first set of vitals taken on scene. The primary outcome investigated was 2-day mortality.

Ethics

Ethics approval for this study was gained from the Auckland University of Technology Ethics Committee (AUTEC Reference: 21/5) with locality approval from Hato Hone St John (HHStJ).

Study setting

The study was conducted in AoNZ. There are two EASs in New Zealand. HHStJ covers approximately 95% of the country, and Wellington Free Ambulance (WFA) covers the Greater Wellington Region, including the Wairarapa.[7]

From January 2020, EAS personnel were formally recognised and registered under the Health Practitioners Competence Assurance Act (2003).[14] All AoNZ EAS personnel (paramedic and above) are required to be registered with and hold an annual practising certificate issued by Te Kaunihera Manapou Paramedic Council.[15] To practice with HHStJ or WFA, EAS personnel also need to obtain and maintain an appropriate Authority to Practice at the level of either First Responder, Emergency Medical Technician (basic life support), Paramedic, Extended Care Paramedic, Intensive Care Paramedic or Critical Care Paramedic (advanced life support).

All practice levels can attend and treat patients, allocate clinical triage Status Codes and make transport decisions. Not all patients assessed by ambulance personnel require transport to hospital and may be discharged at scene, linked to primary care support or transported to other medical facilities.[7] Although the NZEWS is used in AoNZ hospitals, it is not currently included in the CPGs followed by the AoNZ ambulance services.[6]

Participants

The cohort was a convenience sample of HHStJ patients attended over a 6-month period (1 July 2022 through 31 December 2022), whose de-identified records were screened for eligibility.

Inclusion criteria: Adult patients (15 years old or older, as defined by AoNZ Health Service classifications[16]), transported to hospital by road ambulance by HHStJ personnel, with a documented full set of initial clinical observations (as required for the NZEWS calculation), and an initial clinical triage Status Code (on scene).

Exclusion criteria: Inter-hospital transfers (as these patients have been attended by hospital staff), patients attended by HHStJ who were not transported for further treatment, patients deceased on Emergency Medical Services arrival and patients suffering an out-of-hospital cardiac arrest.

Variables

Patient demographic variables included age, sex, ethnicity, deprivation and rurality. Other descriptive variables were the location of the event and case type (trauma or medical). Age was considered a continuous variable. All other variables were considered categorical.

Ethnicity was initially categorised based on the Ministry of Health level 1 prioritised ethnicity guidelines[17] (NZ Māori, Pacific peoples, Asian, Middle Eastern/Latin American/African [MELAA], Others and European). Due to low numbers in the MELAA and Other categories, these were included within the European group, which was designated as European/others.

The New Zealand Deprivation (NZDep) score is a measure of socioeconomic status in AoNZ based on nine variables recorded via the national census[18] relating to income, housing, employment, qualifications, family structure and access to transport and communications.[19] NZDep scores are published for 'meshblocks', which are the smallest area units for statistical purposes in AoNZ.[20] NZDep scores for the meshblock of the patient's residential address were used. For this study, NZDep decile scores were up-grouped into quintiles, where Quintile 1 represents the least deprived 20% of areas, and Quintile 5 represents the most deprived 20% of areas of AoNZ.

Meshblocks were also utilised to determine rurality, using the Geographic Classification for Health definition for the address of the event attended by EAS.[21] The location of the patient was further characterised as either Aged Care Facility, Public, Healthcare Facility, Home or Other.

In AoNZ, the severity of a pre-hospital patient's condition is currently categorised into one of five clinical triage Status Codes based on ambulance paramedics' clinical judgement. These are a numerical estimate of a patient's clinical condition. The status codes are: 0 – dead, 1 – immediate threat to life, 2 – potential threat to life, 3 – unlikely threat to life, 4 – no threat to life. Patients with an initial clinical triage Status Code of 0 were not included in this study as per the exclusion criteria. The initial patient clinical triage Status Code recorded on the Electronic Patient Report Form (ePRF) was used.

The NZEWS was calculated from the first full set of recorded patient observations (respiratory rate, oxygen saturation, temperature, systolic blood pressure, heart rate and level of consciousness.[22] Based on the total NZEWS score, patients were categorised into five colour-coded groups (White 0, Yellow 1–5, Orange 6–7, Red 8–9, Blue ≥10) with White being the lowest risk of deterioration and Blue the highest. A single outlying vital sign triggers grouping into the high-risk Red or Blue groups.[23]

The primary outcome was 2-day mortality from ambulance attendance. This was used in place of 48-h mortality because precise time-of-death data were unavailable. Short-term mortality is commonly used for evaluating pre-hospital EWS research. A 2-day time frame captures delayed early deterioration following emergency department admission, while remaining closely linked to pre-hospital care.[11,13]

Data sources

All EAS in AoNZ use an ePRF. Data recorded on ePRFs by attending EAS personnel are held in a data repository, the Aotearoa New Zealand Paramedic Care Collection (ANZPaCC). Access to and use of the de-identified ANZPaCC dataset is managed by WFA and HHStJ. This study only used data from HHStJ. The ANZPaCC is linked to Manatū Hauora Ministry of Health records, allowing access to additional data such as mortality and ethnicity.[24]

Statistical methods

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) software version 29.0.[25] Categorical variables were described as counts and proportions. Continuous variables were expressed as median (IQR). A Pearson chi-squared test was used to compare the independent categorical variables with 2-day mortality. An Independent-samples Mann–Whitney *U* test was used to compare continuous variables. Cases with missing data were handled using pairwise deletion.

Logistic regression models were used to investigate the relationship between the independent variables and 2-day mortality. Binary logistic regression was used to calculate unadjusted odds ratio (UOR) outcome differences in 2-day mortality. Multiple variable binary regression was used to calculate the adjusted odds ratio (AOR) to identify independent variables associated with 2-day mortality after other predictor variables were controlled. Variables with an UOR p-value of <0.2 were selected for entry into the model to avoid excluding potentially important predictors or confounders before adjustment (age, sex, ethnicity, NZDep, location, case type, initial clinical triage Status Code and initial NZEWS).

The area under the receiver operating characteristic curve (AUROC) was calculated with a 95% confidence interval (95% CI) to assess the overall diagnostic performance of both the initial NZEWS and the initial clinical triage Status Code for predicting 2-day in-hospital mortality. AUROCs were compared using the DeLong test for correlated ROC curves as implemented in the pROC package in R.[26] Youden's index was calculated to establish the optimal cut-off point by determining the maximal value of sensitivity and specificity. At this optimal cut-off, true positives (patients correctly identified as at high risk who died within 2 days), false positives (patients incorrectly identified as high risk who survived beyond 2 days), true negatives (patients correctly identified as low risk who survived beyond 2 days) and false negatives (patients incorrectly identified as low risk who died within 2 days) were determined. Using these values, positive predictive value (PPV), negative predictive value (NPV) and post-test mortality were calculated to quantify the probability that patients classified as high-risk experienced 2-day mortality (PPV and post-test mortality) and the probability that patients classified as low-risk survived beyond 2 days (NPV).

Results

During the 6-month period, a total of 198,065 patients (>15 years of age) were attended by HHStJ. Of these patients, 53% ($n = 125{,}278$) met the inclusion criteria and had a calculable NZEWS (Figure 1). The 2-day mortality rate within the included cohort was 1.2% ($n = 1443$). The patient and clinical characteristics of the NZEWS calculable cohort were similar to those of cases excluded without calculable NZEWS due to missing vital sign measures (Table 1). Clinical triage Status Codes were missing in only a small proportion of cases ($n = 216$).

Patient characteristics

The median age of the cohort was 69 years (IQR 49–81). Patients who died within 2 days were older (median 80 years, IQR 71–88) than those who survived beyond 2 days (median 69 years, IQR 48–81) (Table 2). The cohort was 53.2% female. Most patients were European/other (71.6%), followed by Māori (15.7%), Asian (5.0%) and Pacific peoples (4.9%) (Table 2). The majority of patients were attended in urban regions (77.7%) and at home (73.1%), with the largest proportion residing in the most deprived areas (NZDep Quintile 5, 27.4%) (Table 2).

Increasing age was associated with higher odds of 2-day mortality (AOR 1.04 per year, 95% CI 1.03–1.04; $p < 0.05$) (Supplemental Table 1). Māori and Pacific peoples had higher odds of mortality than European/others (AOR 1.34 and 1.36, respectively; $p < 0.05$), and rural residence was also associated with increased odds (AOR 1.17, 95% CI 1.02–1.33; $p < 0.05$) (Supplemental Table 1). Compared with home, attendance in aged care facilities was associated with higher odds of 2-day mortality (AOR 1.85, 95% CI 1.61–2.13; $p < 0.05$) (Supplemental Table 1). Deprivation was not significantly associated with mortality.

Clinical characteristics

Medical cases accounted for the majority of cases (medical 81.6%, $n = 102{,}216$; trauma 18.4%, $n = 23{,}062$) (Table 3). Trauma patients had 20% reduced odds of 2-day mortality when compared to medical patients (AOR 0.80, 95% CI: 0.65–0.98; $p < 0.05$) (Supplemental Table 2).

The highest proportion of patients were in the initial clinical triage Status Code 3 group (67.8%, $n = 84{,}909$), and the least were in the initial clinical triage Status Code 1 group (2.3%, $n = 2864$) (Table 3). The initial clinical triage Status Code had a significant association with 2-day mortality, with increasing risk of deterioration with decreasing clinical triage Status Code (increasing acuity) ($p < 0.05$; Supplemental Table 2). When compared to patients with an initial clinical triage Status Code of 4 (no threat to life), patients with an initial clinical Status Code of 3 (unlikely threat to life) had 87% greater odds of 2-day mortality (AOR 1.87, 95% CI: 1.20–2.91; $p < 0.05$); patients with an initial clinical Status Code of 2 (potential threat to life had four-fold increased odds of 2-day mortality [AOR 4.22, 95% CI: 2.69–6.60; $p < 0.05$]; and patients with an initial clinical triage Status Code of 1 [immediate threat to life] had 14-fold increased odds of 2-day mortality [AOR 14.13, 95% CI: 8.88–22.48; $p < 0.05$]) (Supplemental Table 2).

Most patients (72.5%) were in the low-risk cohort, with a NZEWS of ≤5 (White, $n = 35{,}364$, 28.2% and Yellow, $n = 55{,}498$, 44.3%) (Table 3). High-risk groups represented 26.1% of the cohort (Red, $n = 20{,}227$, 16.1% and Blue, $n = 12{,}547$, 10.0%) (Table 3). The NZEWS Orange group was the smallest (1.3%, $n = 1642$). The initial NZEWS had a significant association with 2-day mortality, with increasing risk of deterioration with increasing NZEWS categories ($p < 0.05$; Supplemental Table 2). When compared to patients with a NZEWS score of 0 (White category, no deviation from normal vital signs), patients with an initial NZEWS of 1–5 (Yellow category) had nearly a three-fold increased odds of 2-day mortality (AOR 2.91, 95% CI:2.17–3.90; $p < 0.05$); patients with an initial NZEWS of 6–7 (Orange category) had nine-fold increased odds of 2-day mortality (AOR 8.90, 95% CI:5.73–13.80; $p < 0.05$); patients with an initial NZEWS of 8–9 (Red category) had a seven-fold increased odds of 2-day mortality (AOR 6.86 95%CI: 5.13–9.17; $p < 0.05$); and patients with an initial NZEWS of ≥10 (Blue category) had 15 times

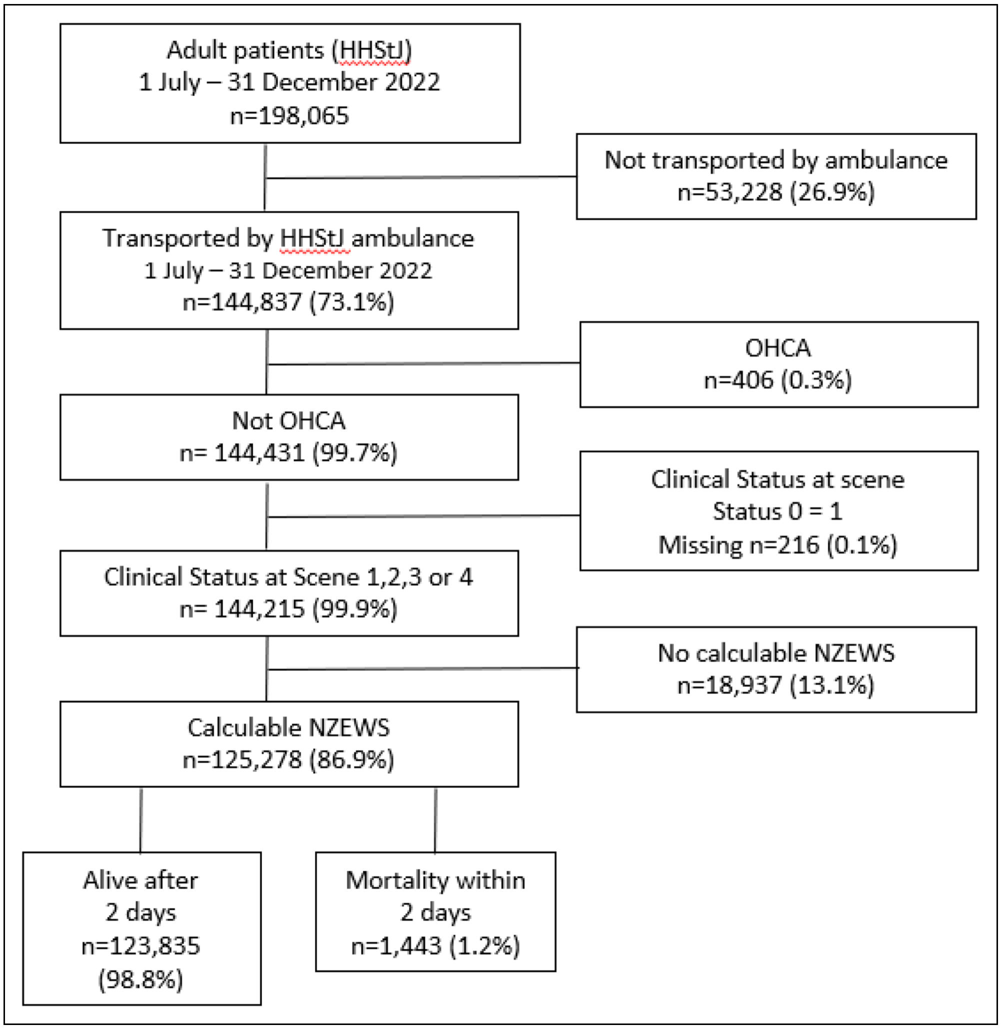

Figure 1. Inclusion and exclusion criteria for cases included in the NZEWS and clinical triage status code analysis. NZEWS: New Zealand Early Warning Score; HHStJ: Hato Hone St John; OHCA: out-of-hospital cardiac arrest.

increased odds of 2-day mortality (AOR 14.67, 95% CI:10.97–19.61; $p < 0.05$) (Supplemental Table 2).

Diagnostic performance of the initial NZEWS and initial clinical triage status code in predicting 2-day mortality

The AUROC analysis demonstrated that NZEWS had superior discriminative performance for predicting 2-day mortality (0.80, 95% CI: 0.79–0.81) compared with the initial clinical Status Codes (0.74, 95% CI: 0.73–0.76) (Figure 2). NZEWS demonstrated greater discrimination for 2-day mortality than clinical triage Status Codes (AUROC 0.803 vs. 0.744). The difference in AUROC was statistically significant (DeLong test: $Z = 9.66$, $p < 0.001$; difference = 0.058, 95% CI: 0.046–0.070).

The initial NZEWS cut-off value that maximised Youden's index for predicting 2-day mortality was 2.5 (equivalent to NZEWS $\geq$ 6, Orange category or higher), with a sensitivity of 0.78 and a specificity of 0.74, corresponding to a Youden's index of 0.51 (Table 4).

The initial clinical triage Status Code cut-off value that maximised Youden's index for predicting 2-day mortality was 2.5 (equivalent to status 1 and 2) with a sensitivity of 0.66 and a specificity of 0.77, corresponding to Youden's index of 0.43 (Table 5).

At these Youden-optimised thresholds, the PPV was 3.5% for NZEWS and 3.3% for clinical triage Status Codes, while the NPV was 99.6% and 99.5%, respectively. For NZEWS, post-test mortality was 3.5% for positive tests and 0.36% for negative tests, compared with 3.3% and 0.53% for clinical triage Status Codes. In absolute terms per 10,000 patients, NZEWS identified 94 true positives and 26 false negatives, with 2569 false positives and 7311 true negatives, whereas clinical triage Status Codes identified 79 true positives and 41 false negatives, with 2280 false positives and 7600 true negatives.

Table 1. Comparison of missing NZEWS cases.

Variable	Calculable NZEWS ($n=125{,}278$; 86.9%)	No calculable NZEWS ($n=18{,}937$; 13.1%)	Total cohort ($n=144{,}215$)
Age, median (IQR) [missing $n=0$]	69, 49–81	58, 34–76	68, 46–81
Missing n = 0			
Sex [missing $n=96$ (0.1%)]			
Female	66,631 (53.2%)	9844 (52.0%)	76,475 (53.1%)
Male	58,567 (46.8%)	9077 (48.0%)	67,644 (46.9%)
Ethnicity [missing $n=4179$ (2.9%)]			
Asian	6284 (5.2%)	870 (4.8%)	7154 (5.1%)
European/Other	89,687 (73.6%)	12,935 (71.2%)	102,622 (73.3%)
NZ Māori	19,713 (16.2%)	3556 (19.5%)	23,249 (16.6%)
Pacific people	6176 (5.1%)	835 (4.6%)	7011 (5.0%)
Deprivation [Missing 2793 (1.9%)]			
Quintile 1 (least deprived)	15,609 (12.7%)	2468 (13.5%)	18,077 (12.8%)
Quintile 2	20,272 (16.5%)	2955 (16.2%)	23,227 (16.4%)
Quintile 3	23,868 (19.4%)	3490 (19.0%)	27,358 (19.3%)
Quintile 4	29,056 (23.6%)	4334 (23.7%)	33,390 (23.6%)
Quintile 5 (most deprived)	34,292 (27.9%)	5078 (27.7%)	39,370 (27.8%)
Rurality [missing $n=163$ (0.1%)]			
Rural	27,796 (22.2%)	4739 (24.9%)	32,535 (22.6%)
Urban	97,366 (77.8%)	14,367 (75.1%)	111,733 (77.4%)
Location [missing $n=1$ (0.0%)]			
Aged care facility	9904 (7.9%)	1098 (5.8%)	11,002 (7.6%)
Healthcare facility	8630 (6.9%)	2523 (13.3%)	11,153 (7.7%)
Home	91,614 (73.1%)	10,466 (55.3%)	102,080 (70.8%)
Other	4553 (3.6%)	1064 (5.6%)	5617 (3.9%)
Public	10,577 (8.4%)	3785 (20.0%)	14,362 (10.0%)
2-day mortality	1443 (1.2%)	316 (1.6%)	1759 (1.2%)
Clinical triage status [missing $n=216$ (0.1%)]			
1	2864 (2.3%)	779 (4.1%)	3643 (2.5%)
2	26,546 (21.2%)	3727 (19.7%)	30,273 (21.0%)
3	84,909 (67.8%)	10,942 (57.8%)	95,851 (66.5%)
4	10,959 (8.7%)	3489 (18.4%)	14,448 (10.0%)
Respiratory rate initial, median (IQR) [Missing $n=708$ (0.5%)]	18, 16–22	18, 16–20	18, 16–22
Oxygen saturation initial, median (IQR) (%) [Missing $n=2596$ (1.8%)]	98, 96–99	98, 96–99	98, 96–99
Use of supplemental oxygen (%) [Missing $n=1643$ (1.1%)			
No	107,932 (86.2%)	15,326 (88.6%)	123,258 (86.5%)
Yes	17,346 (13.8%)	1968 (11.4%)	19,314 (13.5%)
Temperature initial, median (IQR) [Missing $n=16{,}128$ (11.2%)]	36.7, 36.2–37.2	36.6, 36.2–37.1	36.7, 36.2–37.2
Systolic blood pressure initial, median (IQR) [Missing $n=3043$ (2.1%)]	141, 125–160	140, 124–156	140, 125–160
Heart rate initial, median (IQR) [Missing $n=659$ (0.5%)]	85, 72–100	83, 71–98	85, 72–100
Level of consciousness initial (AVPU) [Missing $n=2$ (0.0%)]			
Alert	119,626 (95.5%)	18,059 (95.4%)	137,685 (95.5%)
Not alert	5652 (4.5%)	876 (4.6%)	6529 (4.5%)

NZEWS: New Zealand Early Warning Score; AVPU: alert, responsive to voice, responsive to pain, unresponsive.

Discussion

This large retrospective study ($n=125{,}278$ patients) compared the diagnostic accuracy of the current clinical triage Status Codes with the NZEWS in predicting 2-day mortality. All clinical triage Status Codes of less than clinical triage Status 4 and all NZEWS scores of greater than 0 were associated with increased odds of 2-day mortality. The strongest association was with the most at-risk groups, with initial clinical triage Status 1 and NZEWS blue category

Table 2. Descriptive analysis of patients – patient characteristics.

	Total, all patients with calculable NZEWS		Patients still alive after 2 days		Patients not alive after 2 days		p value*
	n	%	*n*	%	*n*	%	
Total cases	125,278	100.0%	123,835	98.8%	1443	1.2%	
Age [missing *n* = 13 (0.01%)]							
Median and IQR**	69		69		80		<0.05
IQR	49–81		48–81		71–88		
Sex [missing *n* = 56 (0.04%)]							
Female	66,631	53.2%	65,896	53.2%	735	50.9%	0.85
Male	58,567	46.7%	57,860	46.7%	707	49.0%	
Other	24	0.0%	24	0.0%	0	0.0%	
Ethnicity [missing *n* = 3418 (2.7%)]							
Asian	6284	5.0%	6207	5.0%	77	5.3%	0.32
European/others	89,687	71.6%	88,328	71.3%	1059	73.3%	
NZ Māori	19,713	15.7%	19,508	15.8%	205	14.2%	
Pacific peoples	6176	4.9%	6100	4.9%	76	5.3%	
Rurality [missing *n* = 116 (0.09%)]							
Urban	97,366	77.7%	96,250	77.8%	1116	77.4%	0.72
Rural	27,796	22.2%	27,470	22.2%	326	22.6%	
Deprivation Score [missing *n* = 2181 (1.7%)]							
Quintile 1 (least deprived)	15,609	12.5%	15,464	12.5%	145	10.0%	<0.05
Quintile 2	20,272	16.2%	20,045	16.2%	227	15.7%	
Quintile 3	23,868	19.1%	23,576	19.0%	292	20.2%	
Quintile 4	29,056	23.2%	28,679	23.2%	377	26.1%	
Quintile 5 (most deprived)	34,292	27.4%	33,906	27.4%	386	26.7%	
Location [missing ***n* = 1]**							
Aged care fa**cility**	9904	7.9%	9546	7.7%	358	24.8%	<0.05
Other	4553	3.6%	4543	3.7%	10	0.7%	
Public	10,577	8.4%	10,542	8.5%	35	2.4%	
Healthcare facility	8630	6.9%	8583	6.9%	47	3.3%	
Home	91,614	73.1%	90,621	73.2%	993	68.8%	

*$p < 0.05$ is significant; χ^2 test for nominal values.
** Age measured in whole years.
NZEWS: New Zealand Early Warning Score.

patients both having over fourteen times increased odds of 2-day mortality compared with clinical triage Status 4 and NZEWS = 0 (white category), respectively.

NZEWS demonstrated better discrimination for 2-day mortality than clinical triage Status Codes (AUROC 0.80 vs. 0.74; good vs. moderate), indicating improved ability to distinguish between patients who died and those who survived. At the evaluated thresholds, NZEWS identified more true deaths per 10,000 patients (94 vs. 79), meaning clinical triage Status Codes missed approximately 15 additional deaths per 10,000 patients. However, NZEWS also classified more survivors as high risk (2569 vs. 2280), reflecting higher sensitivity at the expense of lower specificity. NPVs were similarly very high for both tools (99.6% vs. 99.5%), consistent with the low mortality prevalence (1.2%) and indicating strong rule-out performance. PPVs were low and comparable (3.5% vs. 3.3%), reflecting the influence of low event prevalence and indicating limited prognostic certainty following a positive result. Thus, the primary distinction between the tools lies in their sensitivity–specificity trade-off rather than predictive values. In the AoNZ pre-hospital setting, greater sensitivity may facilitate earlier recognition of patients at risk of deterioration and support timely escalation of care. However, the lower specificity of NZEWS may increase over-triage, with more patients without imminent risk classified as high acuity, potentially increasing activation of high-acuity pathways, transport to higher-level facilities and downstream impacts on emergency department workload and ambulance availability.[27] By contrast, clinical triage Status Codes produce fewer false positives, which may reduce unnecessary escalation or resource use, but their lower sensitivity means that some high-risk patients may be missed, delaying escalation or appropriate care.[27] Further research should evaluate optimal thresholds and assess how these tools can be integrated into pre-hospital triage pathways to maximise clinical benefit.

Previous research[12,28–36] has suggested that EWS cut-offs that maximise the balance between sensitivity and

Table 3. Descriptive analysis of patients – clinical characteristics.

	Total, all patients with calculable NZEWS		Patients still alive after 2 days		Patients not alive after 2 days		
	N	%	*n*	%	*n*	%	*p* value*
Total cases	125,278	100.0%	123,835	98.8%	1443	1.2%	
Case type [missing *n* = 0]							
Medical	102,216	81.6%	100,883	81.5%	1333	92.4%	<0.05
Trauma	23,062	18.4%	22,952	18.5%	110	7.6%	
Clinical triage status code (initial) [missing *n* = 0]							
1	2864	2.3%	2550	2.1%	314	21.8%	<0.05
2	26,546	21.2%	25,902	20.9%	644	44.6%	
3	84,909	67.8%	84,445	68.2%	464	32.2%	
4	10,959	8.7%	10,938	8.8%	21	1.5%	
NZEWS (initial) [missing *n* = 0] (total EWS initial colour)							
0 (White)	35,364	28.2%	35,309	28.5%	55	3.8%	<0.05
1–5 (Yellow)	55,498	44.3%	55,231	44.6%	267	18.5%	
6–7 (Orange)	1642	1.3%	1608	1.3%	34	2.4%	
8–9 (Red)	20,227	16.1%	19,871	16.0%	356	24.7%	
10+ (Blue)	12,547	10.0%	11,816	9.5%	731	50.7%	

*$p < 0.05$ is significant; χ^2 test for nominal values.
EWS = early warning scores ; NZEWS: New Zealand Early Warning Score.

specificity for detecting short-term mortality in the pre-hospital setting are generally in the high-risk categories (NEWS and NEWS2 score of 7–9), with lower cut-off points often resulting in poor sensitivity and specificity.[8] As these higher EWS scores are reasonably uncommon in the pre-hospital setting, the utility of EWS may be limited.[8] However, in this research, the NZEWS cut-off point that maximised the balance between sensitivity and specificity (Youden's index) to detect 2-day mortality was lower at a NZEWS score of 6 (Orange category). This suggests that the use of the NZEWS may identify a greater number of at-risk patients in the AoNZ pre-hospital setting. The adoption of NZEWS may, therefore, have some benefit in the early identification of at-risk patients in the pre-hospital setting.

The NZEWS would be relatively easy to implement in the current pre-hospital setting: NZEWS is based on vital signs that are typically obtained as part of routine patient assessment and are straightforward to interpret.[37] The methods by which paramedics would calculate the EWS have not been well-researched.[38] To have real value, an EWS needs to be calculated automatically in real time, as this improves speed and accuracy.[38] Training would be required to ensure reliable assessment and appropriate interpretation. NZEWS should be used to support, rather than replace, paramedic clinical judgement, particularly where deterioration may not yet be reflected in abnormal vital signs. These include specific pathologies such as myocardial infarction,[28] older patients, those with multiple comorbidities, and Māori and Pacific peoples.[39] These elements may be incorporated, subjectively and depending on the paramedic's clinical experience, into the current system of clinical triage Status Codes. Integration into electronic patient care records and clear escalation pathways linked to score thresholds may facilitate consistent use, while consideration of the potential for increased over-triage will be important in resource-constrained pre-hospital systems.

Table 4. Initial NZEWS cut-off value for predicting 2-day mortality.

Initial NZEWS	Sensitivity	Specificity	Youden's index
0 (White)	1.00	0.00	0.00
1–5 (Yellow)	0.96	0.28	0.25
6–7 (Orange)	0.78	0.74	0.51
8–9 (Red)	0.75	0.74	0.50
10+ (Blue)	0.51	0.90	0.41
	0.00	1.00	0.00

NZEWS: New Zealand Early Warning Score.

Other factors associated with increased 2-day in-hospital mortality in this study, including older age, Māori and Pacific ethnicity and rural location, highlight potential limitations of a standardised NZEWS. Older patients (>65 years) have altered physiological responses, often showing general deterioration rather than specific changes in vital signs, which reduces the predictive performance of EWS.[40,41] Similarly, Māori and Pacific patients experience higher comorbidities and socioeconomic barriers,[42] and NZEWS may underestimate their risk, potentially contributing to health disparities.[43,44] Mortality is also higher in rural populations, possibly reflecting interactions with age, ethnicity and access to care.[45,46] Although associations between these variables and 2-day mortality do not directly evaluate

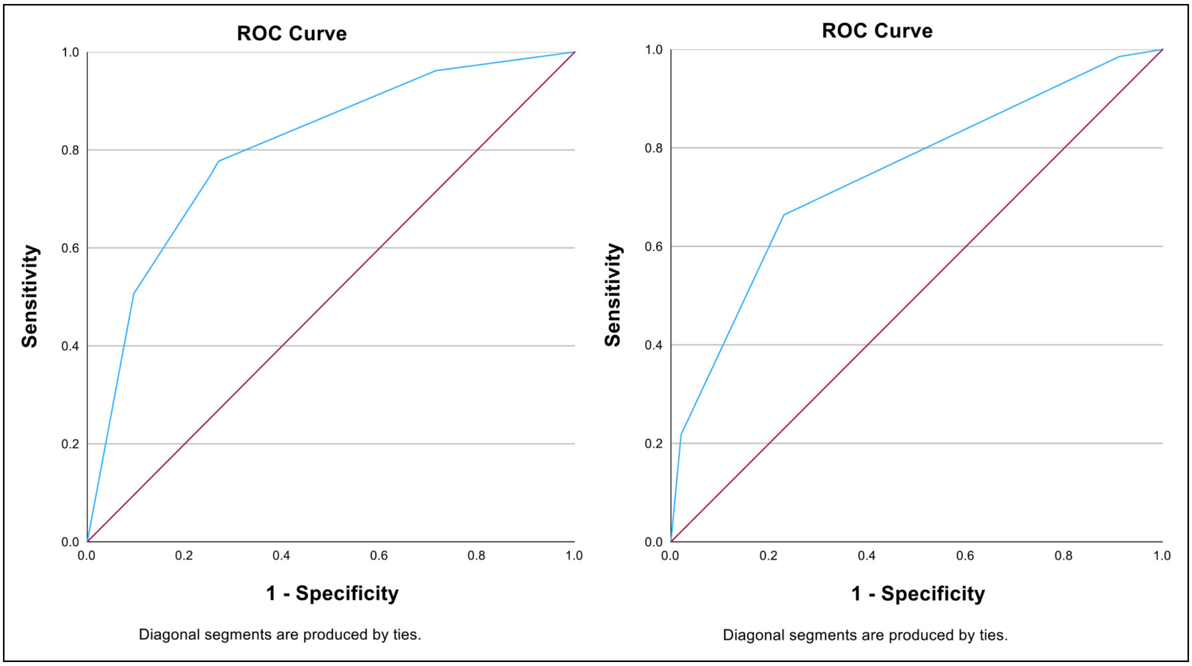

Figure 2. AUROC diagnostic performance of NZEWS and Clinical Triage Status Codes. AUROC: area under the receiver operating characteristics; NZEWS: New Zealand Early Warning Score.

modified NZEWS performance, incorporating age, ethnicity and rurality considerations into NZEWS could improve risk prediction and address inequities in pre-hospital triage. These findings suggest avenues for further research to optimise NZEWS thresholds, explore additional patient-level factors and enhance its utility across diverse populations.

Paramedics are often called upon to make critical clinical decisions in unpredictable and complex environments with limited information and support.[47] Emotional and cognitive stress, along with the fatigue of long hours and shift work, add further challenges to clinical decision-making.[3] It is perhaps in this context that the additional support of an EWS in the pre-hospital setting would add the most benefit.

Limitations

Those patients without a full set of initial vital signs required for calculation of the NZEWS were excluded from the study, leading to a risk of bias in the selected cohort. At the time of this retrospective observational study, pre-hospital clinicians were not required to measure all vital signs needed to calculate a NZEWS during the clinical assessment. A prospective methodology may have reduced the number of missing vital sign observations and therefore reduced the number of excluded patients.

For statistical analysis, the NZEWS were considered in their colour categories rather than continuous numerical scores. This may have limited the conclusions that could be drawn from the data, such as precise cut-off thresholds.

The retrospective use of routinely collected data may have introduced systematic bias. Clinical triage Status Codes incorporate paramedic judgement and may be influenced by contextual pressures and healthcare system factors.

It was not evaluated whether any paramedic interventions had occurred before the first set of vitals was recorded. The vital signs may have been taken at different times depending on the treatment priorities identified by the attending paramedics. Repeat patients (more than one visit by EAS personnel) were included in the study without any particular consideration.

Patients with pre-existing ‘do not resuscitate orders’ or other advance directives were not identifiable in this dataset and thus were included.

Repeat attendances to the same patient were not accounted for, meaning some individual patients may have contributed multiple observations. This may have reduced statistical independence and affected the precision of the estimated association and diagnostic accuracy measures.

Table 5. Initial clinical status code cut-off value for predicting 2-day mortality.

Initial clinical triage status code	Sensitivity	Specificity	Youden's index
	1.00	0.00	0.00
<4	0.99	0.09	0.07
<3	0.66	0.77	0.43
<2	0.22	0.98	0.20
	0.00	1.00	0.00

Although the study period did not coincide with COVID-19 lockdown periods in AoNZ, the pandemic may still have influenced patient case-mix, presentation severity and pre-hospital or hospital care pathways, potentially affecting 2-day mortality and the observed performance of NZEWS and clinical triage Status Codes. This may limit the generalisability of the results. In addition, vaccination mandates were in place, resulting in a predominantly vaccinated population.

Although AUROC is commonly used to assess EWS performance, the low prevalence of 2-day mortality in pre-hospital populations can lead to overestimation of discriminative performance when AUROC is used in isolation. To provide a more clinically meaningful evaluation, additional performance measures (including sensitivity, specificity, predictive values and post-test mortality) were also considered.

Conclusion

This large retrospective study found that NZEWS had higher diagnostic accuracy for predicting 2-day mortality compared with clinical triage Status Codes, though this came with increased over-triage. NZEWS may therefore serve as a valuable adjunct to support the identification of patients at risk of clinical deterioration. Clinical triage Status Codes help limit unnecessary escalation but may miss patients at imminent risk. Future research should explore whether a pre-hospital-focused EWS, optimised thresholds and consideration of patient-level factors could improve predictive performance, enhance equity and support safer, more effective pre-hospital triage. These findings provide a foundation for refining NZEWS and guiding evidence-based implementation in resource-constrained pre-hospital systems.

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Ethical considerations

Ethics approval for this study was gained from the Auckland University of Technology Ethics Committee (AUTEC Reference: 21/5) with locality approval from Hato Hone St John.

Author contribution(s)

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Data availability statement

Due to the nature of this research, supporting data is not available.

Supplemental material

Supplemental material for this article is available online.

References

1. Bourke-Matas E, Bosley E, Smith K, et al. Challenges to recognising patients at risk of out-of-hospital clinical deterioration. *Australas Emerg Care* 2023; 26: 24–29.
2. Patel R, Nugawela MD, Edwards HB, et al. Can early warning scores identify deteriorating patients in pre-hospital settings? A systematic review. *Resuscitation* 2018; 132: 101–111.
3. Perona M, Rahman M and O'Meara P. Paramedic judgement, decision-making and cognitive processing: a review of the literature. *Australas J Paramed* 2019; 16: 1–12.
4. Brown E and Bleetman A. Ambulance alerting to hospital: the need for clearer guidance. *Emerg Med J* 2006; 23: 811–814.
5. Challen K and Goodacre SW. Predictive scoring in non-trauma emergency patients: a scoping review. *Emerg Med J* 2011; 28: 827–837.
6. National Ambulance Sector Working Group. Emergency Ambulance Services Clinical Procedures and Guidelines. 2024 02/03/2024, https://cpg.stjohn.org.nz/tabs/guidelines.
7. Todd VF, Swain A, Howie G, et al. Factors associated with emergency medical service reattendance in low acuity patients not transported by ambulance. *Prehosp Emerg Care* 2022; 26: 66–77.
8. Guan G, Lee CMY, Begg S, et al. The use of early warning system scores in prehospital and emergency department settings to predict clinical deterioration: a systematic review and meta-analysis. *PLoS One* 2022; 17: e0265559.

9. Psirides A, Hill J and Hurford S. A review of rapid response team activation parameters in New Zealand hospitals. *Resuscitation* 2013; 84: 1040–1044.
10. Royal College of Physicians. National Early Warning Score (NEWS): Standardising the assessment of acute-illness severity in the National Health Service. 2012.
11. Hoikka M, Silfvast T and Ala-Kokko TI. Does the prehospital National Early Warning Score predict the short-term mortality of unselected emergency patients? *Scand J Trauma Resusc Emerg Med* 2018; 26: 48–54.
12. Lindskou TA, Ward LM, Søvsø MB, et al. Prehospital early warning scores to predict mortality in patients using ambulances. *JAMA Netw Open* 2023; 6: e2328128.
13. Pirneskoski J, Kuisma M, Olkkola KT, et al. Prehospital national early warning score predicts early mortality. *Acta Anaesthesiol Scand* 2019; 63: 676–683.
14. Manatū Hauora Ministry of Health. Health Practitioners Competence Assurance Act: Manatū Hauora Ministry of Health; 2003 [cited 2023 16 December], https://www.health.govt.nz/our-work/regulation-health-and-disability-system/health-practitioners-competence-assurance-act.
15. Kaunihera Manapou Paramedic Council. Annual Practising Certificate: Kaunihera Manapou Paramedic Council; 2024 [cited 2024 20 January], https://www.paramediccouncil.org.nz/PCNZ/Paramedics/Annual-practising-certificate/PCNZ/2.Paramedics/Annual-practising-certificate.aspx?hkey=821c2c75-e0e8-44be-b2fe-40b17353ff9b.
16. Health MHMo. Overview of the New Zealand Health Survey Methodology: Manatū Hauora Ministry of Health; 2024 [cited 2026 28 April], https://minhealthnz.shinyapps.io/nz-health-survey-2024-25-annual-data-explorer/_w_dae29413bb9040ffb1ebe32624a3f85f/&hash;!/methodology.
17. Ministry of Health. HISO 10001:2017 Ethnicity Data Protocols 2017. In: Health Mo, editor. 2017.
18. Statistics New Zealand. New Zealand Census: Statistics New Zealand; 2018 [cited 2023 10 September]. https://www.stats.govt.nz/topics/census.
19. Atkinson J, Salmond C and Crampton P. *NZDep2013 index of deprivation*. Department of Public Health, 2014.
20. Statistics New Zealand. Census meshblock dataset 2018: Statistics New Zealand; 2018 [cited 2023 25 September], https://datafinder.stats.govt.nz/layer/92199-meshblock-2018-high-definition/.
21. Whitehead J, Davie G, de Graaf B, et al. Defining rural in Aotearoa New Zealand: a novel geographic classification for health purposes. *N Z Med J* 2021; 135: 24–40.
22. Todd VF, Moylan M, Howie G, et al. Predictive value of the New Zealand Early Warning Score for early mortality in low-acuity patients discharged at scene by paramedics: an observational study. *BMJ Open* 2022; 12: e058462.
23. Health Quality and Safety Commission. New Zealand Early Warning Score vital sign chart user guide 2017. Health Quality and Safety Commission; 2017.
24. Kibblewhite C, Todd VF, Howie G, et al. Out-of-hospital emergency airway management practices: a nationwide observational study from Aotearoa New Zealand. *Resuscitation Plus* 2023; 15: 100432.
25. IBM Corporation. SPSS Statistics for Windows (Version 29). 2022.
26. Robin X, Turck N, Hainard A, et al. pROC: an open-source package for R and S+ to analyze and compare ROC curves. *BMC Bioinform* 2011; 12: 77.
27. Kim K and Oh B. Prehospital triage in emergency medical services system: a scoping review. *Int Emerg Nurs* 2023; 69: 101293.
28. Martín-Rodríguez F, Castro-Villamor MÁ, del Pozo Vegas C, et al. Analysis of the early warning score to detect critical or high-risk patients in the prehospital setting. *Intern Emerg Med* 2019; 14: 581–589.
29. Martín-Rodríguez F, López-Izquierdo R, Del Pozo Vegas C, et al. Accuracy of National Early Warning Score 2 (NEWS2) in prehospital triage on in-hospital early mortality: a multi-center observational prospective cohort study. *Prehosp Disaster Med* 2019; 34: 610–618.
30. Martín-Rodríguez F, López-Izquierdo R, Del Pozo Vegas C, et al. A multicenter observational prospective cohort study of association of the prehospital national early warning score 2 and hospital triage with early mortality. *Emerg Med Int* 2019; 2019: 5147808.
31. Martín-Rodríguez F, López-Izquierdo R, del Pozo Vegas C, et al. Can the prehospital national early warning score 2 identify patients at risk of in-hospital early mortality? A prospective, multicenter cohort study. *Heart Lung* 2020; 49: 585–591.
32. Shaw J, Fothergill RT, Clark S, et al. Can the prehospital national early warning score identify patients most at risk from subsequent deterioration? *Emerg Med J* 2017; 34: 533–537.
33. Silcock DJ, Corfield AR, Gowens PA, et al. Validation of the national early warning score in the prehospital setting. *Resuscitation* 2015; 89: 31–35.
34. Hoikka M, Silfvast T and Ala-Kokko TI. Does the prehospital National Early Warning Score predict the short-term mortality of unselected emergency patients? *Scand J Trauma Resusc Emerg Med* 2018; 26: 48.
35. Ruan H, Zhu Y, Tang Z, et al. Modified early warning score in assessing disease conditions and prognosis of 10,517 prehospital emergency cases. *Int J Clin Exp Med* 2016; 9: 14554–8.
36. Semeraro F, Corona G, Scquizzato T, et al. New early warning score: EMS off-label use in out-of-hospital patients. *J Clin Med* 2021; 10. https://doi.org/10.3390/jcm10122617
37. Martín-Rodríguez F, Sanz-García A, Ortega GJ, et al. Tracking the national early warning score 2 from prehospital care to the emergency department: a prospective, ambulance-based, observational study. *Prehosp Emerg Care* 2023; 27: 75–83.
38. Williams TA, Tohira H, Finn J, et al. The ability of early warning scores (EWS) to detect critical illness in the prehospital setting: a systematic review. *Resuscitation* 2016; 102: 35–43.

39. Walsh M and Grey C. The contribution of avoidable mortality to the life expectancy gap in Maori and Pacific populations in New Zealand – a decomposition analysis. *N Z Med J (Online)* 2019; 132: 46–60.
40. Pirneskoski J, Lääperi M, Kuisma M, et al. Ability of prehospital news to predict 1-day and 7-day mortality is reduced in older adult patients. *Emerg Med J* 2021; 38: 913–918.
41. Nissen SK, Candel BG, Nickel CH, et al. The impact of age on predictive performance of national early warning score at arrival to emergency departments: development and external validation. *Ann Emerg Med* 2022; 79: 354–363.
42. Gurney J, Stanley J and Sarfati D. The inequity of morbidity: disparities in the prevalence of morbidity between ethnic groups in New Zealand. *J Comorb* 2020; 10: 2235042X2097116–20971168.
43. Pirret AM and Kazula LM. The impact of a modified New Zealand Early Warning Score (M–NZEWS) and NZEWS on ward patients triggering a medical emergency team activation: a mixed methods sequential design. *Intensive Crit Care Nurs* 2021; 62: 102963.
44. Pirret AM and Kazula LM. Removing modifications to the New Zealand Early Warning Score – does ethnicity matter? A multimethod research design. *Intensive Crit Care Nurs* 2022; 68: 103141.
45. Nixon G, Davie G, Whitehead J, et al. Comparison of urban and rural mortality rates across the lifespan in Aotearoa/New Zealand: a population-level study. *J Epidemiol Community Health* 2023; 77: 571–577.
46. Crengle S, Davie G, Whitehead J, et al. Mortality outcomes and inequities experienced by rural Māori in Aotearoa New Zealand. *Lancet Reg Health West Pac* 2022; 28: 100570.
47. O'Hara R, Johnson M, Siriwardena AN, et al. A qualitative study of systemic influences on paramedic decision making: care transitions and patient safety. *J Health Serv Res Policy* 2015; 20: 45–53.