BMJ Open

Prehospital national early warning score predicts outpatient disposition at the Emergency Department in a Japanese tertiary hospital

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034602
Article Type:	Original research
Date Submitted by the Author:	08-Oct-2019
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Keywords:	Early warning scores, Ambulance, Prehospital

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Takuro Endo; Prehospital NEWS in Japan

Original article

Title of the article

Prehospital national early warning score predicts outpatient disposition at the Emergency Department in a Japanese tertiary hospital

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Word count

Key Message Box: 144 Words

Abstract: 300 Words

Main text: 2,993 words

No of Table: 3

No of Figure: 3

No of Supplementary Table: 8

No of Supplementary figure: 1

No of Reference: 24

Keywords

emergency department

prehospital care

emergency ambulance systems, effectiveness

early warning score

Article summary

- NEWS was developed for in-hospital patients in 2012 and has recently been verified for use in prehospital setting. As a result of prehospital NEWS verification in several countries such as the United Kingdom, it is known that prehospital NEWS predicts death and outpatient disposition (hospitalization or not) with high accuracy.
- In Japan, in-hospital EWS is beginning to be used gradually, but there is no report about use or verification of out-of-hospital EWS. This retrospective study shows in Japan where the aging of the population is extremely advanced, outpatient disposition was predicted with high accuracy by NEWS calculated from vital signs in prehospital setting. This result strengthens universal value of prehospital NEWS not only in a specific country but also in different race and fast-aging countries.
- This study has several limitations. It was a retrospective study conducted in a single center. Therefore, the findings may not be generalizable to all populations in Japan. judgment for deciding the outpatient disposition of each emergency physician is standardized referring to guidelines but does not match exactly.

Abstract

Objectives

The national early warning score (NEWS) was originally developed in the UK to assess hospitalized patients. We examined whether the NEWS can be applied to patients transported by an ambulance in Japan.

Methods

Patients transported to a Japanese tertiary hospital between April 2017 and March 2018 were assessed. The NEWS from vital signs recorded by paramedics was calculated. The emergency department (ED) disposition data were categorized into the following groups: discharged from the ED, admitted to the ward, admitted to the intensive care unit (ICU), or died in the ED. The predictive performance of the NEWS for patient dispositions using receiver operating characteristics curves was assessed. Patient dispositions were compared among NEWS-based categories after adjusting for age, gender, and presence of traumatic injury.

Results

Of the 2,847 patients, the mean (± standard deviation) NEWS of patients who were discharged from the ED (n=1330, 3.7 ± 2.9), admitted to the ward (n=1263,6.3 ± 3.8), admitted to the ICU (n=232, 9.4 ± 4.0), and died in the ED (n=22,11.7 ± 2.9) were statistically different in each group ($p<0.001$). Prehospital NEWS's C-statistics (95% confidence interval; CI) for admission to the ward, admission to the ICU, or death in the ED was 0.73 (0.72-0.75), admission to the ICU or death in the ED was 0.81 (0.78-0.83), and death in the ED was 0.90 (0.87-0.93). After adjusting for age, gender and trauma, the odds ratio (95% CI) of admission to the ICU or death in the ED for the high-risk category (NEWS ≥7) was 13.8 (8.9-21.6) and that for the medium-risk category (NEWS 5–6) was 4.2 (2.5-7.1).

Conclusion

Based on the findings from a Japanese tertiary hospital setting, our study shows that prehospital NEWS can identify patients at risk of adverse outcomes. The NEWS stratification had a strong correlation with patient dispositions.

Takuro Endo; Prehospital NEWS in Japan

Main text

Introduction

Early warning score (EWS) was developed as a guide for a quick assessment and early diagnosis of an acute illness in patients admitted to hospitals.[1] It was intended to serve as a track and trigger tool to make consistent assessments of illness severity as well as to provide useful baseline data to evaluate the patient's clinical progress.[2]

In 2012, The Royal College of Physicians developed the national early warning score (NEWS) to improve early detection rates of clinical deterioration. Initially, the NEWS was used to predict illness severity and deterioration in a hospital setting.[3] Since 2015, it has been implemented across counties in the West of England area, with the aim of computing the NEWS for all patients prior to a referral to an acute care facility.[4] Furthermore, in a previous study, in-depth qualitative interviews with healthcare professionals had been carried out to identify the barriers and facilitators to the implementation of NEWS in prehospital, primary care, and community settings.[5] In this study, participants described that NEWS could support clinical decision-making around the escalation of care, and provide a clear means of communicating clinical acuity between clinicians and across different healthcare organizations.

A recent review showed that very low and high EWS could distinguish between patients who were not likely and those who were likely to deteriorate in the prehospital setting.[6] Some studies have also begun to apply NEWS extensively in prehospital settings and emergency departments.[7-13] Most studies have used mortality as a primary outcome for evaluating prehospital setting NEWS[8-13]. Meanwhile, in 2017, Shaw et al. used subsequent discharge disposition as the primary outcome.[7]

It is not clear how factors, such as health care systems, geographical conditions, and race, affect EWS. Within Asia, three countries—Iran, Hong Kong, and China—have published reports on EWS in prehospital settings[11-13]; however, in Japan, this has never been reported.

While life expectancy in Japan is high, it also faces the problem of an aging society[14]. The proportions of populations aged 65 years and higher in Iran, China, Hong Kong, the UK, and Japan are 5.6%, 9.6%,.6%, 17.8%, and 26.3%, respectively.[15] Given the

rapidly aging society, an increasing number of ambulance deliveries for patients with multiple comorbidities is expected to become more common than before. However, studies evaluating NEWS in prehospital settings in aging countries are limited. Thus, the present study aimed to examine the use of NEWS in the aging society of Japan and its application to emergency transportation.

Method

Patient and public involvement

Patients or the public were not involved in the design of the study.

Setting and population

This observational cohort study was conducted at St Marianna University School of Medicine, a 1,200-bed tertiary teaching hospital in Kawasaki city, Kanagawa prefecture. The Kawasaki city covers a geographical area of 144 km^2, and has a population of 1.5 million people. The number of emergency ambulance transportations in this city is estimated to be 72,000 incidents per year.[16] There are 25 emergency hospitals in the city, of which St. Marianna Medical University Hospital is the biggest one.[17] In principle, it is up to the paramedics to decide which hospital they should transport the patient to, based on the severity of the patient's condition and the distance to the hospital.[18]

Participants

In this study, we enrolled patients transported to our hospital by ambulance between April 2016 and March 2017. The requirement of obtaining patients' informed consent was waived because the data were anonymous. The following patients were excluded: 1) those aged less than 16 years and pregnant, as they are not the subjects according to the original NEWS definition; 2) patients transport from another hospital, as it is not a prehospital setting (this rule was the same for a previous study [10]); 3) cardio-pulmonary arrest (CPA) cases.

Sources of data

Prehospital data and hospital data were collected separately, after which they were integrated. Prehospital data were recorded on a paper by paramedics at the scene, and data on chief complaints and vital signs, including heart rate, respiratory rate, systolic blood pressure, arterial oxygen saturation, temperature, and conscious level, were collected.

Chief complaints were categorized based on the Advanced Medical Priority Dispatch

System (AMPDS) categories as in a previous study [8]. Patients were categorized into the following four groups depending on their disposition, based on a previous study[7]: discharge from the emergency department (ED), admission to the ward, intensive care unit (ICU) admission, or death in the ED.

NEWS

NEWS ranges from 0 to 20. Each vital sign is scored from 0 to 3. When a patient is given supplementary oxygen, two points are added to the total score (Supplementary Table 1).[3] We calculated the total post hoc NEWS from the vital signs.

Statistical analyses

SPSS® Ver.25 (Chicago, IL, USA) was used for statistical analyses. A p-value <0.05 was considered statistically significance. Patients' age, gender, and the presence of traumatic injury were summarized by the four categories based on their ED disposition, and presented the chief complaints made during the ambulance call. Distributions of NEWS were compared between the ED disposition groups using the Kruskal–Wallis test.

We assessed the discriminatory ability of the continuous-scale NEWS to predict patient ED dispositions, using receiver operating characteristics (ROC) curves and the area under the curves (C-statistics). For the ordered nature of the ED disposition outcome (discharge from the ED, ward or ICU admission, or death in the ED), we combined the outcomes as follows: 1) ward or ICU admission, or death in the ED, 2) admission to the ICU or death in the ED and 3) death in the ED, which would provide more interpretable results than analysis of each disposition outcome.

From the ROC curves, we obtained sensitivity and specificity of possible cut-off points that served as coordinate points for the ROC curves, from which possible cut-off values for risk categorization were derived.

Finally, two combined outcomes (ICU admission or death in the ED and death in the ED) were compared among the NEWS-based categories, without and after adjusting for age, gender, and the presence of traumatic injury.

The study protocol was approved by the Institutional Review Board of St. Marianna University, School of Medicine.

Results

Participants' baseline characteristics

The total number of emergency ambulance transportation to the hospital was 5,640 during this study period. After exclusions, 2,847 cases were selected for analyses (Figure 1). Of the 2,847 cases, 1,330 (46.7%) were discharged from the ED, 1,263 (44.4%) were admitted to the ward, 232 (8.1%) were admitted to the ICU, and 22 (0.8%) died in the ED. The mean (±standard deviation) age of the participants was 66.5 ±19.6 years, and the proportion of male participants was 53.5%. The mean ages of patients who were discharged from the ED, admitted to the ward, admitted to the ICU, and those who died in the ED were 63.9 ± 20.3, 68.8 ± 18.8, 68.5 ± 18.7, and 72.6 ± 20.2, respectively. ($p<0.001$;Table 1)

Patients' chief complaints at the time of calling an ambulance were sick calls (19.8%), unconsciousness (13.8%), and breathing difficulty (13.3%) in Table 1. Other chief complaints of the patients at the time of calling an ambulance (Supplementary Table 2) included traumatic injury (8.3%), stroke (7.4%), abdominal pain (6.6%), hemorrhage (5.9%), chest pain (5.9%), headache (4.1%), back pain (3.3%), and drug overdose (3.1%). Furthermore, the chief complaints of each patient disposition group are presented in Table 1 and Supplementary Tables 3–6.

NEWS for each patient disposition group

The boxplots in Figure 2 illustrates the distribution of prehospital NEWSs for each disposition group. As shown in Supplementary Table 7, the median and mean (± standard deviation) NEWSs increased for groups discharged from the ED (3 and 3.7 ± 3.9), admitted to the ward (6 and 6.3 ± 3.8), admitted to ICU (9 and 9.4 ± 4.0), and died in the ED (11.5 and 11.7 ± 2.9). The distributions significantly differed between patient disposition groups according to the Kruskal-Wallis test ($p<0.001$).

Discriminative performance of NEWS in the prehospital setting

Figure 3 shows the ROCs for patient disposition combined outcomes by continuous-scale NEWS. The area under the receiver-operating characteristics (AUROCs) (95% confidence interval [CI]) for prehospital NEWS for ward/ICU admission or death in the ED, ICU admission or death in the ED, and death in the ED were 0.73 (0.72–0.75), 0.81 (0.78–0.83), and 0.90 (0.87–0.93), respectively.

Supplementary Figure 1 also shows the ROCs of the prediction of each patient's disposition—discharged from the ED, admitted to the ward, admitted to the ICU, and died in the ED—using NEWS.

Cut-off NEWSs for clinical risk categories

Based on the coordinate points of the ROC curve (Supplementary Table 8), the "high risk" cut-off was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1-specificity of 0.30 for admission to the ICU or death in the ED), and the "low risk" cut-off was set between 4 and 5 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the ward/ICU admission or death in the ED). Accordingly, we adopted the categorization scheme for low-risk (NEWS≤4), medium-risk (5 or 6), and high-risk (≥7).

Risk category by patient disposition group

Table 2 shows that higher NEWS is associated with deteriorating patient disposition. In the low-risk group (*n*=1,327), the highest proportion of patients were discharged from the ED (*n*=853, 64.3%), followed by those admitted to the ward (*n*=451, 34.0%), admitted to the ICU (*n*=23, 1.7%), and died in the ED (*n*=0, 0%). Conversely, patients in the high-risk group (*n*=979) had a greater probability of being admitted to the ward (*n*=568, 58.0%), being admitted to the ICU (*n*=172, 17.6%), and dying in the ED (*n*=22, 0.8%). Focusing on those who died in the ED, 100% (n=22) of the participants were categorized as high-risk participants.

The relationship between NEWS risk level and outcome

Binary logistic regression models were used to further examine the relationship between the NEWS risk category and the combined patient disposition outcomes (Table 3; note that death in the ED occurred only in the high-risk group, and we did not perform the logistic analysis for death in the ED). ICU admission or death in the ED in the medium-risk group (odds ratio: 4.2, 95% CI: 2.5 to 7.1, p<0.001) and the high risk group (odds ratio: 13.8; 95% CI: 8.9 to 21.6, p<0.001) significantly increased in

comparison to the low-risk group even after adjusting for age, gender, and trauma. Similarly, admission to the ward/the ICU or death in the ED in the medium-risk group (odds ratio: 1.9; 95% CI: 1.6 to 2.4, p<0.001) and the high-risk group (odds ratio: 6.1; 95% CI: 5.0 to 7.3, p<0.001) also increased comparison to the low-risk group.

Discussion

This study aimed to evaluate the efficacy of NEWS to predict patient disposition in prehospital settings. Our findings indicate that prehospital NEWS could identify critical patients and those at risk of adverse outcomes. In recent years, several studies have conducted on prehospital EWS, and four representative reports[7-10] of NEWS have been published. A 2018 study conducted in Finland [10] showed the highest for 12,426 cases in two hospitals using short-term mortality rate as the primary outcome. Only a recent previous study of 287 patients conducted in the UK used patient disposition as the primary outcome.[7] The present study examined 2,847 cases, which is by far largest among studies that used patient disposition as the primary outcome.

The present study found that prehospital NEWS predicted patient disposition in an ED in Japan. Once the patient was categorized as high-risk or medium-risk based on their NEWS, the probability of ICU admission or death in the ED increased. We demonstrated the usefulness of prehospital NEWS in predicting the severity of an illness among participants with different demographic characteristics. Our findings indicate the usefulness of NEWS even for the older population.

Previous studies have used risk category with odds ratios to calculate early death within 24 or 48 hours after hospitalization [8 10]. Our study is the first = in which outpatient clinical outcomes were calculated by risk category with odds ratio. In 2017, a study showed that high-risk patients (those with NEWS ≥7) demonstrated a relatively higher risk for a one-day mortality rate of 101.5 compared to the low-risk group (≤4). Moreover, for medium-risk patients (NEWS 5,6), a greater risk for one-day mortality rate of 4.4 was seen compared to low-risk patients, without adjusting for age, gender and trauma. In our research, the rate of ICU admission or death in the ED in the medium-risk group (odds ratio: 4.2, 95% CI: 2.5 to 7.1, p<0.001) and the high-risk group (odds ratio: 14.0; 95% CI: 9.0 to 21.8, p<0.001) significantly increased in comparison to the low-risk group, without adjusting for age, gender and trauma (Table3).

In a previous study conducted in the UK in 2016, patients who died or were admitted to the ICU had higher NEWS than those admitted to the ward or discharged from the ED. [7] On the other hand, the present study found differences in the mean NEWSs on all segments (Figure2 and Supplementary Table 7). The higher average NEWSs than those in the previous study for all groups could be explained by the fact that data were collected at a tertiary medical institution. Thus, it is appropriate to use an objective scoring system such as NEWS to compare the attributes of patients transported by ambulances.

Further, it is worth noting that the cut-off NEWS in the prehospital setting did not differ from cut-off value for NEWS in the hospital setting.[3] A few studies have reported the validity of the cut-off values for the NEWS in out-hospital settings. In the previous four studies[7-10], patients were categorized into low-, medium-, and high-risk groups, according to the guidelines by the Royal College of Physicians.[3]
According to the definition of NEWS based on in-hospital patients, validation was considered necessary to confirm risk classification for out-of-hospital patients. Thus, ROC curve and specified coordinate points were evaluated. The cut-off NEWSs for prehospital assessment was in line with the definition for in-hospital NEWS prediction (Supplementary Table 8). As medical interventions are not applied in the prehospital environment, cut-off scores for the risk categories will differ from those in an in-hospital environment. Thus, future studies should use larger datasets to confirm this finding.

In Japan, some studies have confirmed the usefulness of EWS in the hospital and triage.[19-22] However, several countries require nationwide in-hospital EWS implementation, and in the UK it has been widely used in prehospital settings, outpatients and emergency services.[4] The paramedics in Japan should directly request the hospital for ambulance acceptance on the scene. In fact, it is often difficult to obtain hospital acceptance for transportation, because the number of transportation has been increasing each year.[17] Furthermore, the duration of making an ambulance call until arrival at the hospital is also gradually increasing.[23 24] This might delay crucial emergency treatments, which in turn might worsen the patient's outcomes. NEWS-based risk stratification helps paramedics understand the severity of the patient's condition and communicate it accurately with a healthcare professional at the hospital. Earlier identification of critical patients might facilitate earlier resuscitation and appropriate critical care.[8]

We used outpatient disposition as the primary outcome in this study. Most previous reports have considered short-term mortality as the primary outcome to assess the usefulness of prehospital NEWS. [6 9 10] As it predicts outpatient outcomes in addition to short-term mortality, the NEWS is a very useful tool. We are also currently analyzing the relationship between prehospital NEWS and mortality rate with more extensive data and exploring the possibility of predicting death more accurately by integrating other factors (chief complaints etc.).

The strengths of this study are as follows. This study is the first in Japan to show that the NEWS can be used in a prehospital setting to predict patient disposition in Japan. Our dataset was much larger compared to those used in previous study[7], which indicates higher reliability. It is noteworthy that the result obtained by calculating the cut-off values for the out-hospital setting is the same as that obtained in the in-hospital setting.

Limitations

This study has several limitations. It was a retrospective study conducted in a single center. Therefore, the findings may not be generalizable to all populations in Japan. Second, judgment for deciding the outpatient disposition of each emergency physician is standardized referring to guidelines but does not match exactly.

Conclusion

Our study suggests the usefulness of NEWS to categorize ED cases at patient's arrival by ambulance. The study also found that elevated NEWS among unselected prehospital patients could predict patient disposition at the ED in Japan. The NEWS has a wide range of uses in prehospital settings. A prospective multicenter study is needed to validate the usefulness of NEWS in the prehospital setting.

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Acknowledgements

We would like to thank our department research assistant Ms. Akiko Hosoyama and our department paramedic Mr. Daigo Ando for their help in collecting the data.

Contributors

TE, KM, SiF and YT conceived the research idea and designed the study. TE, ShF, TN DA and AH collected the data. TE, MT, JT, TN, NS and TS provided statistical advice on study design and analysed the data. TE, AH and SiF chaired the data oversight committee. TE, HCH and TY drafted the first version of the manuscript. TE, SiF and YT takes public responsibility of the contents of this paper.

Funding

This work was jointly funded by St. Marianna University School of Medicine Research Grant 2018 and The Yuumi Memorial Foundation for Home Health Care Grant 2017.

Competing interests

None declared.

Patient consent

Not required.

Ethics approval

The research protocol received approval from the ethics committee of the Institutional Review Board of St Marianna University School of Medicine, No 4325.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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Table 1. Patient characteristics by the patient disposition outcomes.

		Patients' disposition			
	All (n=2,847)	Discharged from the ED (n=1,330)	Admitted to the ward (n=1,263)	Admitted to the ICU (n=232)	Died in the ED (n=22)
Age(years) Mean ± SD	66.5 ± 19.6	63.9 ± 20.3	68.8 ± 18.8	68.5 ± 18.7	72.6 ± 20.2
Male (%)	53.5	49.2	56.1	64.2	50.0
Non-trauma (%)	88.3	85.9	90.4	89.2	100.0
Chief complaint	Sick call (19.8%)	Sick call (24.0%)	Breathing difficulty (17.5%)	Subject unconscious (28.0 %)	Subject unconscious (50.0%)
	Subject unconscious (13.8%)	Traumatic injuries (11.1%)	Sick call (17.4%)	Breathing Difficulty (18.1%)	Sick call (22.7%)
	Breathing difficulty (13.3%)	Breathing difficulty (8.6%)	Subject unconscious (16.0%)	Chest pain/Sick call (8.6%)	Chest pain (13.6%)

ED: emergency department
ICU: intensive care unit
SD: standard deviation

Table 2. Distributions of patient disposition outcomes by risk categories based on NEWS.

NEWS clinical risk level	Patient disposition				
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	All
Low risk (score 0–4)	64.3 % (n=853)	34.0 % (n=451)	1.7 % (n=23)	0.0 % (n=0)	100 % (n=1,327)
Medium risk (score 5–6)	48.1 % (n=260)	45.1 % (n=244)	6.8 % (n=37)	0.0 % (n=0)	100 % (n=541)
High risk (score 7 or more)	22.2 % (n=217)	58.0 % (n=568)	17.6 % (n=172)	2.2 % (n=22)	100 % (n=979)
Total	46.7 % (n=1,330)	44.4 % (n=1,263)	8.1 % (n=232)	0.8 % (n=22)	100 % (n=2,847)

NEWS: national early warning score

ED: emergency department

ICU: intensive care unit

Table 3. Logistic regression analysis for the association between combined patient disposition outcomes and NEWS risk category.

		Unadjusted			Age-, Gender- and Trauma-Adjusted		
	Event %	Odds Ratio	95% CI	p-value	Odds Ratio	95% CI	p-value
Event1. Admission to the ICU or death in the ED							
NEWS risk							
Low	1.7	1.00	ref		1.00	ref	
Medium	6.8	4.16	2.45-7.07	<.0001	4.18	2.46-7.11	<.0001
High	19.8	14.01	9.01-21.77	<.0001	13.83	8.88-21.6	<.0001
Age					1.00	1.00-1.01	0.44
Gender					1.41	1.07-1.86	0.02
Trauma					1.17	0.74-1.85	0.51
Event 2. Admission to the Ward or ICU or death in the ED							
NEWS risk							
Low	35.7	1.00	ref			1.00	ref
Medium	51.9	1.95	1.59-2.38	<.0001	1.94	1.58-2.39	<.0001
High	77.8	6.32	5.24-7.63	<.0001	6.06	5.01-7.33	<.0001
Age					0.99	0.99-0.99	0.00
Gender					0.75	0.64-0.88	0.00
Trauma					1.17	0.91-1.50	0.22

NEWS: national early warning score
CI: confidential interval
ICU: intensive care unit
ED: emergency department

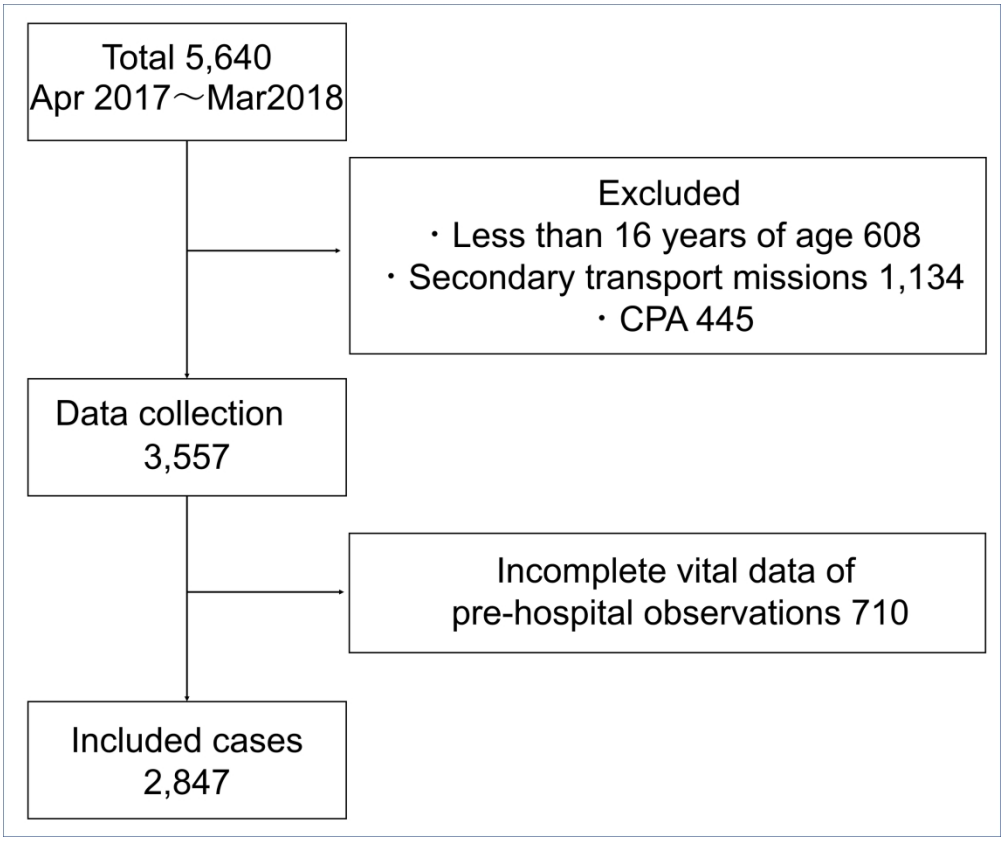


Figure 1. Flow diagram of cases included in the analysis.
CPA: cardio-pulmonary arrest

259x215mm (300 x 300 DPI)

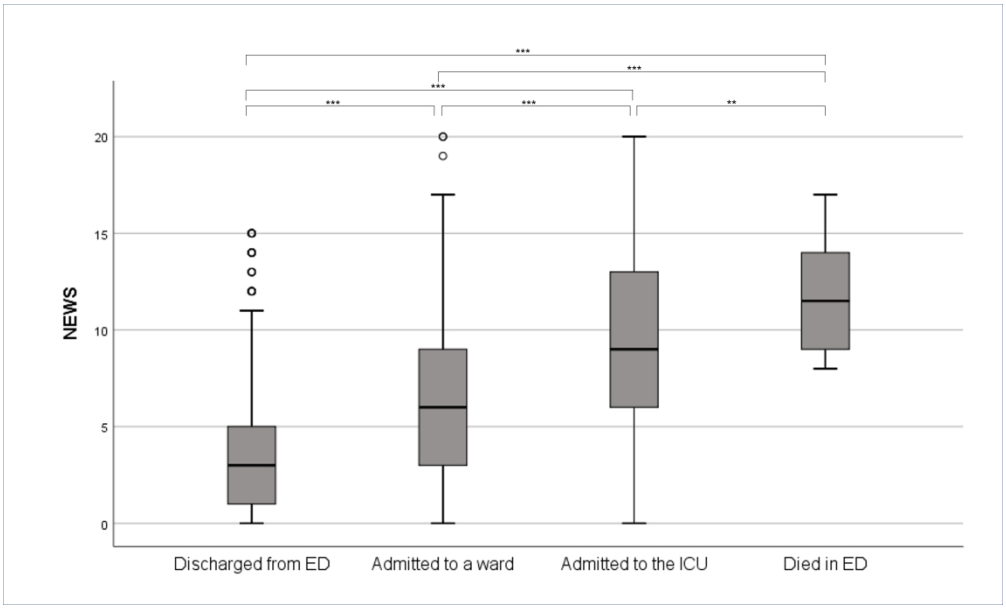


Figure2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxson tests.

NEWS: national early warning score
ED: emergency department
ICU: intensive care unit
** p<0.01, *** p<0.001

479x287mm (300 x 300 DPI)

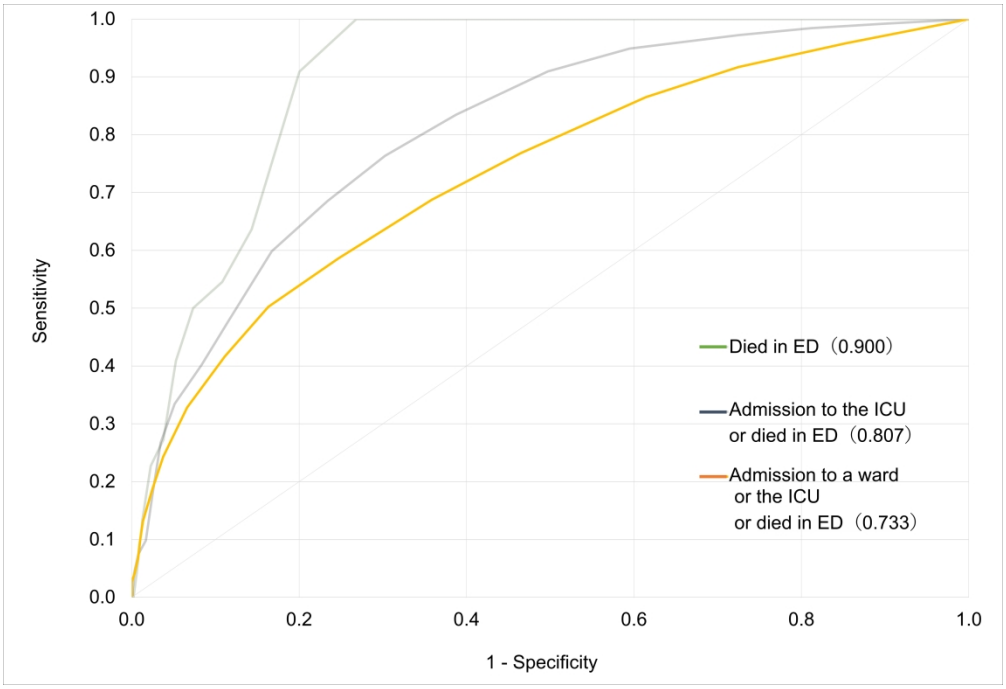


Figure 3.
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.
NEWS: national early warning score
ED: emergency department
ICU: intensive care unit

400x273mm (300 x 300 DPI)

Supplementary Table 1. Scoring system of NEWS.

Physiological parameters	+3	+2	+1	0	+1	+2	+3
Respiration Rate	≦8		9～11	12～20		21～24	25≦
Oxygen Saturations	≦91	92～93	94～95	≧96			
Any Supplemental Oxygen		Yes		No			
Temperature	≦35.0		35.1～36.0	36.1～38.0	38.1～39.0	39.1≦	
Systolic Blood Pressure	≦90	91～100	101～110	111～219			220≦
Heart rate	≦40		41～50	51～90	91～110	111～130	131≦
Level of Consciousness				Alert			V.P.U

NEWS: national early warning score
V: voice responsive
P: pain responsive
U: unconscious

Supplementary Table 2. Breakdown of number of presentation by AMPDS category.

AMPDS category	%	Cases
Sick Call	19.8	564
Subject Unconscious	13.8	392
Breathing Difficulty	13.3	379
Traumatic Injuries	8.3	236
Stroke	7.4	212
Abdominal Pain	6.6	187
Hemorrhage	5.9	169
Chest Pain	5.9	167
Headache	4.1	117
Back Pain	3.3	93
Overdose	3.1	89
Seizures	2.4	68
Heart Problem	1.7	48
Traffic Collision	1.7	48
Choking	0.5	15
Burn Subject	0.4	12
Eye Problem	0.4	11
Psychiatric Problem	0.4	10
Stab Gunshot Penetrating Trauma	0.4	10
Falls	0.2	7
Drowning	0.2	5
Assault	0.1	3
Allergic Reaction	0.1	2
Diabetic Problems	0.1	2
Environmental Exposure	0.0	1
Total	100	2,847

AMPDS: advanced medical priority dispatch system

Supplementary Table 3. Breakdown of number of presentation by AMPDS category among patients discharged from ED (*n* = 1330).

AMPDS category	%	Cases
Sick Call	24.0	319
Traumatic Injuries	11.1	148
Breathing Difficulty	8.6	114
Subject Unconscious	8.6	114
Abdominal Pain	7.5	100
Hemorrhage	7.2	96
Chest Pain	6.3	84
Headache	6.0	80
Stroke	5.1	68
Back Pain	4.1	54
Heart Problem	3.1	41
Seizures	2.8	37
Overdose	2.0	27
Traffic Collision	0.9	12
Eye Problem	0.7	9
Stab Gunshot Penetrating Trauma	0.5	7
Burn Subject	0.5	6
Assault	0.2	3
Choking	0.2	3
Psychiatric Problem	0.2	3
Allergic Reaction	0.2	2
Diabetic Problems	0.1	1
Drowning	0.1	1
Falls	0.1	1
Total	100	1,330

AMPDS: advanced medical priority dispatch system
ED: emergency department

Supplementary Table 4. Breakdown of number of presentation by AMPDS category among patients admitted to a ward (*n* = 1263).

AMPDS category	%	Cases
Breathing Difficulty	17.5	221
Sick Call	17.4	220
Subject Unconscious	16.0	202
Stroke	10.6	134
Traumatic Injuries	6.4	81
Abdominal Pain	5.8	73
Hemorrhage	5.4	68
Chest Pain	4.8	60
Overdose	4.0	51
Headache	2.9	36
Back Pain	2.5	32
Seizures	1.9	24
Traffic Collision	1.7	22
Choking	0.6	8
Heart Problem	0.5	6
Psychiatric Problem	0.5	6
Burn Subject	0.4	5
Falls	0.3	4
Drowning	0.2	3
Stab Gunshot Penetrating Trauma	0.2	3
Eye Problem	0.2	2
Diabetic Problems	0.1	1
Environmental Exposure	0.1	1
Total	100	1,263

AMPDS: advanced medical priority dispatch system

Supplementary Table 5. Breakdown of number of presentation by AMPDS category among patients admitted to the ICU (*n* = 232).

AMPDS category	%	Cases
Subject Unconscious	28.0	65
Breathing Difficulty	18.1	42
Chest Pain	8.6	20
Sick Call	8.6	20
Abdominal Pain	6.0	14
Traffic Collision	6.0	14
Overdose	4.7	11
Stroke	4.3	10
Back Pain	3.0	7
Seizures	3.0	7
Traumatic Injuries	3.0	7
Hemorrhage	2.2	5
Choking	1.7	4
Falls	0.9	2
Burn Subject	0.4	1
Drowning	0.4	1
Headache	0.4	1
Heart Problem	0.4	1
Total	100	232

ICU: intensive care unit

AMPDS: advanced medical priority dispatch system

Supplementary Table 6. Breakdown of number of presentation by AMPDS category among patients died in ED (n = 220).

AMPDS category	%	Cases
Subject Unconscious	50.0	11
Sick Call	22.7	5
Chest Pain	13.6	3
Breathing Difficulty	9.1	2
Psychiatric Problem	4.5	1
Total	100	22

AMPDS: advanced medical priority dispatch system
ED: emergency department

Supplementary Table 7. Summary statistics of prehospital NEWS by patient dispositions.

		Patient disposition			
	All (n=2,847)	Discharged from ED (*n* = 1330)	Admitted to a ward (*n* = 1263)	Admitted to the ICU (*n* = 232)	Died in ED (*n* = 22)
Median	5	3	6	9	11.5
Range	0-20	0-15	0-20	0-20	8-17
Mean±SD	5.4±3.9	3.7±2.9	6.3±3.8	9.4±4.0	11.7±2.9

NEWS: national early warning score
ED: emergency department
ICU: intensive care unit
SD: standard deviation

Supplementary Table 8. Coordinate points of the ROC curves in Figure 2 (main text) with corresponding sensitivity and specificity.

Score	Admitted to a ward or admitted to the ICU or died in ED (C = 0.733)		Admitted to the ICU or died in ED (C = 0.807)		Died in ED (C = 0.900)	
	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity
-1.00	1.000	1.000	1.000	1.000	1.000	1.000
0.50	0.958	0.853	0.992	0.901	1.000	0.908
1.50	0.917	0.725	0.984	0.812	1.000	0.826
2.50	0.865	0.614	0.972	0.726	1.000	0.746
3.50	0.768	0.465	0.949	0.595	1.000	0.623
4.50	0.688	0.359	0.909	0.497	1.000	0.530
5.50	0.586	0.247	0.835	0.388	1.000	0.423
6.50	0.502	0.163	0.764	0.303	1.000	0.339
7.50	0.417	0.111	0.685	0.234	1.000	0.268
8.50	0.328	0.066	0.598	0.167	0.909	0.200
9.50	0.243	0.038	0.476	0.115	0.636	0.143
10.50	0.188	0.025	0.402	0.083	0.545	0.108
11.50	0.132	0.014	0.335	0.051	0.500	0.073
12.50	0.096	0.010	0.268	0.035	0.409	0.053
13.50	0.068	0.008	0.185	0.025	0.273	0.038
14.50	0.042	0.004	0.098	0.017	0.227	0.023

15.50	0.026	0.000	0.075	0.008	0.136	0.013
16.50	0.013	0.000	0.043	0.003	0.045	0.006
17.50	0.004	0.000	0.012	0.001	0.000	0.002
18.50	0.003	0.000	0.004	0.001	0.000	0.001
19.50	0.002	0.000	0.004	0.001	0.000	0.001

ROC: receiver operating characteristics

ED: emergency department

ICU: intensive care unit

Supplementary legend:

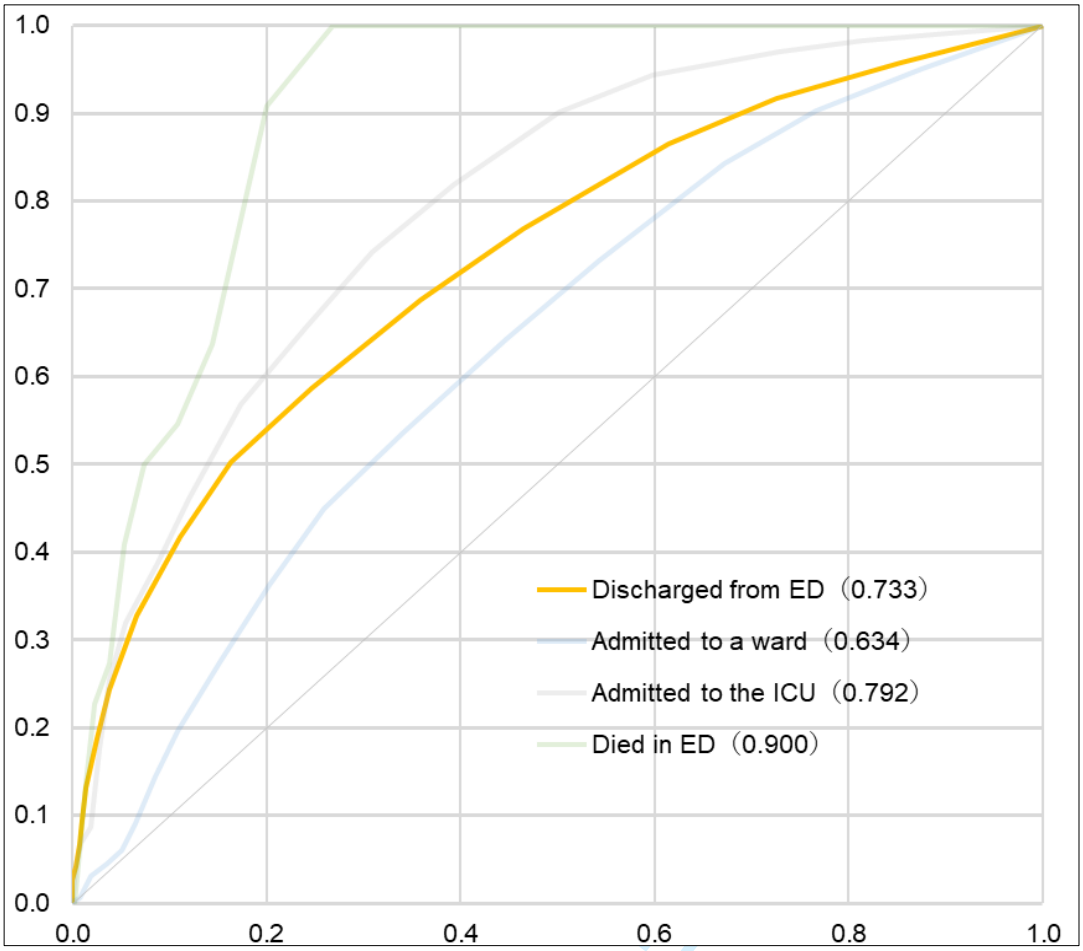
Supplementary Figure 1. The ROC curves of the prediction of NEWS for each patient disposition. Each area under the curve (C-statistic) is depicted in the parenthesis in the graph.

Vertical line: sensitivity
Horizontal line: 1-specificity

ROC: receiver operating characteristic
NEWS: national early warning score
ED: emergency department
ICU: intensive care unit

Takuro Endo; Prehospital NEWS in Japan

Supplementary Figure 1.



BMJ Open

A retrospective study to evaluate the efficacy of prehospital National Early Warning Score to predict outpatient disposition at the Emergency Department in a Japanese tertiary hospital.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034602.R1
Article Type:	Original research
Date Submitted by the Author:	30-Jan-2020
Complete List of Authors:	Endo, Takuro; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Yoshida, Toru; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Shinozaki, Tomohiro; Tokyo University of Science, Department of Information and Computer Technology, Faculty of Engineering Motohashi, Takako; St Marianna University School of Medicine, Department of Preventive Medicine Hsu, Hsiang-Chin; National Cheng Kung University Hospital, Emergency Medicine Fukuda, Shunsuke; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Tsukuda, Jumpei; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Naito, Takaki; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Morisawa, Kenichiro; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Shimozawa, Nobuhiko; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Taira, Yasuhiko; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Fujitani, Shigeki; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine
Primary Subject Heading:	Emergency medicine
Secondary Subject Heading:	Emergency medicine, Medical management
Keywords:	Early warning scores, Ambulance, Prehospital

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Original article

Title of the article

A retrospective study to evaluate the efficacy of prehospital National Early Warning Score to predict outpatient disposition at the Emergency Department in a Japanese tertiary hospital.

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Takuro Endo; Prehospital NEWS in Japan

Word count

Abstract: 300 Words

Key Message Box: 121 Words

Main text: 3,408 words

No of Table: 3

No of Figure: 3

No of Supplementary Table: 4

No of Supplementary figure: 0

No of Reference: 24

Keywords

emergency department

prehospital care

emergency ambulance systems, effectiveness

early warning score

Abstract

Objectives

The National Early Warning Score (NEWS) was originally developed in the United Kingdom to assess hospitalized patients. We examined whether the NEWS can be applied to patients transported by an ambulance in Japan.

Methods

Patients transported to a Japanese tertiary hospital between April 2017 and March 2018 were assessed. The NEWS from vital signs recorded by paramedics was calculated. The emergency department (ED) disposition data were categorized into the following groups: discharged from the ED, admitted to the ward, admitted to the intensive care unit (ICU), or died in the ED. The predictive performance of the NEWS for patient dispositions using receiver operating characteristics curves was assessed. Patient dispositions were compared among NEWS-based categories after adjusting for age, gender, and presence of traumatic injury.

Results

Of the 2,847 patients, the mean (± standard deviation) NEWS of patients who were discharged from the ED (n=1330, 3.7 ± 2.9), admitted to the ward (n=1263,6.3 ± 3.8), admitted to the ICU (n=232, 9.4 ± 4.0), and died in the ED (n=22,11.7 ± 2.9) were statistically different in each group ($p<0.001$). Prehospital NEWS's C-statistics (95% confidence interval; CI) for admission to the ward, admission to the ICU, or death in the ED was 0.73 (0.72-0.75), admission to the ICU or death in the ED was 0.81 (0.78-0.83), and death in the ED was 0.90 (0.87-0.93). After adjusting for age, gender and trauma, the odds ratio (95% CI) of admission to the ICU or death in the ED for the high-risk category (NEWS ≥7) was 13.8 (8.9-21.6) and that for the medium-risk category (NEWS 5–6) was 4.2 (2.5-7.1).

Conclusion

Based on the findings from a Japanese tertiary hospital setting, our study shows that prehospital NEWS can identify patients at risk of adverse outcomes. The NEWS stratification had a strong correlation with patient dispositions.

Strengths and limitations

- This study is a first retrospective study to evaluate the efficacy of prehospital National Early Warning Score (NEWS) calculated from vital signs described by paramedics in Japan.
- Sample number of this study is larger than the prior study; therefore it works as external validation of prehospital NEWS for predicting outpatient disposition at the Emergency Department.
- This study was conducted in an aging society Japan, the result will be helpful when other countries become an aging society.
- This study also examined how adjustment for age, gender, and trauma changed the association between the NEWS risk score and outcomes.
- It was conducted in a single center; therefore, the findings may not be generalizable to all populations in Japan.

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Main text

Introduction

Early warning score (EWS) was developed as a guide for a quick assessment and early diagnosis of an acute illness in patients admitted to hospitals.[1] It was intended to serve as a track and trigger tool to make consistent assessments of illness severity as well as to provide useful baseline data to evaluate the patient's clinical progress.[2]

In 2012, The Royal College of Physicians developed the National Early Warning Score (NEWS) to improve early detection rates of clinical deterioration. Initially, the NEWS was used to predict illness severity and deterioration in a hospital setting.[3] Since 2015, it has been implemented across counties in the West of England area, with the aim of computing the NEWS for all patients prior to a referral to an acute care facility.[4] Furthermore, in a previous study, in-depth qualitative interviews with healthcare professionals had been carried out to identify the barriers and facilitators to the implementation of NEWS in prehospital, primary care, and community settings.[5] In this study, participants described that NEWS could support clinical decision-making around the escalation of care, and provide a clear means of communicating clinical acuity between clinicians and across different healthcare organizations.

A recent review showed that very low and high EWS could distinguish between patients who were not likely and those who were likely to deteriorate in the prehospital setting.[6]Some studies have also begun to apply NEWS extensively in prehospital settings and emergency departments.[7-13] Most studies have used mortality as a primary outcome for evaluating prehospital setting NEWS[8-13]. Meanwhile, in 2017, Shaw et al. used subsequent discharge disposition as the primary outcome.[7]

It is not clear how factors, such as health care systems, geographical conditions, and race, affect EWS. Within Asia, three countries—Iran, Hong Kong, and China—have published reports on EWS in prehospital settings[11-13]; however, in Japan, this has never been reported.

While life expectancy in Japan is high, it also faces the problem of an aging society[14]. The proportions of populations aged 65 years and higher in Iran, China, Hong Kong, the United Kingdom (UK) , and Japan are 5.6%, 9.6%,15.1%,17.8%, and 26.3%,

respectively.[15] Given the rapidly aging society, an increasing number of ambulance deliveries for patients with multiple comorbidities is expected to become more common than before. However, studies evaluating NEWS in prehospital settings in aging countries are limited. Thus, the present study aimed to examine the use of NEWS in the aging society of Japan and its application to emergency transportation.

Method

Patient and public involvement

Patients or the public were not involved in the design of the study.

Setting and population

This observational cohort study was conducted at St Marianna University School of Medicine, a 1,200-bed tertiary teaching hospital in Kawasaki city, Kanagawa prefecture. The Kawasaki city covers a geographical area of 144 km^2 and has a population of 1.5 million people. The number of emergency ambulance transportations in this city is estimated to be 72,000 incidents per year.[16] There are 25 emergency hospitals in the city, of which St. Marianna Medical University Hospital is the biggest one.[17] Between April 2016 and March 2017, the number of patients conveyed by ambulance was 5,640 and the number of walk-in patients was 16,922.

In principle, it is up to the paramedics to decide which hospital they should transport the patient to, based on the severity of the patient's condition and the distance to the hospital.[18]

Participants

In this study, we enrolled patients transported to our hospital by ambulance between April 2016 and March 2017. The requirement of obtaining patients' informed consent was waived because the data were anonymous. The following patients were excluded: 1) those aged less than 16 years and pregnant, as they are not the subjects according to the original NEWS definition; 2) patients transport from another hospital, as it is not a prehospital setting (this rule was the same for a previous study [10]); 3) cardio-pulmonary arrest (CPA) cases.

Sources of data

Prehospital data and hospital data were collected separately, after which they were integrated. Prehospital data were recorded on a paper by paramedics at the scene, and

data on chief complaints and vital signs, including heart rate, respiratory rate, systolic blood pressure, arterial oxygen saturation, temperature, and conscious level, were collected.

Chief complaints were categorized based on the Advanced Medical Priority Dispatch System (AMPDS) categories as in a previous study [8]. However, in Japan, this code was not used in practice. The appropriate code number was added using the chief complaint item of the paper written by the paramedics after transport.

Patients were categorized into the following four groups depending on their disposition, based on a previous study[7]: discharge from the emergency department (ED), admission to the ward, intensive care unit (ICU) admission, or death in the ED.

NEWS

NEWS ranges from 0 to 20. Each vital sign is scored from 0 to 3. When a patient is given supplementary oxygen, two points are added to the total score (Supplementary Table 1).[3] We calculated the total post hoc NEWS from the vital signs.

Statistical analyses

SPSS® Ver.25 (Chicago, IL, USA) was used for statistical analyses. A p-value <0.05 was considered statistically significance. Patients' age, gender, and the presence of traumatic injury were summarized by the four categories based on their ED disposition, and presented the chief complaints made during the ambulance call. Distributions of NEWS were compared between the ED disposition groups using the Kruskal–Wallis test.

We assessed the discriminatory ability of the continuous-scale NEWS to predict patient ED dispositions, using receiver operating characteristics (ROC) curves and the area under the curves (C-statistics). For the ordered nature of the ED disposition outcome (discharge from the ED, ward or ICU admission, or death in the ED), we combined the outcomes as follows: 1) ward or ICU admission, or death in the ED, 2) admission to the ICU or death in the ED and 3) death in the ED, which would provide more interpretable results than analysis of each disposition outcome.

To obtain candidate cut-off values for hospital disposition, we started with Youden's index (sensitivity + specificity - 1). Among the range, we carefully chose high/middle-risk and middle/low-risk cut points that appropriately reflect clinical requirement. Details are

described in the Supplement Table 2.

Finally, two combined outcomes (ICU admission or death in the ED and death in the ED) were compared among the NEWS-based categories, without and after adjusting for age, gender, and the presence of traumatic injury.

The study protocol was approved by the Institutional Review Board of St. Marianna University, School of Medicine.

Results

Participants' baseline characteristics

The total number of emergency ambulance transportation to the hospital was 5,640 during this study period. After exclusions, 2,847 cases were selected for analyses (Figure 1).

Of the 2,847 cases, 1,330 (46.7%) were discharged from the ED, 1,263 (44.4%) were admitted to the ward, 232 (8.1%) were admitted to the ICU, and 22 (0.8%) died in the ED. The mean (±standard deviation) age of the participants was 66.5 ±19.6 years, median age is 73 years (lower to upper quartile: 53-82), with a bimodal (modes around 44 and 82) and asymmetric instead of unimodal, symmetric distribution, and the proportion of male participants was 53.5%. The mean ages of patients who were discharged from the ED, admitted to the ward, admitted to the ICU, and those who died in the ED were 63.9 ± 20.3, 68.8 ± 18.8, 68.5 ± 18.7, and 72.6 ± 20.2, respectively. ($p<0.001$;Table 1)

Patients' chief complaints at the time of calling an ambulance were sick person (19.8%), unconsciousness (13.8%), and breathing difficulty (13.3%) in Table 1. Other chief complaints of the patients at the time of calling an ambulance (Supplementary Table 3) included traumatic injury (8.3%), stroke (7.4%), abdominal pain (6.6%), hemorrhage (5.9%), chest pain (5.9%), headache (4.1%), back pain (3.3%), and drug overdose (3.1%). Furthermore, the chief complaints of each patient disposition group are presented in Table 1 and Supplementary Table 3.

NEWS for each patient disposition group

The boxplots in Figure 2 illustrates the distribution of prehospital NEWSs for each

disposition group. As shown in Supplementary Table 4, the median and mean (± standard deviation) NEWSs increased for groups discharged from the ED (3 and 3.7 ± 3.9), admitted to the ward (6 and 6.3 ± 3.8), admitted to ICU (9 and 9.4 ± 4.0), and died in the ED (11.5 and 11.7 ± 2.9). The distributions significantly differed between patient disposition groups according to the Kruskal-Wallis test ($p<0.001$).

Discriminative performance of NEWS in the prehospital setting

Figure 3 shows the ROC curves for patient disposition combined outcomes by continuous-scale NEWS. The area under the receiver-operating characteristics (AUROCs) (95% confidence interval; CI) for prehospital NEWS for ward/ICU admission or death in the ED, ICU admission or death in the ED, and death in the ED were 0.73 (0.72–0.75), 0.81 (0.78–0.83), and 0.90 (0.87–0.93), respectively.

Cut-off NEWSs for clinical risk categories

Based on the coordinate points of the ROC curve (Supplementary Table 2), the “high risk” cut-off was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1-specificity of 0.30 for admission to the ICU or death in the ED), and the “low risk” cut-off was set between 4 and 5 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the ward/ICU admission or death in the ED). How to choose these values is described in Supplementary Table 2.

Accordingly, we adopted the categorization scheme for low-risk (NEWS≤4), medium-risk (5 or 6), and high-risk (≥7).

Risk category by patient disposition group

Table 2 shows that higher NEWS is associated with deteriorating patient disposition. In the low-risk group (*n*=1,327), the highest proportion of patients were discharged from the ED (*n*=853, 64.3%), followed by those admitted to the ward (*n*=451, 34.0%), admitted to the ICU (*n*=23, 1.7%), and died in the ED (*n*=0, 0%). Conversely, patients in the high-risk group (*n*=979) had a greater probability of being admitted to the ward (*n*=568, 58.0%), being admitted to the ICU (*n*=172, 17.6%), and dying in the ED (*n*=22, 0.8%). Focusing on those who died in the ED, 100% (n=22) of the participants were categorized as high-risk participants.

The relationship between NEWS risk level and outcome

Binary logistic regression models were used to further examine the relationship

between the NEWS risk category and the combined patient disposition outcomes (Table 3; note that death in the ED occurred only in the high-risk group, and we did not perform the logistic analysis for death in the ED). ICU admission or death in the ED in the medium-risk group (odds ratio: 4.2, 95% CI: 2.5 to 7.1, p<0.001) and the high risk group (odds ratio: 13.8; 95% CI: 8.9 to 21.6, p<0.001) significantly increased in comparison to the low-risk group even after adjusting for age, gender, and trauma. Similarly, admission to the ward/the ICU or death in the ED in the medium-risk group (odds ratio: 1.9; 95% CI: 1.6 to 2.4, p<0.001) and the high-risk group (odds ratio: 6.1; 95% CI: 5.0 to 7.3, p<0.001) also increased comparison to the low-risk group.

Discussion

This study aimed to evaluate the efficacy of NEWS to predict patient disposition in prehospital settings. Our findings indicate that prehospital NEWS could identify critical patients and those at risk of adverse outcomes. The aim of this study was not to clarify when to use NEWS to predict outcomes more accurately, but to verify whether the paramedics could determine the severity from vital sign scores at the time of patient contact.

In recent years, several studies have conducted on prehospital EWS, and four representative reports[7-10] of NEWS have been published. A 2018 study conducted in Finland [10] showed the highest for 12,426 cases in two hospitals using short-term mortality rate as the primary outcome. Only a recent previous study of 287 patients conducted in the UK used patient disposition as the primary outcome.[7] The present study examined 2,847 cases, which is by far largest among studies that used patient disposition as the primary outcome.

In this case, there is 20% incomplete data for which no vital signs were obtained. Vital signs of patients transported from Kawasaki City were written on paper by paramedics and we got it. On the other hand, vital signs of patients transported from other areas (Tokyo, Yokohama next to Kawasaki) were not written on the report after transportation. These data could not be allowed to access for the personal privacy. Definitely we excluded 20% of the data for which no vital signs were obtained but the only difference is the area that has been transported and it is presumed to be essentially the same as the other 80% of patients.

The present study found that prehospital NEWS predicted patient disposition in an ED in Japan. Once the patient was categorized as high-risk or medium-risk based on their NEWS, the probability of ICU admission or death in the ED increased. We demonstrated the usefulness of prehospital NEWS in predicting the severity of an illness among participants with different demographic characteristics. Our findings indicate the usefulness of NEWS even for the older population.

It has been confirmed that prehospital NEWS fully predicts outpatient disposition even in an aging society, such as in Japan. Addition to our result and following the results of previous studies predicting outpatient disposition in the UK and other countries, these results suggest that prehospital NEWS might be available globally. It suggests that NEWS could be used when countries become an aging society like Japan in the future.

Previous studies have used risk category with odds ratios to calculate early death within 24 or 48 hours after hospitalization [8 10]. Our study is the first study in which outpatient clinical outcomes were calculated by risk category with odds ratio. In 2017, a study[7] showed that high-risk patients (those with NEWS ≥7) demonstrated a relatively higher risk for a one-day mortality rate of 101.5 compared to the low-risk group (≤4). Moreover, for medium-risk patients (NEWS 5,6), a greater risk for one-day mortality rate of 4.4 was seen compared to low-risk patients, without adjusting for age, gender and trauma.

In our research, the rate of ICU admission or death in the ED in the medium-risk group (odds ratio: 4.2, 95% CI: 2.5 to 7.1, p<0.001) and the high-risk group (odds ratio: 14.0, 95% CI: 9.0 to 21.8, p<0.001) significantly increased in comparison to the low-risk group, without adjusting for age, gender and trauma (Table3).

This study also examined how adjustment for age, gender, and trauma changed the association between the NEWS risk score and outcomes. The results of the analysis shown in Table 3 suggest that the use of the NEWS risk score with or without considering age, gender and trauma was clinically useful.

In a previous study conducted in the UK in 2016, patients who died or were admitted to the ICU had higher NEWS than those admitted to the ward or discharged from the ED. [7] On the other hand, the present study found differences in the mean NEWSs on all segments (Figure2 and Supplementary Table 4). The higher average NEWSs than

those in the previous study for all groups could be explained by the fact that data were collected at a tertiary medical institution. Thus, it is appropriate to use an objective scoring system such as NEWS to compare the attributes of patients transported by ambulances.

Further it is worth noting that the cut-off NEWS in the prehospital setting did not differ from cut-off value for NEWS in the hospital setting.[3] A few studies have reported the validity of the cut-off values for the NEWS in out-hospital settings. In the previous four studies[7-10], patients were categorized into low-, medium-, and high-risk groups, according to the guidelines by the Royal College of Physicians.[3]

According to the definition of NEWS based on in-hospital patients, validation was considered necessary to confirm risk classification for out-of-hospital patients. Thus, ROC curve and specified coordinate points were evaluated. The cut-off NEWSs for prehospital assessment was in line with the definition for in-hospital NEWS prediction (Supplementary Table 2). As medical interventions are not applied in the prehospital environment, cut-off scores for the risk categories will differ from those in an in-hospital environment. Thus, future studies should use larger datasets to confirm this finding.

In Japan, some studies have confirmed the usefulness of EWS in the hospital and triage.[19-22] However, several countries require nationwide in-hospital EWS implementation, and in the UK it has been widely used in prehospital settings, outpatients and emergency services.[4] The paramedics in Japan should directly request the hospital for ambulance acceptance on the scene. In fact, it is often difficult to obtain hospital acceptance for transportation, because the number of transportation has been increasing each year.[17] Furthermore, the duration of making an ambulance call until arrival at the hospital is also gradually increasing.[23 24] This might delay crucial emergency treatments, which in turn might worsen the patient's outcomes. NEWS-based risk stratification helps paramedics understand the severity of the patient's condition and communicate it accurately with a healthcare professional at the hospital. Earlier identification of critical patients might facilitate earlier resuscitation and appropriate critical care.[8]

We used outpatient disposition as the primary outcome in this study. Most previous reports have considered short-term mortality as the primary outcome to assess the usefulness of prehospital NEWS. [6 9 10] As it predicts outpatient outcomes in addition to

short-term mortality, the NEWS is a very useful tool.

We are also currently analyzing the relationship between prehospital NEWS and mortality rate with more extensive data and exploring the possibility of predicting death more accurately by integrating other factors (chief complaints etc.). This study is the first step towards implementation of prehospital NEWS as a prehospital triage tool. In Japan there is no triage tool in the prehospital setting. The Japan Triage and Acuity Scale (JTAS) is currently used in the outpatient setting but it does not assume an emergency site. Aiming for using prehospital NEWS as a triage tool, additional analysis of “false positive” and “false negative” would be required. It is necessary to clarify what kind of cases are "Go home despite high score" and "ICU hospitalization despite low score". Next step we will analyze these data.

The strengths of this study are as follows. This study is the first in Japan to show that the NEWS can be used in a prehospital setting to predict patient disposition in Japan. Our dataset was much larger compared to those used in previous study[7], which indicates higher reliability. It is noteworthy that the result obtained by calculating the cut-off values for the out-hospital setting is the same as that obtained in the in-hospital setting.

Limitations

This study has several limitations. It was a retrospective study conducted in a single center. Therefore, the findings may not be generalizable to all populations in Japan. Second, judgment for deciding the outpatient disposition of each emergency physician is standardized referring to guidelines but does not match exactly.

Conclusion

Our study suggests the usefulness of NEWS to categorize ED cases at patient’s arrival by ambulance. The study also found that elevated NEWS among unselected prehospital patients could predict patient disposition at the ED in Japan. The NEWS has a wide range of uses in prehospital settings. A prospective multicenter study is needed to validate the usefulness of NEWS in the prehospital setting.

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Acknowledgements

We would like to thank our department research assistant Ms. Akiko Hosoyama and our department paramedic Mr. Daigo Ando for their help in collecting the data.

Contributors

TE, KM, SiF and YT conceived the research idea and designed the study. TE, ShF, TN collected the data. TE, MT, JT, TN, NS and TS provided statistical advice on study design and analysed the data. TE and SiF chaired the data oversight committee. TE, HCH and TY drafted the first version of the manuscript. TE, SiF and YT takes public responsibility of the contents of this paper.

Funding

This work was jointly funded by St. Marianna University School of Medicine Research Grant 2018 and The Yuumi Memorial Foundation for Home Health Care Grant 2017.

Competing interests

None declared.

Patient consent

Not required.

Ethics approval

The research protocol received approval from the ethics committee of the Institutional Review Board of St Marianna University School of Medicine, No 4325.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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Table 1. Patient characteristics by the patient disposition outcomes.

	All (n=2,847)		Patients' disposition							
			Discharged from the ED (n=1,330)		Admitted to the ward (n=1,263)		Admitted to the ICU (n=232)		Died in the ED (n=22)	
Age (years) Mean±SD	66.5 ± 19.6		63.9 ± 20.3		68.8 ± 18.8		68.5 ± 18.7		72.6 ± 20.2	
Male (%)	53.5		49.2		56.1		64.2		50	
Non-trauma (%)	88.3		85.9		90.4		89.2		100	
Chief complaint *	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases
Sick person	19.8	564	24	319	17.4	220	8.6	20	22.7	5
Subject unconscious	13.8	392	8.6	114	16	202	28	65	50	11
Breathing difficulty	13.3	379	8.6	114	17.5	221	18.1	42	9.1	2
Traumatic injuries	8.3	236	11.1	148	6.4	81	3	7	0	0
Chest pain	5.9	167	6.3	84	4.8	60	8.6	20	13.6	3

* A list of chief complaint containing the top three in each category

ED: emergency department

ICU: intensive care unit

SD: standard deviation

Table 2. Distributions of patient disposition outcomes by risk categories based on NEWS.

NEWS clinical risk level	Patient disposition				
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	All
Low risk (score 0–4)	64.3 % (n=853)	34.0 % (n=451)	1.7 % (n=23)	0.0 % (n=0)	100 % (n=1,327)
Medium risk (score 5–6)	48.1 % (n=260)	45.1 % (n=244)	6.8 % (n=37)	0.0 % (n=0)	100 % (n=541)
High risk (score 7 or more)	22.2 % (n=217)	58.0 % (n=568)	17.6 % (n=172)	2.2 % (n=22)	100 % (n=979)
Total	46.7 % (n=1,330)	44.4 % (n=1,263)	8.1 % (n=232)	0.8 % (n=22)	100 % (n=2,847)

NEWS: National Early Warning Score

ED: emergency department

ICU: intensive care unit

Table 3. Logistic regression analysis for the association between combined patient disposition outcomes and NEWS risk category.

		Unadjusted			Age-, Gender- and Trauma-Adjusted		
	Event %	Odds Ratio	95% CI	p-value	Odds Ratio	95% CI	p-value
Event1. Admission to the ICU or death in the ED							
NEWS risk							
Low	1.7	1.00	ref		1.00	ref	
Medium	6.8	4.16	2.45-7.07	<.0001	4.18	2.46-7.11	<.0001
High	19.8	14.01	9.01-21.77	<.0001	13.83	8.88-21.6	<.0001
Age					1.00	1.00-1.01	0.44
Gender					1.41	1.07-1.86	0.02
Trauma					1.17	0.74-1.85	0.51
Event 2. Admission to the Ward or ICU or death in the ED							
NEWS risk							
Low	35.7	1.00	ref			1.00	ref
Medium	51.9	1.95	1.59-2.38	<.0001	1.94	1.58-2.39	<.0001
High	77.8	6.32	5.24-7.63	<.0001	6.06	5.01-7.33	<.0001
Age					0.99	0.99-0.99	0.00
Gender					0.75	0.64-0.88	0.00
Trauma					1.17	0.91-1.50	0.22

NEWS: National Early Warning Score

CI: confidential interval

ICU: intensive care unit

ED: emergency department

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Figure legend/caption

Figure 1.
Flow diagram of cases included in the analysis.

CPA: cardio-pulmonary arrest

Figure2.
Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxson tests.

NEWS: National Early Warning Score
ED: emergency department
ICU: intensive care unit
** p<0.01, *** p<0.001

Figure 3.
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined
disposition.

NEWS: National Early Warning Score
ED: emergency department
ICU: intensive care unit

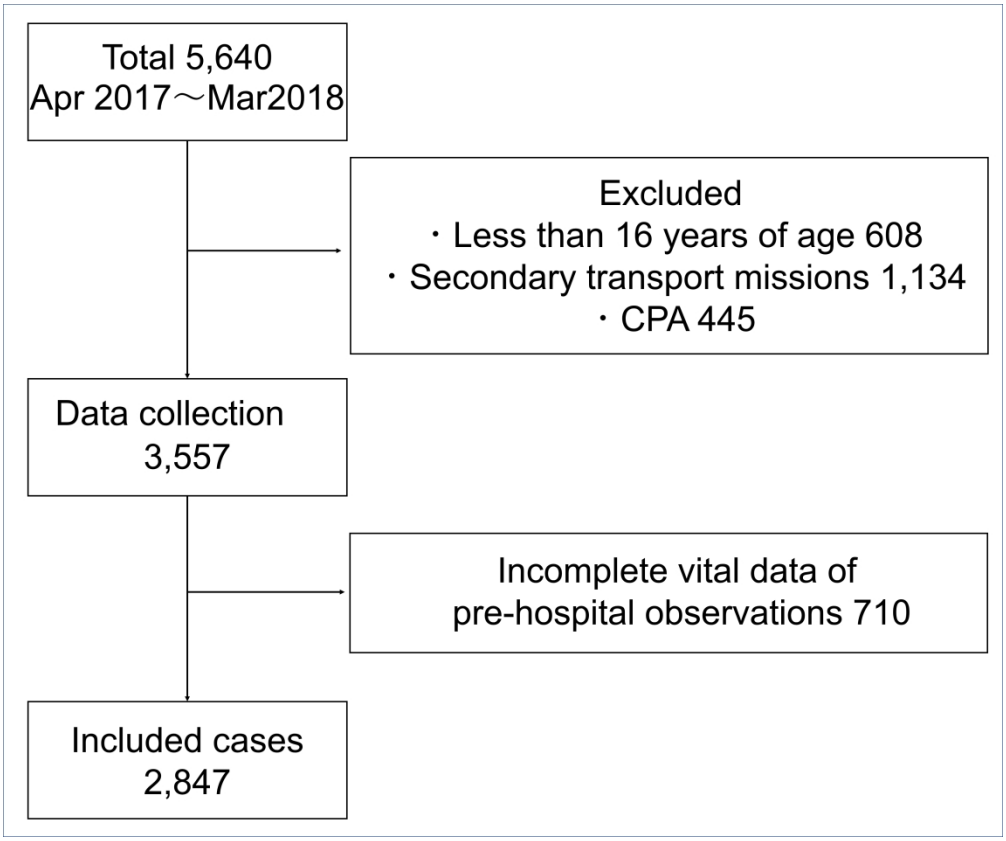

Figure 1. Flow diagram of cases included in the analysis.
CPA: cardio-pulmonary arrest

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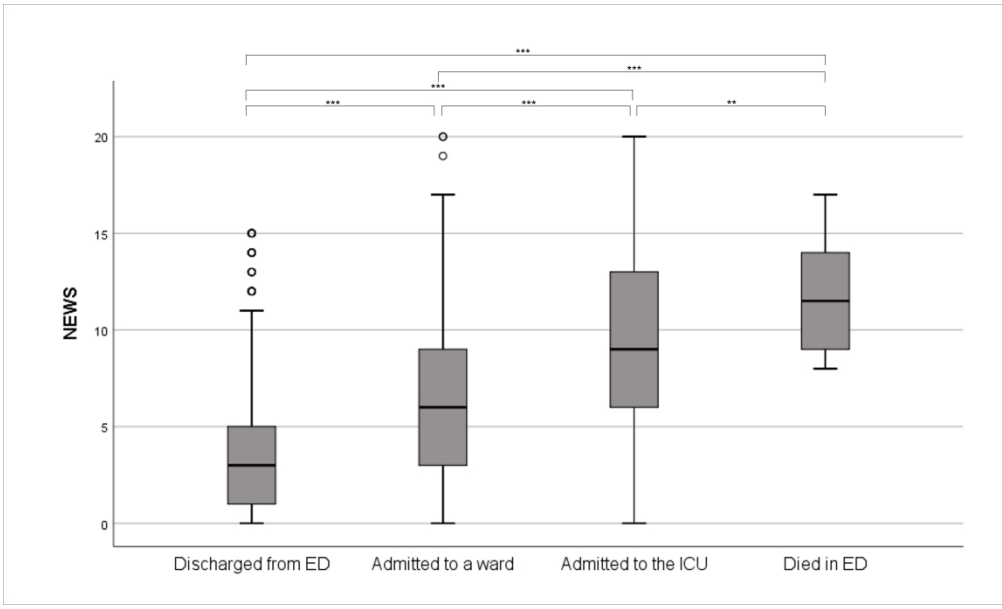

Figure2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxson tests.

NEWS: national early warning score
ED: emergency department
ICU: intensive care unit
** p<0.01, *** p<0.001

479x287mm (350 x 350 DPI)

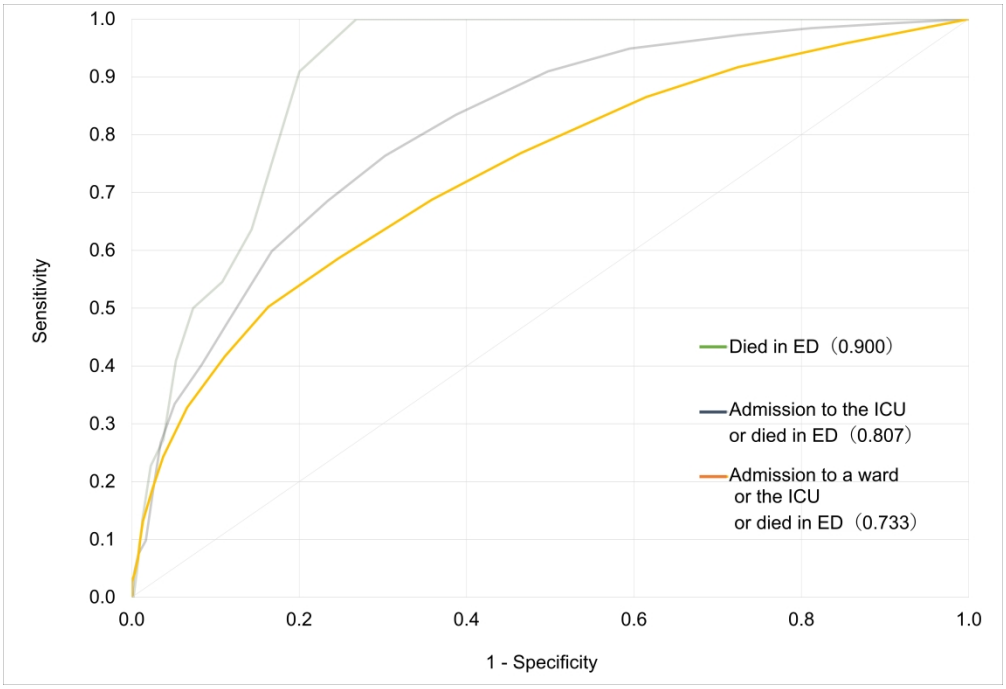

Figure 3.
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.
NEWS: national early warning score
ED: emergency department
ICU: intensive care unit

400x273mm (350 x 350 DPI)

Supplementary Table 1. Scoring system of NEWS.

Physiological parameters	+3	+2	+1	0	+1	+2	+3
Respiration Rate	≦8		9～11	12～20		21～24	25≦
Oxygen Saturations	≦91	92～93	94～95	≧96			
Any Supplemental Oxygen		Yes		No			
Temperature	≦35.0		35.1～36.0	36.1～38.0	38.1～39.0	39.1≦	
Systolic Blood Pressure	≦90	91～100	101～110	111～219			220≦
Heart rate	≦40		41～50	51～90	91～110	111～130	131≦
Level of Consciousness				Alert			V.P.U

NEWS: National Early Warning Score

V: voice responsive

P: pain responsive

U: unconscious

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Supplementary Table 2. Coordinate points of the ROC curves in Figure 2 (main text) with corresponding sensitivity and specificity.

Score	Admitted to a ward or admitted to the ICU or died in ED (C = 0.733)		Admitted to the ICU or died in ED (C = 0.807)		Died in ED (C = 0.900)	
	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity
-1.00	1.000	1.000	1.000	1.000	1.000	1.000
0.50	0.958	0.853	0.992	0.901	1.000	0.908
1.50	0.917	0.725	0.984	0.812	1.000	0.826
2.50	0.865	0.614	0.972	0.726	1.000	0.746
3.50	0.768	0.465	0.949	0.595	1.000	0.623
4.50	0.688	0.359	0.909	0.497	1.000	0.530
5.50	0.586	0.247	0.835	0.388	1.000	0.423
6.50	0.502	0.163	0.764	0.303	1.000	0.339
7.50	0.417	0.111	0.685	0.234	1.000	0.268
8.50	0.328	0.066	0.598	0.167	0.909	0.200
9.50	0.243	0.038	0.476	0.115	0.636	0.143
10.50	0.188	0.025	0.402	0.083	0.545	0.108
11.50	0.132	0.014	0.335	0.051	0.500	0.073
12.50	0.096	0.010	0.268	0.035	0.409	0.053
13.50	0.068	0.008	0.185	0.025	0.273	0.038
14.50	0.042	0.004	0.098	0.017	0.227	0.023
15.50	0.026	0.000	0.075	0.008	0.136	0.013

16.50	0.013	0.000	0.043	0.003	0.045	0.006
17.50	0.004	0.000	0.012	0.001	0.000	0.002
18.50	0.003	0.000	0.004	0.001	0.000	0.001
19.50	0.002	0.000	0.004	0.001	0.000	0.001

ROC: receiver operating characteristics
ED: emergency department
ICU: intensive care unit

Because there is no principled statistical criterion for selecting an optimal cutoff point without information on "cost", we carefully chose the cut points (4.5 and 6.5) from the combinations of three sets of sensitivity and 1 - specificity presented in Supplement Table 4 from a clinical practice viewpoint. As a starting point, we calculated Youden's index, which is defined as a difference between sensitivity and 1 - specificity, or "sensitivity + specificity - 1"; we found the following values to be considered as candidate cut points for NEWS:

	Youden's index		
Cut point	Ward/ICU/Death	ICU/Death	Death
3.5	0.303	0.354	0.377
4.5	0.329	0.412	0.47
5.5	0.339	0.447	0.577
6.5	0.339	0.461	0.661
7.5	0.306	0.451	0.732
8.5	0.262	0.431	0.709

For a "high/middle-risk" cut point, sensitivity for death and ICU admission is crucial. Among the values lower than 7.5 (sensitivity of 1 for death), we chose a value 6.5 because relatively higher sensitivity of ICU admission or death (about 3/4, or 75%).

Next, we considered that a "middle/low-risk" cut point should have had high sensitivity for a ward admission and minimal degree of specificity, e.g., over 50%-60%. Such points may be 3.5 or 4.5; we chose 4.5 because it has a better balance of sensitivity and specificity for ICU admission, too.

Supplementary Table 3. Breakdown of number of presentations by AMPDS category.

All patients			Discharged from ED			Admitted to a ward			Admitted to the ICU			Died in ED		
Category	%	Cases	Category	%	Cases	Category	%	Cases	Category	%	Cases	Category	%	Cases
Sick Person	19.8	564	Sick Person	24	319	Breathing Difficulty	17.5	221	Subject Unconscious	28	65	Subject Unconscious	50	11
Subject Unconscious	13.8	392	Traumatic Injuries	11.1	148	Sick Person	17.4	220	Breathing Difficulty	18.1	42	Sick Person	22.7	5
Breathing Difficulty	13.3	379	Breathing Difficulty	8.6	114	Subject Unconscious	16	202	Chest Pain	8.6	20	Chest Pain	13.6	3
Traumatic Injuries	8.3	236	Subject Unconscious	8.6	114	Stroke	10.6	134	Sick Person	8.6	20	Breathing Difficulty	9.1	2
Stroke	7.4	212	Abdominal Pain	7.5	100	Traumatic Injuries	6.4	81	Abdominal Pain	6	14	Psychiatric Problem	4.5	1
Abdominal Pain	6.6	187	Hemorrhage	7.2	96	Abdominal Pain	5.8	73	Traffic Collision	6	14	-	-	-
Hemorrhage	5.9	169	Chest Pain	6.3	84	Hemorrhage	5.4	68	Overdose	4.7	11	-	-	-
Chest Pain	5.9	167	Headache	6	80	Chest Pain	4.8	60	Stroke	4.3	10	-	-	-
Headache	4.1	117	Stroke	5.1	68	Overdose	4	51	Back Pain	3	7	-	-	-
Back Pain	3.3	93	Back Pain	4.1	54	Headache	2.9	36	Seizures	3	7	-	-	-
Overdose	3.1	89	Heart Problem	3.1	41	Back Pain	2.5	32	Traumatic Injuries	3	7	-	-	-
Seizures	2.4	68	Seizures	2.8	37	Seizures	1.9	24	Hemorrhage	2.2	5	-	-	-

Heart Problem	1.7	48	Overdose	2	27	Traffic Collision	1.7	22	Choking	1.7	4	-	-	-
Traffic Collision	1.7	48	Traffic Collision	0.9	12	Choking	0.6	8	Falls	0.9	2	-	-	-
Choking	0.5	15	Eye Problem	0.7	9	Heart Problem	0.5	6	Burn Subject	0.4	1	-	-	-
Burn Subject	0.4	12	Stab Gunshot Penetrating	0.5	7	Psychiatric Problem	0.5	6	Drowning	0.4	1	-	-	-
Eye Problem	0.4	11	Burn Subject	0.5	6	Burn Subject	0.4	5	Headache	0.4	1	-	-	-
Psychiatric Problem	0.4	10	Assault	0.2	3	Falls	0.3	4	Heart Problem	0.4	1	-	-	-
Stab Gunshot Penetrating	0.4	10	Choking	0.2	3	Drowning	0.2	3	-	-	-	-	-	-
Falls	0.2	7	Psychiatric Problem	0.2	3	Stab Gunshot Penetrating	0.2	3	-	-	-	-	-	-
Drowning	0.2	5	Allergic Reaction	0.2	2	Eye Problem	0.2	2	-	-	-	-	-	-
Assault	0.1	3	Diabetic Problems	0.1	1	Diabetic Problems	0.1	1	-	-	-	-	-	-
Allergic Reaction	0.1	2	Drowning	0.1	1	Environmental Exposure	0.1	1	-	-	-	-	-	-
Diabetic	0.1	2	Falls	0.1	1	-	-	-	-	-	-	-	-	-

Problems														
Environmental Exposure	0	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	100	2847	Total	100	1330	Total	100	1263	Total	100	232	Total	100	22

Supplementary Table 4. Summary statistics of prehospital NEWS by patient dispositions.

		Patient disposition			
	All (n=2,847)	Discharged from ED (*n* = 1330)	Admitted to a ward (*n* = 1263)	Admitted to the ICU (*n* = 232)	Died in ED (*n* = 22)
Median	5	3	6	9	11.5
Range	0-20	0-15	0-20	0-20	8-17
Mean±SD	5.4±3.9	3.7±2.9	6.3±3.8	9.4±4.0	11.7±2.9

NEWS: National Early Warning Score

ED: emergency department

ICU: intensive care unit

SD: standard deviation

TRIPOD Checklist: Prediction Model Validation

Section/Topic	Item	Checklist Item	Page
Title and abstract			
Title	1	Identify the study as developing and/or validating a multivariable prediction model, the target population, and the outcome to be predicted.	P1
Abstract	2	Provide a summary of objectives, study design, setting, participants, sample size, predictors, outcome, statistical analysis, results, and conclusions.	P4
Introduction			
Background and objectives	3a	Explain the medical context (including whether diagnostic or prognostic) and rationale for developing or validating the multivariable prediction model, including references to existing models.	P6
	3b	Specify the objectives, including whether the study describes the development or validation of the model or both.	P6-7
Methods			
Source of data	4a	Describe the study design or source of data (e.g., randomized trial, cohort, or registry data), separately for the development and validation data sets, if applicable.	P7-8
	4b	Specify the key study dates, including start of accrual; end of accrual; and, if applicable, end of follow-up.	P7
Participants	5a	Specify key elements of the study setting (e.g., primary care, secondary care, general population) including number and location of centres.	P7
	5b	Describe eligibility criteria for participants.	P7
	5c	Give details of treatments received, if relevant.	None
Outcome	6a	Clearly define the outcome that is predicted by the prediction model, including how and when assessed.	P8-9
	6b	Report any actions to blind assessment of the outcome to be predicted.	None
Predictors	7a	Clearly define all predictors used in developing or validating the multivariable prediction model, including how and when they were measured.	P8-9
	7b	Report any actions to blind assessment of predictors for the outcome and other predictors.	P8-9
Sample size	8	Explain how the study size was arrived at.	P7
Missing data	9	Describe how missing data were handled (e.g., complete-case analysis, single imputation, multiple imputation) with details of any imputation method.	P11
Statistical analysis methods	10c	For validation, describe how the predictions were calculated.	P8-9
	10d	Specify all measures used to assess model performance and, if relevant, to compare multiple models.	P8-9
	10e	Describe any model updating (e.g., recalibration) arising from the validation, if done.	P8-9
Risk groups	11	Provide details on how risk groups were created, if done.	P8-9
Development vs. validation	12	For validation, identify any differences from the development data in setting, eligibility criteria, outcome, and predictors.	P8-9
Results			
Participants	13a	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful.	P9
	13b	Describe the characteristics of the participants (basic demographics, clinical features, available predictors), including the number of participants with missing data for predictors and outcome.	P9
	13c	For validation, show a comparison with the development data of the distribution of important variables (demographics, predictors and outcome).	P9-10
Model performance	16	Report performance measures (with CIs) for the prediction model.	P10-11
Model-updating	17	If done, report the results from any model updating (i.e., model specification, model performance).	None
Discussion			
Limitations	18	Discuss any limitations of the study (such as nonrepresentative sample, few events per predictor, missing data).	P14
Interpretation	19a	For validation, discuss the results with reference to performance in the development data, and any other validation data.	P11-12
	19b	Give an overall interpretation of the results, considering objectives, limitations, results from similar studies, and other relevant evidence.	P11-13
Implications	20	Discuss the potential clinical use of the model and implications for future research.	P14
Other information			
Supplementary information	21	Provide information about the availability of supplementary resources, such as study protocol, Web calculator, and data sets.	P15
Funding	22	Give the source of funding and the role of the funders for the present study.	P15

We recommend using the TRIPOD Checklist in conjunction with the TRIPOD Explanation and Elaboration document.

BMJ Open

A retrospective study to evaluate the efficacy of prehospital National Early Warning Score to predict outpatient disposition at the Emergency Department in a Japanese tertiary hospital.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034602.R2
Article Type:	Original research
Date Submitted by the Author:	11-Mar-2020
Complete List of Authors:	Endo, Takuro; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Yoshida, Toru; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Shinozaki, Tomohiro; Tokyo University of Science, Department of Information and Computer Technology, Faculty of Engineering Motohashi, Takako; St Marianna University School of Medicine, Department of Preventive Medicine Hsu, Hsiang-Chin; National Cheng Kung University Hospital, Emergency Medicine Fukuda, Shunsuke; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Tsukuda, Jumpei; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Naito, Takaki; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Morisawa, Kenichiro; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Shimozawa, Nobuhiko; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Taira, Yasuhiko; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Fujitani, Shigeki; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine
Primary Subject Heading:	Emergency medicine
Secondary Subject Heading:	Emergency medicine, Medical management
Keywords:	Early warning scores, Ambulance, Prehospital

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Original article

Title of the article

A retrospective study to evaluate the efficacy of prehospital National Early Warning Score to predict outpatient disposition at the Emergency Department in a Japanese tertiary hospital

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Takuro Endo; Prehospital NEWS in Japan

Word count

Abstract: 299 Words

Key message box: 124 Words

Main text: 3,466 words

No. of Tables: 3

No. of Figures: 3

No. of Supplementary Tables: 4

No. of Supplementary Figures: 0

No. of References: 24

Keywords: Emergency department, prehospital care, emergency ambulance systems, effectiveness, early warning score

Abstract

Objectives

The National Early Warning Score (NEWS) was originally developed in the United Kingdom to assess hospitalized patients. We examined whether the NEWS can be applied to patients transported by an ambulance in Japan.

Methods

Patients transported to a Japanese tertiary hospital between April 2017 and March 2018 were assessed and the NEWS recorded by paramedics was calculated. Emergency department (ED) disposition data were categorized into the following groups: discharged from the ED, admitted to the ward, admitted to the intensive care unit (ICU), or died in the ED. The predictive performance of the NEWS for patient disposition using receiver operating characteristic curves was assessed. Patient dispositions were compared among NEWS-based categories after adjusting for age, gender, and presence of traumatic injury.

Results

Of the 2,847 patients, the mean (± standard deviation) NEWS of patients who were discharged from the ED (n=1,330, 3.7 ± 2.9), admitted to the ward (n=1,263,6.3 ± 3.8), admitted to the ICU (n=232, 9.4 ± 4.0), and died in the ED (n=22,11.7 ± 2.9) were statistically different in each group ($p < 0.001$). Prehospital NEWS's C-statistics (95% confidence interval ;CI) for admission to the ward, admission to the ICU, or death in the ED was 0.73 (0.72–0.75), admission to the ICU or death in the ED was 0.81 (0.78–0.83), and death in the ED was 0.90 (0.87–0.93). After adjusting for age, gender, and trauma, the odds ratio (95% CI) of admission to the ICU or death in the ED for the high-risk category (NEWS ≥ 7) was 13.8 (8.9–21.6), and that for the medium-risk category (NEWS 5–6) was 4.2 (2.5–7.1).

Conclusion

Based on the findings from a Japanese tertiary hospital setting, our study shows that prehospital NEWS can identify patients at risk of adverse outcomes. The NEWS stratification had a strong correlation with patient disposition.

Strengths and limitations

- This study is the first retrospective study to evaluate the efficacy of the prehospital National Early Warning Score (NEWS) calculated from vital signs described by paramedics in Japan.
- The sample number in this study was larger than that in the previous study; therefore, it functions as an external validation of prehospital NEWS for predicting outpatient disposition at the Emergency Department.
- This study was conducted in an aging society in Japan, and the results will likely be generalizable to other aging societies.
- This study also examined how adjustment for age, gender, and trauma changed the association between the NEWS and outcomes.
- Since the study was conducted in a single center, the findings may not be generalizable to all Japanese populations.

Takuro Endo; Prehospital NEWS in Japan

Main text

Introduction

The early warning score (EWS) was developed as a guide for quick assessment and early diagnosis of an acute illness in patients admitted to hospitals.[1] It was intended to serve as a track and trigger tool to make consistent assessments of illness severity, as well as to provide useful baseline data to evaluate the patient's clinical progress.[2]

In 2012, The Royal College of Physicians developed the National Early Warning Score (NEWS) to improve early detection rates of clinical deterioration. Initially, the NEWS was used to predict illness severity and deterioration in a hospital setting.[3] Since 2015, it has been implemented across counties in the West of England, with the aim of computing the NEWS for all patients prior to a referral to an acute care facility.[4] Furthermore, in a previous study, in-depth qualitative interviews with healthcare professionals were carried out to identify the barriers and facilitators of the implementation of NEWS in prehospital, primary care, and community settings.[5] In this study, participants described that the NEWS could support clinical decision-making around the escalation of care, and provide a clear means of communicating clinical acuity between clinicians and across different healthcare organizations.

A recent review showed that very low and high EWS could distinguish between patients who were unlikely and likely to deteriorate in the prehospital setting, respectively.[6] Some studies have also begun to apply NEWGendertensively in prehospital settings and emergency departments, and the majority have used mortality as a primary outcome for evaluating prehospital setting NEWS.[7-13] Meanwhile, in 2017, Shaw et al. used subsequent discharge disposition as the primary outcome.[7]

It is not clear how factors such as health care systems, geographical conditions, and race, affect the EWS. Three countries within Asia, Iran, Hong Kong, and China, have published reports on EWS in prehospital settings[11-13]; however, this has not yet been reported in Japan.

While life expectancy in Japan is high, it also faces the problem of an aging society[14]. The proportions of people aged 65 years and higher in Iran, China, Hong Kong, the United Kingdom (UK), and Japan are 5.6%, 9.6%,15.1%,17.8%, and 26.3%,

respectively.[15] Given the rapidly aging society, the number of ambulance deliveries for patients with multiple comorbidities are only expected to increase. However, studies evaluating the NEWS in prehospital settings in aging countries are limited. Thus, the present study aimed to examine the use of NEWS in the aging society of Japan and its application to emergency transportation.

Method

Patient and public involvement

Patients or the public were not involved in the design of the study.

Setting and population

This observational cohort study was conducted at St Marianna University School of Medicine, a 1,200-bed tertiary teaching hospital in Kawasaki city, Kanagawa prefecture. Kawasaki city covers a geographical area of 144 km^2 and has a population of 1.5 million people. The number of emergency ambulance transportations in this city is estimated to be 72,000 incidents per year.[16] There are 25 emergency hospitals in the city, of which St. Marianna Medical University Hospital is the largest.[17] Between April 2016 and March 2017, the number of patients transported by ambulance was 5,640, and the number of walk-in patients was 16,922.

In principle, it is up to the paramedics to decide which hospital they should transport the patient to, based on the severity of the patient's condition and the distance to the hospital.[18]

Participants

In this study, we enrolled patients transported to our hospital by ambulance between April 2016 and March 2017. The requirement for obtaining patients' informed consent was waived because the data were anonymous. The following patients were excluded: 1) Those aged less than 16 years; 2) pregnant; 3) patients transported from another hospital, as it is not a prehospital setting (this rule was the same for a previous study [10]); and 4) cardio-pulmonary arrest (CPA) cases.

Data sources

Prehospital and hospital data were collected separately and integrated. Prehospital data were recorded on paper by paramedics at the scene, and data on chief complaints and vital signs, including heart rate, respiratory rate, systolic blood pressure, arterial oxygen

saturation, temperature, and consciousness were collected.

Chief complaints were categorized based on the Advanced Medical Priority Dispatch System (AMPDS) categories as described in a previous study [8]. However, in Japan, this code has not been used in practice. The appropriate code number was added using the chief complaint item of the paper written by the paramedics after transport.

Patients were categorized into the following four groups based on their disposition, in accordance with a previous study[7]: discharge from the emergency department (ED), admission to the ward, intensive care unit (ICU) admission, or death in the ED.

NEWS

The NEWS ranges from 0 to 20, and each vital sign is scored from 0 to 3. When a patient is given supplementary oxygen, two points are added to the total score (Supplementary Table 1).[3] We calculated the total post hoc NEWS from the vital signs.

Statistical analysis

SPSS® Ver.25 (Chicago, IL, USA) was used for statistical analysis. A p-value < 0.05 was considered statistically significant. Patients' age, gender, and the presence of traumatic injury were summarized by the four categories based on their ED disposition and chief complaints made during the ambulance call. The distribution of NEWS were compared between the ED disposition groups using the Kruskal-Wallis test.

We assessed the discriminatory ability of the continuous-scale NEWS to predict patient ED dispositions, using receiver operating characteristic (ROC) curves and the area under the curves (C-statistics). For the ordered nature of ED disposition outcomes (discharge from the ED, ward or ICU admission, or death in the ED), we combined the outcomes as follows: 1) ward or ICU admission, or death in the ED; 2) admission to the ICU or death in the ED; and 3) death in the ED. These classifications were considered to provide more interpretable results than analysis of each disposition outcome alone.

To obtain candidate cut-off values for hospital disposition, we started with Youden's index (sensitivity + specificity - 1). Among these ranges, we carefully chose high/middle-risk and middle/low-risk cut-off points that appropriately reflected clinical requirements (Supplementary Table 2).

Finally, two combined outcomes (ICU admission or death in the ED and death in the ED) were compared among the NEWS-based categories, without and after adjusting for age, gender, and the presence of traumatic injury.

The study protocol was approved by the Institutional Review Board of St. Marianna University, School of Medicine.

Results

Participants' baseline characteristics.

The total number of patients who were transported to the hospital by emergency ambulance was 5,640 during the study period. After exclusion, 2,847 cases were selected for analysis (Figure 1).

In the current study, there were 20% incomplete data for which no vital signs were obtained. The vital signs of patients transported from Kawasaki City were written on paper by paramedics and given to hospital staff. On the other hand, the vital signs of patients transported from other areas (Tokyo, Yokohama next to Kawasaki) were not written on the report after transportation. These data could not be accessed due to privacy regulations. We excluded 20% of the data for which no vital signs were obtained, but the only difference was the area that the patients were transported from; thus, we assume that there would be no significant differences in the baseline characteristics between these patients and the other 80%.

Of the 2,847 cases, 1,330 (46.7%) were discharged from the ED, 1,263 (44.4%) were admitted to the ward, 232 (8.1%) were admitted to the ICU, and 22 (0.8%) died in the ED. The mean (± standard deviation) age of the participants was 66.5 ± 19.6 years and the median age was 73 years (lower to upper quartile: 53–82), with bimodal (modes around 44 and 82) and asymmetric, instead of unimodal and symmetric distributions. The proportion of male participants was 53.5%. The mean ages of the patients who were discharged from the ED, admitted to the ward, admitted to the ICU, and those who died in the ED were 63.9 ± 20.3, 68.8 ± 18.8, 68.5 ± 18.7, and 72.6 ± 20.2, respectively ($p < 0.001$) (Table 1).

The main chief complaints of the patients at the time of calling an ambulance were a

sick person (19.8%), unconsciousness (13.8%), and breathing difficulty (13.3%) (Table 1). Other chief complaints included traumatic injury (8.3%), stroke (7.4%), abdominal pain (6.6%), hemorrhage (5.9%), chest pain (5.9%), headache (4.1%), back pain (3.3%), and drug overdose (3.1%). The chief complaints of each patient disposition group are presented in Table 1 and Supplementary Table 3.

NEWS for each patient disposition group

The boxplots in Figure 2 illustrate the distribution of prehospital NEWSs for each disposition group. As shown in Supplementary Table 4, the median and mean (± standard deviation) NEWSs increased for groups discharged from the ED (3 and 3.7 ± 3.9), admitted to the ward (6 and 6.3 ± 3.8), admitted to ICU (9 and 9.4 ± 4.0), and died in the ED (11.5 and 11.7 ± 2.9). The distributions significantly differed between patient disposition groups according to the Kruskal-Wallis test ($p < 0.001$).

Discriminative performance of the NEWS in the prehospital setting

Figure 3 shows the ROC curves for patient disposition combined outcomes using a continuous-scale NEWS. The area under the receiver-operating characteristics (AUROCs) (95% confidence interval [CI]) for prehospital NEWS for ward/ICU admission or death in the ED, ICU admission or death in the ED, and death in the ED were 0.73 (0.72.0.75), 0.81 (0.78.0.83), and 0.90 (0.87.0.93), respectively.

Cut-off NEWSs for clinical risk categories

Based on the coordinate points of the ROC curve (Supplementary Table 2), the “high risk” cut-off was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1-specificity of 0.30 for admission to the ICU or death in the ED), and the “low risk” cut-off was set between 4 and 5 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the ward/ICU admission or death in the ED). The selection of these values is described in Supplementary Table 2.

Accordingly, we adopted the categorization scheme for low-risk (NEWS ≤ 4), medium-risk (5 or 6), and high-risk (≥ 7).

Risk category by patient disposition group

Table 2 shows that a higher NEWS was associated with deteriorating patient disposition. In the low-risk group (n = 1,327), the highest proportion of patients were

discharged from the ED (n = 853, 64.3%), followed by those admitted to the ward (n = 451, 34.0%), admitted to the ICU (n = 23, 1.7%), and died in the ED (n = 0, 0%). Conversely, patients in the high-risk group (n = 979) had a greater probability of being admitted to the ward (n = 568, 58.0%), being admitted to the ICU (n = 172, 17.6%), and dying in the ED (n = 22, 0.8%). Focusing on those who died in the ED, 100% (n = 22) of the participants were categorized as high-risk participants.

Relationship between NEWS risk level and outcome

Binary logistic regression models were used to further examine the relationship between the NEWS risk category and the combined patient disposition outcomes (Table 3; note that death in the ED occurred only in the high-risk group, and we did not perform logistic analysis for death in the ED). ICU admission or death in the ED in the medium-risk group (odds ratio: 4.2, 95% CI: 2.5. 7.1, p < 0.001) and the high-risk group (odds ratio: 13.8; 95% CI: 8.9. 21.6, p < 0.001) increased significantly compared to the low-risk group even after adjusting for age, gender, and trauma. Similarly, admission to the ward, ICU, or death in the ED in the medium-risk group (odds ratio: 1.9; 95% CI: 1.6. 2.4, p < 0.001) and the high-risk group (odds ratio: 6.1; 95% CI: 5.0. 7.3, p < 0.001) also increased significantly compared to the low-risk group.

Discussion

This study aimed to evaluate the efficacy of NEWS in predicting patient disposition in prehospital settings. Our findings indicate that prehospital NEWS could identify critical patients and those at risk of adverse outcomes. The aim of this study was not to clarify when to use NEWS to predict outcomes more accurately, but to verify whether the paramedics could determine the severity from vital sign scores at the time of patient contact.

In recent years, several studies have been conducted on prehospital EWS, and four representative reports[7-10] of NEWS have been published. A 2018 study conducted in Finland [10] showed the highest for 12,426 cases in two hospitals using short-term mortality rate as the primary outcome. Only a recent study of 287 patients conducted in the UK used patient disposition as the primary outcome.[7] The present study examined 2,847 cases, which is by far the largest among the previous studies to have used patient disposition as the primary outcome.

The present study found that prehospital NEWS predicted patient disposition in an ED in Japan. Once the patient was categorized as high-risk or medium-risk based on their NEWS, the probability of ICU admission or death in the ED increased. We demonstrated the usefulness of prehospital NEWS in predicting the severity of an illness among participants with different demographic characteristics. Our findings indicate the usefulness of NEWS, even for the older population.

It has been confirmed that prehospital NEWS fully predicts outpatient disposition, even in an aging society, such as in Japan. Our results and those of previous studies predicting outpatient disposition in the UK and other countries, suggest that prehospital NEWS might be available globally. This suggests that NEWS could be used when other countries become aging societies in the future.

Previous studies have used risk categories with odds ratios to calculate early death within 24 or 48 hours of hospitalization [8 10]. Our study is the first study in which the outpatient clinical outcomes were calculated by risk category with odds ratio. In 2017, a study[7] showed that high-risk patients (those with a NEWS ≥ 7) demonstrated a relatively higher risk for a one-day mortality rate of 101.5 compared to the low-risk group (≤ 4). Moreover, for medium-risk patients (NEWS, 5,6), a greater risk for one-day mortality rate of 4.4 was seen compared to low-risk patients, without adjusting for age, gender, and trauma.

In our research, the rate of ICU admission or death in the ED in the medium-risk group (odds ratio: 4.2, 95% CI: 2.5. 7.1, $p < 0.001$) and the high-risk group (odds ratio: 14.0, 95% CI: 9.0. 21.8, $p < 0.001$) increased significantly compared to the low-risk group, without adjusting for age, gender, and trauma (Table 3).

This study also examined how adjustment for age, gender, and trauma changed the association between the NEWS risk score and outcomes. The results of the analysis shown in Table 3 suggest that the use of the NEWS risk score, with or without considering age, gender, and trauma, was clinically useful.

In a previous study conducted in the UK in 2016, patients who died or were admitted to the ICU had a higher NEWS than those admitted to the ward or discharged from the ED.[7] On the other hand, the present study found differences in the mean NEWSs for all segments (Figure 2 and Supplementary Table 4). The higher average NEWSs in all

groups compared to those observed in the previous study could be explained by the fact that data were collected at a tertiary medical institution. Thus, it is appropriate to use an objective scoring system such as NEWS to compare the attributes of patients transported by ambulances. Furthermore, it is worth noting that the cut-off NEWS in the prehospital setting did not differ from that in the hospital setting.[3] A few studies have reported the validity of the cut-off values for the NEWS in outpatient settings. In the previous four studies[7-10], patients were categorized into low-, medium-, and high-risk groups, according to the guidelines of the Royal College of Physicians.[3] After examining the cut-off value in our data, we divided the risk categories into three categories. This classification based on our results is the same as the conventional in-hospital NEWS category.

According to the definition of NEWS based on in-hospital patients, validation was considered necessary to confirm the risk classification for out-of-hospital patients. Thus, the ROC curve and specified coordinate points were evaluated. The cut-off NEWSs for prehospital assessment were in line with the definition for in-hospital NEWS prediction (Supplementary Table 2). As medical interventions are not applied in the prehospital environment, the cut-off scores for the risk categories will differ from those in the in-hospital environment. Thus, future studies should use larger datasets to confirm this finding.

In Japan, some studies have confirmed the usefulness of EWS in the hospital and triage.[19-22] However, several countries require nationwide in-hospital EWS implementation, and in the UK this has been widely used in prehospital settings, outpatients, and emergency services.[4] Paramedics in Japan should directly request the hospital for ambulance acceptance on the scene. In fact, it is often difficult to obtain hospital acceptance for transportation because the number of transportations has increased each year.[17] Furthermore, the time from making the ambulance call until arrival at the hospital is also gradually increasing.[23 24] This might delay crucial emergency treatments, which in turn might worsen the patient's outcomes. NEWS-based risk stratification helps paramedics understand the severity of the patient's condition and communicate it accurately with a healthcare professional at the hospital. Earlier identification of critical patients might facilitate earlier resuscitation and appropriate critical care.[8]

We used outpatient disposition as the primary outcome in this study. Most previous

reports have considered short-term mortality as the primary outcome to assess the usefulness of prehospital NEWS. [6 9 10] As it predicts outpatient outcomes in addition to short-term mortality, the NEWS is a very useful tool.

We are also currently analyzing the relationship between prehospital NEWS and mortality rate with more extensive data and exploring the possibility of predicting death more accurately by integrating other factors (chief complaints, etc.). This study is the first step towards the implementation of prehospital NEWS as a prehospital triage tool. In Japan, there is no triage tool in the prehospital setting. The Japan Triage and Acuity Scale (JTAS) is currently used in the outpatient setting, but it does not assume an emergency site. To use prehospital NEWS as a triage tool, additional analysis of “false positive” and “false negative” is required. It is necessary to clarify what kind of cases are "Go home despite high score" and "ICU hospitalization despite low score". These data should be assessed in a future study.

The strengths of this study are as follows: This study is the first in Japan to show that the NEWS can be used in a prehospital setting to predict patient disposition in Japan. Our dataset was much larger than those used in a previous study[7], which indicates higher reliability. It is noteworthy that the result obtained by calculating the cut-off values for the out-hospital setting is the same as that obtained in the in-hospital setting.

Limitations

This study has several limitations. This was a retrospective study conducted in a single center, and as a result, the findings may not be generalizable to all populations in Japan. Second, the judgment for deciding the outpatient disposition of each emergency physician was standardized by referring to guidelines but did not match exactly.

Conclusion

Our study suggests the usefulness of NEWS in categorizing ED cases at patient’s arrival by ambulance. The study also found that elevated NEWS among unselected prehospital patients could predict patient disposition at the ED in Japan. The NEWS has a wide range of uses in prehospital settings. A prospective multicenter study is needed to validate the usefulness of NEWS in the prehospital setting.

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Acknowledgements

We would like to thank our department research assistant Ms. Akiko Hosoyama and our department paramedic Mr. Daigo Ando for their help in collecting the data.

Contributors

TE, KM, SiF, and YT conceived the research idea and designed the study. TE, ShF, and TN collected the data. TE, MT, JT, TN, NS, and TS provided statistical advice on study design and analyzed the data. TE and SiF chaired the data oversight committee. TE, HCH, and TY drafted the first version of the manuscript. TE, SiF, and YT take public responsibility for the contents of this paper.

Funding

This work was jointly funded by the St. Marianna University School of Medicine Research Grant 2018 and the Yuumi Memorial Foundation for Home Health Care Grant 2017.

Competing interests

None declared.

Patient consent

Not required.

Ethics approval

The research protocol received approval from the ethics committee of the Institutional Review Board of St Marianna University School of Medicine, No. 4325.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data were available.

Takuro Endo; Prehospital NEWS in Japan

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Table 1. Patient characteristics by patient disposition outcomes

	All (n = 2,847)		Patient disposition							
			Discharged from the ED (n = 1,330)		Admitted to the ward (n = 1,263)		Admitted to the ICU (n = 232)		Died in the ED (n = 22)	
Age (years) mean ± SD	66.5 ± 19.6		63.9 ± 20.3		68.8 ± 18.8		68.5 ± 18.7		72.6 ± 20.2	
Male (%)	53.5		49.2		56.1		64.2		50	
Non-trauma (%)	88.3		85.9		90.4		89.2		100	
Chief complaint *	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases
Sick person	19.8	564	24	319	17.4	220	8.6	20	22.7	5
Subject unconscious	13.8	392	8.6	114	16	202	28	65	50	11
Breathing difficulty	13.3	379	8.6	114	17.5	221	18.1	42	9.1	2
Traumatic injuries	8.3	236	11.1	148	6.4	81	3	7	0	0
Chest pain	5.9	167	6.3	84	4.8	60	8.6	20	13.6	3

* A list of chief complaints, containing the top three in each category

ED: Emergency department

ICU: Intensive care unit

SD: Standard deviation

Table 2. Distributions of patient disposition outcomes by risk categories based on NEWS

NEWS clinical risk level	Patient disposition				
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	All
Low risk (score 0–4)	64.3% (n = 853)	34.0% (n = 451)	1.7% (n = 23)	0.0% (n = 0)	100% (n = 1,327)
Medium risk (score 5–6)	48.1% (n = 260)	45.1% (n = 244)	6.8% (n = 37)	0.0 % (n = 0)	100% (n = 541)
High risk (score 7 or more)	22.2% (n = 217)	58.0% (n = 568)	17.6% (n = 172)	2.2% (n = 22)	100 % (n = 979)
Total	46.7 % (n=1,330)	44.4% (n = 1,263)	8.1% (n = 232)	0.8% (n = 22)	100% (n = 2,847)

NEWS: National Early Warning Score

ED: Emergency department

ICU: Intensive care unit

Table 3. Logistic regression analysis for the association between combined patient disposition outcomes and NEWS risk category

		Unadjusted			Age-, gender- and trauma-adjusted		
	Event %	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Event 1. Admission to the ICU or death in the ED							
NEWS risk							
Low	1.7	1.00	ref		1.00	ref	
Medium	6.8	4.16	2.45–7.07	< 0.0001	4.18	2.46-7.11	< 0.0001
High	19.8	14.01	9.01-21.77	< 0.0001	13.83	8.88-21.6	< 0.0001
Age					1.00	1.00-1.01	0.44
Gender					1.41	1.07-1.86	0.02
Trauma					1.17	0.74-1.85	0.51
Event 2. Admission to the Ward or ICU, or death in the ED							
NEWS risk							
Low	35.7	1.00	ref			1.00	ref
Medium	51.9	1.95	1.59-2.38	< 0.0001	1.94	1.58-2.39	< 0.0001
High	77.8	6.32	5.24-7.63	< 0.0001	6.06	5.01-7.33	< 0.0001
Age					0.99	0.99-0.99	0.00
Gender					0.75	0.64-0.88	0.00
Trauma					1.17	0.91-1.50	0.22

NEWS: National Early Warning Score

CI: Confidence interval

ICU: Intensive care unit

ED: Emergency department

Figure legend/caption

Figure 1.
Flow diagram of included cases

CPA: Cardiopulmonary arrest

Figure 2.
Boxplots of NEWS by patient disposition outcomes, and results of pairwise Wilcoxon tests

NEWS: National Early Warning Score
ED: Emergency department
ICU: Intensive care unit
** $p < 0.01$, *** $p < 0.001$

Figure 3.
Receiver operating characteristic (ROC) curves of the prediction of NEWS for combined patient disposition

NEWS: National Early Warning Score
ED: Emergency department
ICU: Intensive care unit

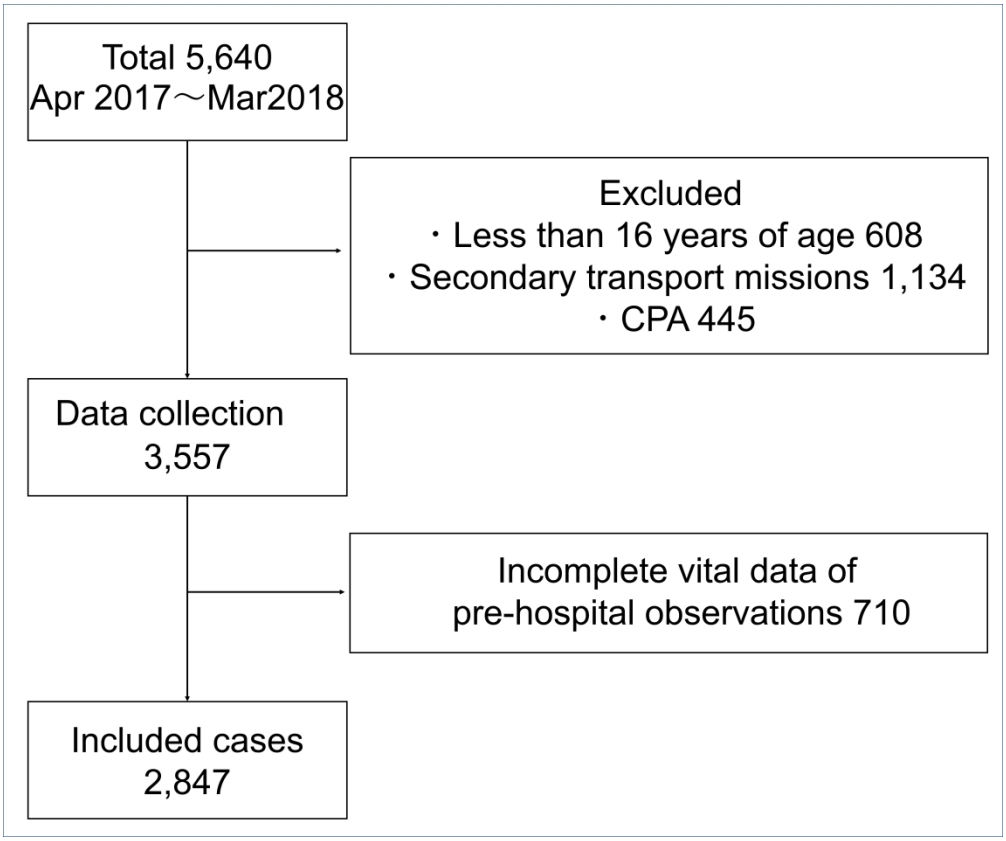

Figure 1. Flow diagram of cases included in the analysis.
CPA: cardio-pulmonary arrest

259x215mm (350 x 350 DPI)

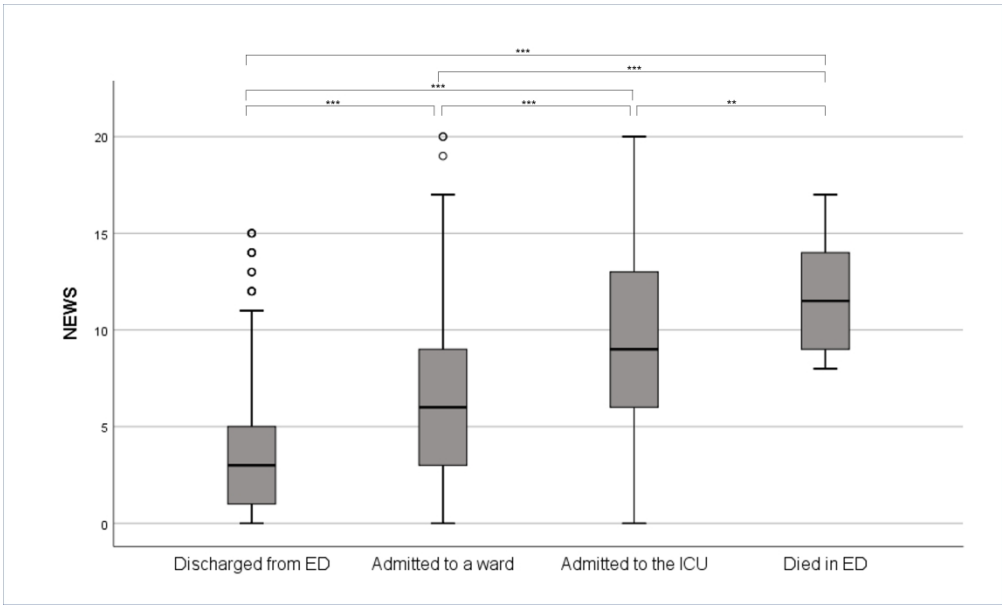

Figure2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxson tests.

NEWS: national early warning score
ED: emergency department
ICU: intensive care unit
** p<0.01, *** p<0.001

479x287mm (350 x 350 DPI)

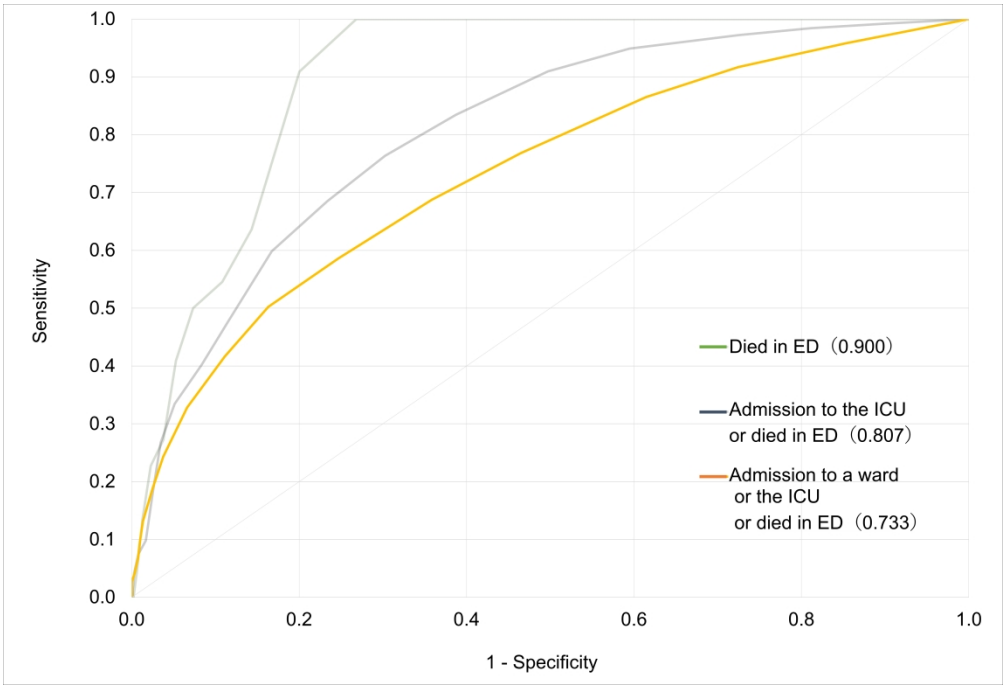

Figure 3.
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.
NEWS: national early warning score
ED: emergency department
ICU: intensive care unit

400x273mm (350 x 350 DPI)

Supplementary Table 1. Scoring system of NEWS.

Physiological parameters	+3	+2	+1	0	+1	+2	+3
Respiration Rate	≦8		9～11	12～20		21～24	25≦
Oxygen Saturations	≦91	92～93	94～95	≧96			
Any Supplemental Oxygen		Yes		No			
Temperature	≦35.0		35.1～36.0	36.1～38.0	38.1～39.0	39.1≦	
Systolic Blood Pressure	≦90	91～100	101～110	111～219			220≦
Heart rate	≦40		41～50	51～90	91～110	111～130	131≦
Level of Consciousness				Alert			V.P.U

NEWS: National Early Warning Score

V: voice responsive

P: pain responsive

U: unconscious

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Supplementary Table 2. Coordinate points of the ROC curves in Figure 2 (main text) with corresponding sensitivity and specificity.

Score	Admitted to a ward or admitted to the ICU or died in ED (C = 0.733)		Admitted to the ICU or died in ED (C = 0.807)		Died in ED (C = 0.900)	
	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity
-1.00	1.000	1.000	1.000	1.000	1.000	1.000
0.50	0.958	0.853	0.992	0.901	1.000	0.908
1.50	0.917	0.725	0.984	0.812	1.000	0.826
2.50	0.865	0.614	0.972	0.726	1.000	0.746
3.50	0.768	0.465	0.949	0.595	1.000	0.623
4.50	0.688	0.359	0.909	0.497	1.000	0.530
5.50	0.586	0.247	0.835	0.388	1.000	0.423
6.50	0.502	0.163	0.764	0.303	1.000	0.339
7.50	0.417	0.111	0.685	0.234	1.000	0.268
8.50	0.328	0.066	0.598	0.167	0.909	0.200
9.50	0.243	0.038	0.476	0.115	0.636	0.143
10.50	0.188	0.025	0.402	0.083	0.545	0.108
11.50	0.132	0.014	0.335	0.051	0.500	0.073
12.50	0.096	0.010	0.268	0.035	0.409	0.053
13.50	0.068	0.008	0.185	0.025	0.273	0.038
14.50	0.042	0.004	0.098	0.017	0.227	0.023
15.50	0.026	0.000	0.075	0.008	0.136	0.013

16.50	0.013	0.000	0.043	0.003	0.045	0.006
17.50	0.004	0.000	0.012	0.001	0.000	0.002
18.50	0.003	0.000	0.004	0.001	0.000	0.001
19.50	0.002	0.000	0.004	0.001	0.000	0.001

ROC: receiver operating characteristics
ED: emergency department
ICU: intensive care unit

Because there is no principled statistical criterion for selecting an optimal cutoff point without information on "cost", we carefully chose the cut points (4.5 and 6.5) from the combinations of three sets of sensitivity and 1 - specificity presented in Supplement Table 4 from a clinical practice viewpoint. As a starting point, we calculated Youden's index, which is defined as a difference between sensitivity and 1 - specificity, or "sensitivity + specificity - 1"; we found the following values to be considered as candidate cut points for NEWS:

	Youden's index		
Cut point	Ward/ICU/Death	ICU/Death	Death
3.5	0.303	0.354	0.377
4.5	0.329	0.412	0.47
5.5	0.339	0.447	0.577
6.5	0.339	0.461	0.661
7.5	0.306	0.451	0.732
8.5	0.262	0.431	0.709

For a "high/middle-risk" cut point, sensitivity for death and ICU admission is crucial. Among the values lower than 7.5 (sensitivity of 1 for death), we chose a value 6.5 because relatively higher sensitivity of ICU admission or death (about 3/4, or 75%).

Next, we considered that a "middle/low-risk" cut point should have had high sensitivity for a ward admission and minimal degree of specificity, e.g., over 50%-60%. Such points may be 3.5 or 4.5; we chose 4.5 because it has a better balance of sensitivity and specificity for ICU admission, too.

Supplementary Table 3. Breakdown of number of presentations by AMPDS category.

All patients			Discharged from ED			Admitted to a ward			Admitted to the ICU			Died in ED		
Category	%	Cases	Category	%	Cases	Category	%	Cases	Category	%	Cases	Category	%	Cases
Sick Person	19.8	564	Sick Person	24	319	Breathing Difficulty	17.5	221	Subject Unconscious	28	65	Subject Unconscious	50	11
Subject Unconscious	13.8	392	Traumatic Injuries	11.1	148	Sick Person	17.4	220	Breathing Difficulty	18.1	42	Sick Person	22.7	5
Breathing Difficulty	13.3	379	Breathing Difficulty	8.6	114	Subject Unconscious	16	202	Chest Pain	8.6	20	Chest Pain	13.6	3
Traumatic Injuries	8.3	236	Subject Unconscious	8.6	114	Stroke	10.6	134	Sick Person	8.6	20	Breathing Difficulty	9.1	2
Stroke	7.4	212	Abdominal Pain	7.5	100	Traumatic Injuries	6.4	81	Abdominal Pain	6	14	Psychiatric Problem	4.5	1
Abdominal Pain	6.6	187	Hemorrhage	7.2	96	Abdominal Pain	5.8	73	Traffic Collision	6	14	-	-	-
Hemorrhage	5.9	169	Chest Pain	6.3	84	Hemorrhage	5.4	68	Overdose	4.7	11	-	-	-
Chest Pain	5.9	167	Headache	6	80	Chest Pain	4.8	60	Stroke	4.3	10	-	-	-
Headache	4.1	117	Stroke	5.1	68	Overdose	4	51	Back Pain	3	7	-	-	-
Back Pain	3.3	93	Back Pain	4.1	54	Headache	2.9	36	Seizures	3	7	-	-	-
Overdose	3.1	89	Heart Problem	3.1	41	Back Pain	2.5	32	Traumatic Injuries	3	7	-	-	-
Seizures	2.4	68	Seizures	2.8	37	Seizures	1.9	24	Hemorrhage	2.2	5	-	-	-

Heart Problem	1.7	48	Overdose	2	27	Traffic Collision	1.7	22	Choking	1.7	4	-	-	-
Traffic Collision	1.7	48	Traffic Collision	0.9	12	Choking	0.6	8	Falls	0.9	2	-	-	-
Choking	0.5	15	Eye Problem	0.7	9	Heart Problem	0.5	6	Burn Subject	0.4	1	-	-	-
Burn Subject	0.4	12	Stab Gunshot Penetrating	0.5	7	Psychiatric Problem	0.5	6	Drowning	0.4	1	-	-	-
Eye Problem	0.4	11	Burn Subject	0.5	6	Burn Subject	0.4	5	Headache	0.4	1	-	-	-
Psychiatric Problem	0.4	10	Assault	0.2	3	Falls	0.3	4	Heart Problem	0.4	1	-	-	-
Stab Gunshot Penetrating	0.4	10	Choking	0.2	3	Drowning	0.2	3	-	-	-	-	-	-
Falls	0.2	7	Psychiatric Problem	0.2	3	Stab Gunshot Penetrating	0.2	3	-	-	-	-	-	-
Drowning	0.2	5	Allergic Reaction	0.2	2	Eye Problem	0.2	2	-	-	-	-	-	-
Assault	0.1	3	Diabetic Problems	0.1	1	Diabetic Problems	0.1	1	-	-	-	-	-	-
Allergic Reaction	0.1	2	Drowning	0.1	1	Environmental Exposure	0.1	1	-	-	-	-	-	-
Diabetic	0.1	2	Falls	0.1	1	-	-	-	-	-	-	-	-	-

Problems														
Environmental Exposure	0	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	100	2847	Total	100	1330	Total	100	1263	Total	100	232	Total	100	22

Supplementary Table 4. Summary statistics of prehospital NEWS by patient dispositions.

		Patient disposition			
	All (n=2,847)	Discharged from ED (*n* = 1330)	Admitted to a ward (*n* = 1263)	Admitted to the ICU (*n* = 232)	Died in ED (*n* = 22)
Median	5	3	6	9	11.5
Range	0-20	0-15	0-20	0-20	8-17
Mean±SD	5.4±3.9	3.7±2.9	6.3±3.8	9.4±4.0	11.7±2.9

NEWS: National Early Warning Score

ED: emergency department

ICU: intensive care unit

SD: standard deviation

TRIPOD Checklist: Prediction Model Validation

Section/Topic	Item	Checklist Item	Page
Title and abstract			
Title	1	Identify the study as developing and/or validating a multivariable prediction model, the target population, and the outcome to be predicted.	P1
Abstract	2	Provide a summary of objectives, study design, setting, participants, sample size, predictors, outcome, statistical analysis, results, and conclusions.	P4
Introduction			
Background and objectives	3a	Explain the medical context (including whether diagnostic or prognostic) and rationale for developing or validating the multivariable prediction model, including references to existing models.	P6
	3b	Specify the objectives, including whether the study describes the development or validation of the model or both.	P6-7
Methods			
Source of data	4a	Describe the study design or source of data (e.g., randomized trial, cohort, or registry data), separately for the development and validation data sets, if applicable.	P7-8
	4b	Specify the key study dates, including start of accrual; end of accrual; and, if applicable, end of follow-up.	P7
Participants	5a	Specify key elements of the study setting (e.g., primary care, secondary care, general population) including number and location of centres.	P7
	5b	Describe eligibility criteria for participants.	P7
	5c	Give details of treatments received, if relevant.	None
Outcome	6a	Clearly define the outcome that is predicted by the prediction model, including how and when assessed.	P8-9
	6b	Report any actions to blind assessment of the outcome to be predicted.	None
Predictors	7a	Clearly define all predictors used in developing or validating the multivariable prediction model, including how and when they were measured.	P8-9
	7b	Report any actions to blind assessment of predictors for the outcome and other predictors.	P8-9
Sample size	8	Explain how the study size was arrived at.	P7
Missing data	9	Describe how missing data were handled (e.g., complete-case analysis, single imputation, multiple imputation) with details of any imputation method.	P11
Statistical analysis methods	10c	For validation, describe how the predictions were calculated.	P8-9
	10d	Specify all measures used to assess model performance and, if relevant, to compare multiple models.	P8-9
	10e	Describe any model updating (e.g., recalibration) arising from the validation, if done.	P8-9
Risk groups	11	Provide details on how risk groups were created, if done.	P8-9
Development vs. validation	12	For validation, identify any differences from the development data in setting, eligibility criteria, outcome, and predictors.	P8-9
Results			
Participants	13a	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful.	P9
	13b	Describe the characteristics of the participants (basic demographics, clinical features, available predictors), including the number of participants with missing data for predictors and outcome.	P9
	13c	For validation, show a comparison with the development data of the distribution of important variables (demographics, predictors and outcome).	P9-10
Model performance	16	Report performance measures (with CIs) for the prediction model.	P10-11
Model-updating	17	If done, report the results from any model updating (i.e., model specification, model performance).	None
Discussion			
Limitations	18	Discuss any limitations of the study (such as nonrepresentative sample, few events per predictor, missing data).	P14
Interpretation	19a	For validation, discuss the results with reference to performance in the development data, and any other validation data.	P11-12
	19b	Give an overall interpretation of the results, considering objectives, limitations, results from similar studies, and other relevant evidence.	P11-13
Implications	20	Discuss the potential clinical use of the model and implications for future research.	P14
Other information			
Supplementary information	21	Provide information about the availability of supplementary resources, such as study protocol, Web calculator, and data sets.	P15
Funding	22	Give the source of funding and the role of the funders for the present study.	P15

We recommend using the TRIPOD Checklist in conjunction with the TRIPOD Explanation and Elaboration document.

BMJ Open

Efficacy of prehospital National Early Warning Score to predict outpatient disposition at an emergency department of a Japanese tertiary hospital: a retrospective study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034602.R3
Article Type:	Original research
Date Submitted by the Author:	07-Apr-2020
Complete List of Authors:	Endo, Takuro; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Yoshida, Toru; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Shinozaki, Tomohiro; Tokyo University of Science, Department of Information and Computer Technology, Faculty of Engineering Motohashi, Takako; St Marianna University School of Medicine, Department of Preventive Medicine Hsu, Hsiang-Chin; National Cheng Kung University Hospital, Emergency Medicine Fukuda, Shunsuke; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Tsukuda, Jumpei; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Naito, Takaki; St Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Morisawa, Kenichiro; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Shimozawa, Nobuhiko; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Taira, Yasuhiko; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine Fujitani, Shigeki; St. Marianna University School of Medicine, Department of Emergency and Critical Care Medicine
Primary Subject Heading:	Emergency medicine
Secondary Subject Heading:	Emergency medicine, Medical management
Keywords:	Early warning scores, Ambulance, Prehospital

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Takuro Endo; Prehospital NEWS in Japan

Original article

Title of the article

Efficacy of prehospital National Early Warning Score to predict outpatient disposition at an emergency department of a Japanese tertiary hospital: a retrospective study

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Word count

Abstract: 299 Words

Key message box: 123 Words

Main text: 3,370 words

No. of Tables: 3

No. of Figures: 3

No. of Supplementary Tables: 4

No. of Supplementary Figures: 0

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No. of References: 24

Keywords: emergency department, prehospital care, emergency ambulance systems, effectiveness, early warning score

ABSTRACT

Objectives

The National Early Warning Score (NEWS) was originally developed to assess hospitalized patients in the United Kingdom. We examined whether the NEWS could be applied to patients transported by ambulance in Japan.

Design

This retrospective study assessed patients and calculated the NEWS from paramedic records. Emergency department (ED) disposition data were categorized into the following groups: discharged from the ED, admitted to the ward, admitted to the intensive care unit (ICU), or died in the ED. The predictive performance of NEWS for patient disposition was assessed using receiver operating characteristic curve analysis. Patient dispositions were compared among NEWS-based categories after adjusting for age, sex, and presence of traumatic injury.

Setting

A tertiary hospital in Japan.

Participants

Overall, 2,847 patients transported by ambulance between April 2017 and March 2018 were included.

Results

The mean (± standard deviation) NEWS differed significantly among patients discharged from the ED (n=1,330, 3.7 ± 2.9), admitted to the ward (n=1,263,6.3 ± 3.8), admitted to the ICU (n=232, 9.4 ± 4.0), and died in the ED (n=22,11.7 ± 2.9) ($p < 0.001$). The prehospital NEWS C-

statistics (95% confidence interval [CI]) for admission to the ward, admission to the ICU, or death in the ED; admission to the ICU or death in the ED; and death in the ED were 0.73 (0.72–0.75), 0.81 (0.78–0.83), and 0.90 (0.87–0.93), respectively. After adjusting for age, sex, and trauma, the odds ratio (95% CI) of admission to the ICU or death in the ED for the high-risk (NEWS ≥7) and medium-risk (NEWS 5–6) categories were 13.8 (8.9–21.6) and 4.2 (2.5–7.1), respectively.

Conclusion

The findings from this Japanese tertiary hospital setting showed that prehospital NEWS could be used to identify patients at a risk of adverse outcomes. NEWS stratification was strongly correlated with patient disposition.

STRENGTHS AND LIMITATIONS

- This is the first retrospective study to evaluate the efficacy of prehospital National Early Warning Score (NEWS) calculated based on vital signs described by paramedics in Japan.
- The sample number in this study was larger than that in a previous study; therefore, it functions as an external validation of prehospital NEWS for predicting outpatient disposition at an emergency department.
- This study was conducted in an aging society in Japan, and the results will likely be generalizable to other aging societies.
- This study also examined how adjustment for age, sex, and trauma changed the association between the NEWS and outcomes.
- Because the study was conducted in a single center, the findings may not be generalizable to all Japanese populations.

Takuro Endo; Prehospital NEWS in Japan

Main text

INTRODUCTION

The early warning score (EWS) was developed as a guide for the quick assessment and early diagnosis of acute illness in patients admitted to hospitals.[1] It was intended to serve as a track and trigger tool for consistent assessment of illness severity and to provide useful baseline data to evaluate a patient's clinical progress.[2]

In 2012, The Royal College of Physicians developed the National Early Warning Score (NEWS) to improve the early detection rates of clinical deterioration. The NEWS was initially used to predict illness severity and deterioration in a hospital setting.[3] Since 2015, it has been implemented across counties in the West of England to compute the NEWS for all patients before referral to acute care facilities.[4] Furthermore, a previous study performed in-depth qualitative interviews of healthcare professionals to identify barriers and facilitators of NEWS implementation in prehospital, primary care, and community settings.[5] In this study, participants indicated that the NEWS could support clinical decision-making for the escalation of care and provide a clear means of communicating clinical acuity among clinicians and different healthcare organizations.

A recent review showed that very low and high EWSs could distinguish among patients who were unlikely and likely to deteriorate in the prehospital setting, respectively.[6] Some studies have also begun to extensively apply the NEWS in prehospital settings and emergency departments, and most of these studies have used mortality as a primary outcome for evaluating prehospital NEWS.[7-13] In contrast, in 2017, Shaw et al. used subsequent discharge disposition as the primary outcome.[7]

It is not clear how factors such as health care systems, geographical conditions, and race affect the EWS. Three Asian countries—Iran, Hong Kong, and China—have published reports on the use of EWS in prehospital settings[11-13]; however, its use has not yet been reported in Japan.

While life expectancy in Japan is high, the country also faces the problem of an aging society.[14] The proportions of people aged 65 years and higher in Iran, China, Hong Kong, the UK, and Japan are 5.6%, 9.6%,15.1%,17.8%, and 26.3%, respectively.[15] Given the rapidly aging society in Japan, the number of ambulance deliveries for patients with multiple comorbidities is only expected to increase. However, studies evaluating the NEWS in prehospital settings in aging countries are limited. Thus, this study examined the use of NEWS in the aging society of Japan and its application during emergency transportation.

METHODS

Patient and public involvement

Patients or the public were not involved in the study design.

Setting and population

This observational cohort study was conducted at St. Marianna University School of Medicine, a 1,200-bed tertiary teaching hospital in Kawasaki city, Kanagawa prefecture. Kawasaki city covers a geographical area of 144 km^2 and has a population of 1.5 million. The estimated number of emergency ambulance transportations in this city is 72,000 incidents per year.[16] There are 25 emergency hospitals in the city, of which St. Marianna Medical University Hospital is the largest.[17] Between April 2016 and March 2017, 5,640 of patients were transported by ambulance, while 16,922 patients were walk-in.

In principle, paramedics decide which hospital they should transport the patient to, based on the severity of the patient's condition and the distance to the hospital.[18]

Participants

This study enrolled patients transported to our hospital by ambulance between April 2016 and March 2017. The requirement for obtaining patients' informed consent was waived because the data were anonymized. The following patients were excluded: 1) those aged <16 years; 2) pregnant patients; 3) patients transported from another hospital because it was not a prehospital setting (this rule was the same for a previous study [10]; and 4) cardiopulmonary arrest cases.

Data sources

Prehospital and hospital data were collected separately and integrated. Prehospital data were recorded on paper by paramedics at the scene and data on chief complaints and vital signs, including heart rate, respiratory rate, systolic blood pressure, arterial oxygen saturation, temperature, and consciousness, were collected.

Chief complaints were categorized based on the Advanced Medical Priority Dispatch System categories as previously described.[8] However, in Japan, these codes have not been used in practice. The appropriate code was added using the chief complaint item recorded on the paper by the paramedics after transportation.

The patients were categorized into the following four groups based on their disposition as described previously:[7] discharge from the emergency department (ED), admission to the ward, admission to the intensive care unit (ICU), or death in the ED.

NEWS

The NEWS ranges from 0 to 20, with each vital sign scored from 0 to 3. When a patient is administered supplementary oxygen, two points are added to the total score (Supplementary Table 1).[3] We calculated the total post hoc NEWS based on the vital signs.

Statistical analysis

IBM SPSS Statistics for Windows, version 25.0 (Armonk, NY, USA) was used for statistical analysis. A p-value <0.05 was considered statistically significant. Patients' age, sex, and presence of traumatic injury were summarized by four categories based on their ED disposition and chief complaints made during the ambulance call. The distributions of the NEWS were compared between the ED disposition groups using Kruskal–Wallis tests.

We assessed the discriminatory ability of the continuous-scale NEWS to predict patient ED dispositions using receiver operating characteristic (ROC) curves and the area under the curves (C-statistics). For the ordered nature of ED disposition outcomes (discharge from the ED, ward or ICU admission, or death in the ED), we combined the outcomes as follows: 1) ward or ICU admission or death in the ED; 2) admission to the ICU or death in the ED; and 3) death in the ED. These classifications were considered to provide more interpretable results than the analysis of each disposition outcome alone.

To obtain candidate cut-off values for hospital disposition, we started with Youden's Index (sensitivity + specificity - 1). Among these ranges, we carefully chose high/middle-risk and middle/low-risk cut-off points that appropriately reflected clinical requirements (Supplementary Table 2).

Finally, two combined outcomes (ICU admission or death in the ED and death in the ED) were compared among the NEWS-based categories without and after adjusting for age, sex, and the

presence of traumatic injury.

The study protocol was approved by the Institutional Review Board of St. Marianna University, School of Medicine.

RESULTS

Participants' baseline characteristics

Overall, 5,640 patients were transported to the hospital by emergency ambulances during the study period. After exclusion, 2,847 cases were selected for analysis (Figure 1).

In the current study, there were 20% incomplete data for which no vital signs were obtained. The vital signs of patients transported from Kawasaki City were written on paper by paramedics and given to hospital staff. However, the vital signs of patients transported from other areas (Tokyo, Yokohama next to Kawasaki) were not written on the report after transportation. These data could not be accessed owing to privacy regulations. We excluded 20% of the data for which no vital signs were obtained; however, the only difference was the area from which the patients were transported; thus, we assumed that there were no significant differences in baseline characteristics between these patients and the other 80% of patients.

Of 2,847 cases, 1,330 (46.7%) were discharged from the ED, 1,263 (44.4%) were admitted to the ward, 232 (8.1%) were admitted to the ICU, and 22 (0.8%) died in the ED. The mean (± standard deviation) age of the participants was 66.5 ± 19.6 years, and the median age was 73 years (lower to upper quartile: 53–82), with bimodal (modes around 44 and 82) and asymmetric distributions rather than unimodal and symmetric distributions. Male patients comprised 53.5% of the participants. The mean ages of the patients discharged from the ED, admitted to the ward,

admitted to the ICU, and died in the ED were 63.9 ± 20.3, 68.8 ± 18.8, 68.5 ± 18.7, and 72.6 ± 20.2 years, respectively ($p < 0.001$) (Table 1).

Table 1. Patient characteristics by patient disposition outcomes

			Patient disposition							
	All (n = 2,847)		Discharged from the ED (n = 1,330)		Admitted to the ward (n = 1,263)		Admitted to the ICU (n = 232)		Died in the ED (n = 22)	
Age (years) mean ± SD	66.5 ± 19.6		63.9 ± 20.3		68.8 ± 18.8		68.5 ± 18.7		72.6 ± 20.2	
Male (%)	53.5		49.2		56.1		64.2		50	
Non-trauma (%)	88.3		85.9		90.4		89.2		100	
Chief complaint *	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases
Sick person	19.8	564	24	319	17.4	220	8.6	20	22.7	5
Subject unconscious	13.8	392	8.6	114	16	202	28	65	50	11
Breathing difficulty	13.3	379	8.6	114	17.5	221	18.1	42	9.1	2
Traumatic injuries	8.3	236	11.1	148	6.4	81	3	7	0	0

Chest pain	5.9	167	6.3	84	4.8	60	8.6	20	13.6	3

* A list of chief complaints containing the top three in each category

ED: Emergency department

ICU: Intensive care unit

SD: Standard deviation

The main chief complaints of the patients at the time of calling an ambulance were a sick person (19.8%), unconsciousness (13.8%), and breathing difficulty (13.3%) (Table 1). The other chief complaints included traumatic injury (8.3%), stroke (7.4%), abdominal pain (6.6%), hemorrhage (5.9%), chest pain (5.9%), headache (4.1%), back pain (3.3%), and drug overdose (3.1%). The chief complaints of each patient disposition group are presented in Table 1 and Supplementary Table 3.

NEWS for each patient disposition group

The boxplots in Figure 2 illustrate the distributions of prehospital NEWSs for each disposition group. As shown in Supplementary Table 4, the median and mean (± standard deviation) NEWSs increased for groups discharged from the ED (3 and 3.7 ± 3.9), admitted to the ward (6 and 6.3 ± 3.8), admitted to the ICU (9 and 9.4 ± 4.0), and died in the ED (11.5 and 11.7 ± 2.9). The distributions differed significantly among the patient disposition groups according to the Kruskal–Wallis test ($p < 0.001$).

Discriminative performance of the NEWS in the prehospital setting

Figure 3 shows the ROC curves for patient disposition combined outcomes using a continuous-scale NEWS. The area under the receiver operating characteristics (95% confidence interval

[CI]) for prehospital NEWS for ward/ICU admission or death in the ED, ICU admission or death in the ED, and death in the ED were 0.73 (0.72.0.75), 0.81 (0.78.0.83), and 0.90 (0.87.0.93), respectively.

Cut-off NEWSs for clinical risk categories

Based on the coordinate points of the ROC curve (Supplementary Table 2), the high-risk cut-off was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1- specificity of 0.30 for admission to the ICU or death in the ED), and the low-risk cut-off was set between 4 and 5 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the ward/ICU admission or death in the ED). The selection of these values is described in Supplementary Table 2.

Accordingly, we adopted the categorization scheme for low (NEWS ≤4), medium (5 or 6), and high (≥7) risks.

Risk category by patient disposition group

Table 2 shows that a higher NEWS was associated with deteriorating patient disposition. In the low-risk group (n = 1,327), the highest proportion of patients was discharged from the ED (n = 853, 64.3%), followed by those admitted to the ward (n = 451, 34.0%), admitted to the ICU (n = 23, 1.7%), and died in the ED (n = 0, 0%). Conversely, patients in the high-risk group (n = 979) had a greater probability of being admitted to the ward (n = 568, 58.0%), being admitted to the ICU (n = 172, 17.6%), and dying in the ED (n = 22, 2.2%). Among those who died in the ED, 100% (n = 22) of the participants were categorized as high risk.

Table 2. Distributions of patient disposition outcomes by risk categories based on NEWS

NEWS clinical risk level	Patient disposition				
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	All
Low risk (score 0-4)	64.3% (n = 853)	34.0% (n = 451)	1.7% (n = 23)	0.0% (n = 0)	100% (n = 1,327)
Medium risk (score 5-6)	48.1% (n = 260)	45.1% (n = 244)	6.8% (n = 37)	0.0 % (n = 0)	100% (n = 541)
High risk (score ≥7)	22.2% (n = 217)	58.0% (n = 568)	17.6% (n = 172)	2.2% (n = 22)	100 % (n = 979)
Total	46.7 % (n=1,330)	44.4% (n = 1,263)	8.1% (n = 232)	0.8% (n = 22)	100% (n = 2,847)

NEWS: National Early Warning Score

ED: Emergency department

ICU: Intensive care unit

Relationship between NEWS risk level and outcome

Binary logistic regression models were used to further examine the relationship between the NEWS risk category and combined patient disposition outcomes (Table 3; note that death in the ED occurred only in the high-risk group and we did not perform logistic analysis for death in the ED). ICU admission or death in the ED in the medium-risk group (odds ratio: 4.2, 95% CI: 2.5–7.1, $p < 0.001$) and the high-risk group (odds ratio: 13.8; 95% CI: 8.9–21.6, $p < 0.001$) increased significantly compared with that in the low-risk group even after adjusting for age, sex, and trauma. Similarly, admission to the ward, ICU, or death in the ED in the medium-risk group (odds ratio: 1.9; 95% CI: 1.6–2.4, $p < 0.001$) and the high-risk group (odds ratio: 6.1;

95% CI: 5.0–7.3, p < 0.001) increased significantly compared with that in the low-risk group.

Table 3. Logistic regression analysis of the association between combined patient disposition outcomes and NEWS risk category

		Unadjusted			Age-, sex- and trauma-adjusted		
	Event %	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Event 1. Admission to the ICU or death in the ED							
NEWS risk							
Low	1.7	1.00	ref		1.00	ref	
Medium	6.8	4.16	2.45–7.07	<0.0001	4.18	2.46–7.11	<0.0001
High	19.8	14.01	9.01–21.77	<0.0001	13.83	8.88–21.6	<0.0001
Age					1.00	1.00–1.01	0.44
Sex					1.41	1.07–1.86	0.02
Trauma					1.17	0.74–1.85	0.51
Event 2. Admission to the ward or ICU, or death in the ED							
NEWS risk							
Low	35.7	1.00	ref			1.00	ref
Medium	51.9	1.95	1.59–2.38	<0.0001	1.94	1.58–2.39	<0.0001
High	77.8	6.32	5.24–7.63	<0.0001	6.06	5.01–7.33	<0.0001
Age					0.99	0.99–0.99	0.00
Sex					0.75	0.64–0.88	0.00
Trauma					1.17	0.91–1.50	0.22

NEWS: National Early Warning Score

CI: Confidence interval

ICU: Intensive care unit

ED: Emergency department

DISCUSSION

This study aimed to evaluate the efficacy of NEWS in predicting patient disposition in prehospital settings. Our findings indicate that prehospital NEWS could identify critical patients and those at a risk of adverse outcomes. This study did not aim to clarify when to use NEWS to more accurately predict outcomes but rather to verify whether paramedics could determine the severity based on vital sign scores at the time of patient contact.

In recent years, several studies have been conducted on prehospital EWS, and four representative reports[7-10] of NEWS have been published. A 2018 study conducted in Finland[10] included the highest number of cases (n=12,426) in two hospitals but used short-term mortality rate as the primary outcome. Only a recent study of 287 patients conducted in the UK used patient disposition as the primary outcome.[7] The present study examined 2,847 cases, which is by far the largest among previous studies to have used patient disposition as the primary outcome.

We found that prehospital NEWS predicted patient disposition in an ED in Japan. Patients categorized as high or medium risk based on their NEWS had increased probabilities of ICU admission or death in the ED. We demonstrated the usefulness of prehospital NEWS in predicting illness severity among participants with different demographic characteristics. Our findings indicate the usefulness of NEWS even in an older population.

Prehospital NEWS has been confirmed to fully predict outpatient disposition, even in aging

societies such as those in Japan. Our results and those of previous studies predicting outpatient disposition in the UK and other countries suggest that prehospital NEWS might be available globally. These findings suggest that the NEWS could be used for aging societies in other countries in the future.

Previous studies have used risk categories with odds ratios to calculate early death within 24 or 48 hours of hospitalization.[8 10] Our study is the first to assess outpatient clinical outcomes based on risk category with odds ratio. A 2017 study[7] showed that high-risk patients (NEWS ≥7) demonstrated a relatively higher risk for a one-day mortality rate of 101.5 compared with the low-risk group (NEWS ≤4). Moreover, for medium-risk patients (NEWS, 5,6), we observed an increased risk of one-day mortality of 4.4 compared with that for low-risk patients, without adjusting for age, sex, and trauma.

In our study, the rate of ICU admission or death in the ED in the medium-risk (odds ratio: 4.2, 95% CI: 2.5–7.1, $p < 0.001$) and high-risk (odds ratio: 14.0, 95% CI: 9.0–21.8, $p < 0.001$) groups increased significantly compared with that in the low-risk group, without adjusting for age, sex, and trauma (Table 3).

This study also examined how adjustment for age, sex, and trauma changed the association between NEWS risk and outcomes. The results of the analysis (Table 3) suggest that the use of the NEWS was clinically useful regardless of age, sex, and trauma.

In a 2016 study conducted in the UK, patients who died or were admitted to the ICU had a higher NEWS than that of patients admitted to the ward or discharged from the ED.[7] However, we observed differences in the mean NEWSs for all segments (Figure 2 and Supplementary Table 4). The higher average NEWSs in all groups compared with those observed in a previous

study could be explained by the fact that the data were collected at a tertiary medical institution. Thus, it is appropriate to use objective scoring systems such as NEWS to compare the attributes of patients transported by ambulance. Furthermore, the cut-off NEWS in the prehospital setting did not differ from that in the hospital setting.[3] Several studies have reported the validity of the cut-off values for the NEWS in outpatient settings. Four previous studies[7-10] categorized patients into low-, medium-, and high-risk groups according to Royal College of Physicians guidelines.[3] After examining the cut-off value in our data, we developed three risk categories. This classification based on our results is the same as that for conventional in-hospital NEWS categories.

According to the definition of NEWS based on in-hospital patients, validation was necessary to confirm the risk classification for out-of-hospital patients. Thus, we evaluated the ROC curves and specified coordinate points. The cut-off NEWSs for prehospital assessment were consistent with the definition for in-hospital NEWS prediction (Supplementary Table 2). As medical interventions are not applied in the prehospital environment, the cut-off scores for the risk categories will differ from those in the in-hospital environment. Thus, future studies should use larger datasets to confirm this finding.

Some studies in Japan have confirmed the usefulness of EWS in hospital and triage settings.[19-22] However, several countries require nationwide in-hospital EWS implementation, and in the UK, this has been widely used in prehospital settings, outpatients, and emergency services.[4] Paramedics in Japan should directly request the hospital for ambulance acceptance on the scene. However, it is often difficult to obtain hospital acceptance for transportation because the number of transportations has increased each year.[17] Furthermore, the time from making the ambulance call until arrival at the hospital is also gradually increasing.[23,24] This might delay crucial emergency treatments, which in turn might worsen patient outcomes. NEWS-based risk

stratification helps paramedics to understand the severity of the patient's condition and communicate it accurately to a healthcare professional at the hospital. Earlier identification of critical patients might facilitate earlier resuscitation and appropriate critical care.[8]

This study used outpatient disposition as the primary outcome. Most previous reports have considered short-term mortality as the primary outcome to assess the usefulness of prehospital NEWS. [6 9 10] As it predicts outpatient outcomes in addition to short-term mortality, the NEWS is a very useful tool.

We are also currently analyzing the relationship between prehospital NEWS and mortality rate with more extensive data and exploring the possibility of more accurately predicting death by integrating other factors (chief complaints, etc.). This study is the first step toward the implementation of prehospital NEWS as a prehospital triage tool. There is currently no triage tool in the prehospital setting in Japan. The Japan Triage and Acuity Scale is currently used in the outpatient setting, but it does not assume an emergency site. To use prehospital NEWS as a triage tool, additional analysis of "false-positive" and "false-negative" rates is required. It is necessary to clarify what kind of cases are "Go home despite high score" and "ICU hospitalization despite low score." These data should be assessed in a future study.

The strengths of this study are as follows. This study is the first in Japan to show that the NEWS can be used in a prehospital setting to predict patient disposition. Our dataset was much larger than that used in a previous study[7], which suggests higher reliability. It is noteworthy that the results obtained by calculating the cut-off values for the out-hospital setting were the same as those obtained for the in-hospital setting.

Limitations

This study had some limitations. This was a retrospective study conducted in a single center; thus, the findings may not be generalizable to all populations in Japan. Second, while the judgments for deciding the outpatient disposition of each emergency physician was standardized by referring to guidelines, they did not match exactly.

CONCLUSION

The results of our study suggest the usefulness of NEWS for categorizing ED cases on patient arrival by ambulance. The study also showed that elevated NEWS among unselected prehospital patients could be used to predict patient disposition at the ED in Japan. The NEWS has a wide range of uses in prehospital settings. A prospective multicenter study is needed to validate the usefulness of the NEWS in the prehospital setting.

ACKNOWLEDGEMENTS

We thank our department research assistant, Ms. Akiko Hosoyama, and our department paramedic, Mr. Daigo Ando, for their help in collecting the data.

CONTRIBUTORS

TE, KM, SiF, and YT conceived the research idea and designed the study. TE, ShF, and TN collected the data. TE, MT, JT, TN, NS, and TS provided statistical advice on the study design and analyzed the data. TE and SiF chaired the data oversight committee. TE, HCH, and TY drafted the first version of the manuscript. TE, SiF, and YT take public responsibility for the contents of this paper.

FUNDING

This work was jointly funded by the St. Marianna University School of Medicine Research Grant 2018 and the Yuumi Memorial Foundation for Home Health Care Grant 2017.

COMPETING INTERESTS

None declared.

PATIENT CONSENT

Not required.

ETHICS APPROVAL

The research protocol received approval from the ethics committee of the Institutional Review Board of St Marianna University School of Medicine (No. 4325).

PROVENANCE AND PEER REVIEW

Takuro Endo; Prehospital NEWS in Japan

Not commissioned; externally peer-reviewed.

DATA SHARING STATEMENT

No additional data were available.

OPEN ACCESS

Takuro Endo; Prehospital NEWS in Japan

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FIGURE LEGENDS

Figure 1.

Flow diagram of the included cases

CPA: Cardiopulmonary arrest

Figure 2.

Boxplots of NEWS by patient disposition outcomes, and results of pairwise Wilcoxon tests

NEWS: National Early Warning Score

ED: Emergency department

ICU: Intensive care unit

** $p < 0.01$, *** $p < 0.001$

Figure 3.

Receiver operating characteristic (ROC) curves of the prediction of NEWS for combined patient disposition

NEWS: National Early Warning Score

ED: Emergency department

ICU: Intensive care unit

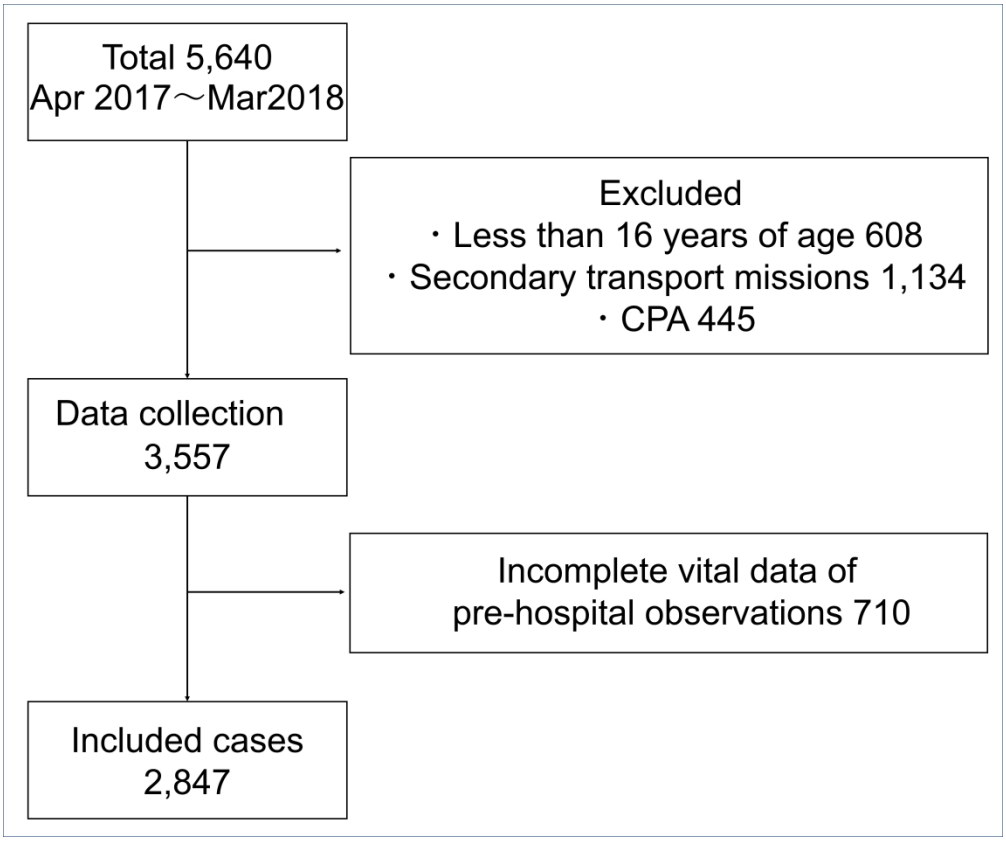

Figure 1. Flow diagram of cases included in the analysis.
CPA: cardio-pulmonary arrest

259x215mm (350 x 350 DPI)

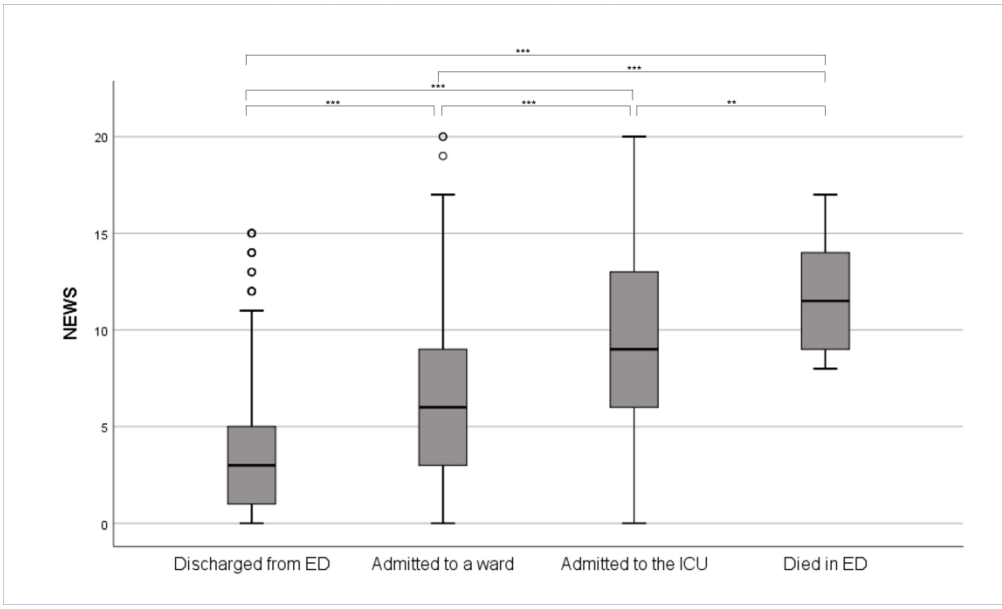

Figure2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxson tests.

NEWS: national early warning score
ED: emergency department
ICU: intensive care unit
** p<0.01, *** p<0.001

479x287mm (350 x 350 DPI)

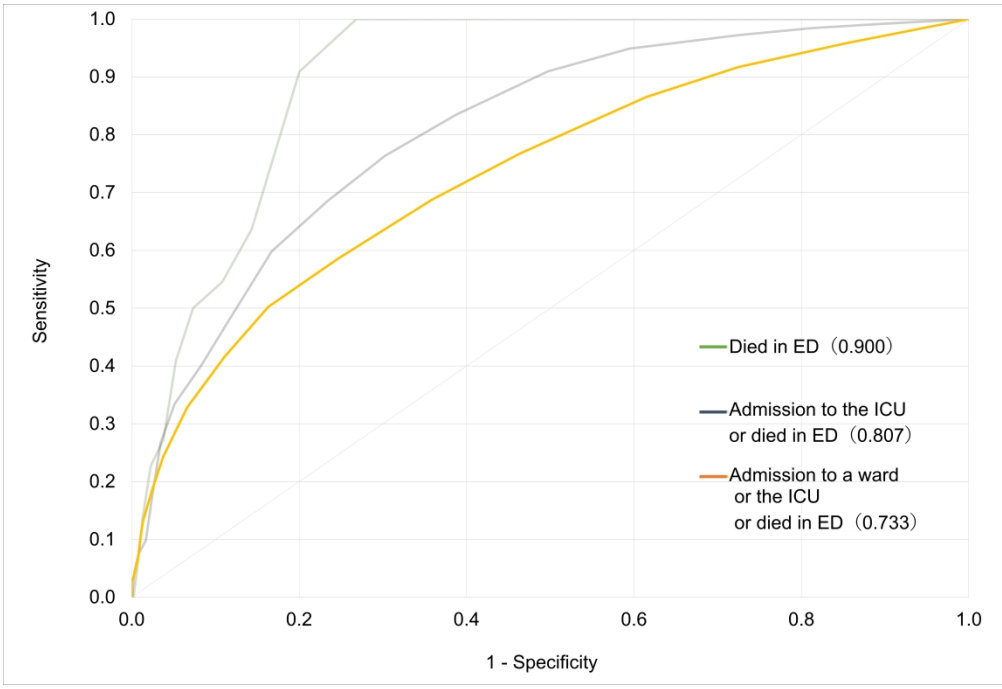

Figure 3.
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.
NEWS: national early warning score
ED: emergency department
ICU: intensive care unit

400x273mm (350 x 350 DPI)

Supplementary Table 1. Scoring system of NEWS.

Physiological parameters	+3	+2	+1	0	+1	+2	+3
Respiration Rate	≦8		9～11	12～20		21～24	25≦
Oxygen Saturations	≦91	92～93	94～95	≧96			
Any Supplemental Oxygen		Yes		No			
Temperature	≦35.0		35.1～36.0	36.1～38.0	38.1～39.0	39.1≦	
Systolic Blood Pressure	≦90	91～100	101～110	111～219			220≦
Heart rate	≦40		41～50	51～90	91～110	111～130	131≦
Level of Consciousness				Alert			V.P.U

NEWS: National Early Warning Score

V: voice responsive

P: pain responsive

U: unconscious

Supplementary Table 2. Coordinate points of the ROC curves in Figure 2 (main text) with corresponding sensitivity and specificity.

Score	Admitted to a ward or admitted to the ICU or died in ED (C = 0.733)		Admitted to the ICU or died in ED (C = 0.807)		Died in ED (C = 0.900)	
	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity	Sensitivity	1 - Specificity
-1.00	1.000	1.000	1.000	1.000	1.000	1.000
0.50	0.958	0.853	0.992	0.901	1.000	0.908
1.50	0.917	0.725	0.984	0.812	1.000	0.826
2.50	0.865	0.614	0.972	0.726	1.000	0.746
3.50	0.768	0.465	0.949	0.595	1.000	0.623
4.50	0.688	0.359	0.909	0.497	1.000	0.530
5.50	0.586	0.247	0.835	0.388	1.000	0.423
6.50	0.502	0.163	0.764	0.303	1.000	0.339
7.50	0.417	0.111	0.685	0.234	1.000	0.268
8.50	0.328	0.066	0.598	0.167	0.909	0.200
9.50	0.243	0.038	0.476	0.115	0.636	0.143
10.50	0.188	0.025	0.402	0.083	0.545	0.108
11.50	0.132	0.014	0.335	0.051	0.500	0.073
12.50	0.096	0.010	0.268	0.035	0.409	0.053
13.50	0.068	0.008	0.185	0.025	0.273	0.038
14.50	0.042	0.004	0.098	0.017	0.227	0.023
15.50	0.026	0.000	0.075	0.008	0.136	0.013

16.50	0.013	0.000	0.043	0.003	0.045	0.006
17.50	0.004	0.000	0.012	0.001	0.000	0.002
18.50	0.003	0.000	0.004	0.001	0.000	0.001
19.50	0.002	0.000	0.004	0.001	0.000	0.001

ROC: receiver operating characteristics
ED: emergency department
ICU: intensive care unit

Because there is no principled statistical criterion for selecting an optimal cutoff point without information on "cost", we carefully chose the cut points (4.5 and 6.5) from the combinations of three sets of sensitivity and 1 - specificity presented in Supplement Table 4 from a clinical practice viewpoint. As a starting point, we calculated Youden's index, which is defined as a difference between sensitivity and 1 - specificity, or "sensitivity + specificity - 1"; we found the following values to be considered as candidate cut points for NEWS:

	Youden's index		
Cut point	Ward/ICU/Death	ICU/Death	Death
3.5	0.303	0.354	0.377
4.5	0.329	0.412	0.47
5.5	0.339	0.447	0.577
6.5	0.339	0.461	0.661
7.5	0.306	0.451	0.732
8.5	0.262	0.431	0.709

For a "high/middle-risk" cut point, sensitivity for death and ICU admission is crucial. Among the values lower than 7.5 (sensitivity of 1 for death), we chose a value 6.5 because relatively higher sensitivity of ICU admission or death (about 3/4, or 75%).

Next, we considered that a "middle/low-risk" cut point should have had high sensitivity for a ward admission and minimal degree of specificity, e.g., over 50%-60%. Such points may be 3.5 or 4.5; we chose 4.5 because it has a better balance of sensitivity and specificity for ICU admission, too.

Supplementary Table 3. Breakdown of number of presentations by AMPDS category.

All patients			Discharged from ED			Admitted to a ward			Admitted to the ICU			Died in ED		
Category	%	Cases	Category	%	Cases	Category	%	Cases	Category	%	Cases	Category	%	Cases
Sick Person	19.8	564	Sick Person	24	319	Breathing Difficulty	17.5	221	Subject Unconscious	28	65	Subject Unconscious	50	11
Subject Unconscious	13.8	392	Traumatic Injuries	11.1	148	Sick Person	17.4	220	Breathing Difficulty	18.1	42	Sick Person	22.7	5
Breathing Difficulty	13.3	379	Breathing Difficulty	8.6	114	Subject Unconscious	16	202	Chest Pain	8.6	20	Chest Pain	13.6	3
Traumatic Injuries	8.3	236	Subject Unconscious	8.6	114	Stroke	10.6	134	Sick Person	8.6	20	Breathing Difficulty	9.1	2
Stroke	7.4	212	Abdominal Pain	7.5	100	Traumatic Injuries	6.4	81	Abdominal Pain	6	14	Psychiatric Problem	4.5	1
Abdominal Pain	6.6	187	Hemorrhage	7.2	96	Abdominal Pain	5.8	73	Traffic Collision	6	14	-	-	-
Hemorrhage	5.9	169	Chest Pain	6.3	84	Hemorrhage	5.4	68	Overdose	4.7	11	-	-	-
Chest Pain	5.9	167	Headache	6	80	Chest Pain	4.8	60	Stroke	4.3	10	-	-	-
Headache	4.1	117	Stroke	5.1	68	Overdose	4	51	Back Pain	3	7	-	-	-
Back Pain	3.3	93	Back Pain	4.1	54	Headache	2.9	36	Seizures	3	7	-	-	-
Overdose	3.1	89	Heart Problem	3.1	41	Back Pain	2.5	32	Traumatic Injuries	3	7	-	-	-
Seizures	2.4	68	Seizures	2.8	37	Seizures	1.9	24	Hemorrhage	2.2	5	-	-	-

Heart Problem	1.7	48	Overdose	2	27	Traffic Collision	1.7	22	Choking	1.7	4	-	-	-
Traffic Collision	1.7	48	Traffic Collision	0.9	12	Choking	0.6	8	Falls	0.9	2	-	-	-
Choking	0.5	15	Eye Problem	0.7	9	Heart Problem	0.5	6	Burn Subject	0.4	1	-	-	-
Burn Subject	0.4	12	Stab Gunshot Penetrating	0.5	7	Psychiatric Problem	0.5	6	Drowning	0.4	1	-	-	-
Eye Problem	0.4	11	Burn Subject	0.5	6	Burn Subject	0.4	5	Headache	0.4	1	-	-	-
Psychiatric Problem	0.4	10	Assault	0.2	3	Falls	0.3	4	Heart Problem	0.4	1	-	-	-
Stab Gunshot Penetrating	0.4	10	Choking	0.2	3	Drowning	0.2	3	-	-	-	-	-	-
Falls	0.2	7	Psychiatric Problem	0.2	3	Stab Gunshot Penetrating	0.2	3	-	-	-	-	-	-
Drowning	0.2	5	Allergic Reaction	0.2	2	Eye Problem	0.2	2	-	-	-	-	-	-
Assault	0.1	3	Diabetic Problems	0.1	1	Diabetic Problems	0.1	1	-	-	-	-	-	-
Allergic Reaction	0.1	2	Drowning	0.1	1	Environmental Exposure	0.1	1	-	-	-	-	-	-
Diabetic	0.1	2	Falls	0.1	1	-	-	-	-	-	-	-	-	-

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Problems														
Environmental Exposure	0	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	100	2847	Total	100	1330	Total	100	1263	Total	100	232	Total	100	22

Supplementary Table 4. Summary statistics of prehospital NEWS by patient dispositions.

		Patient disposition			
	All (n=2,847)	Discharged from ED (*n* = 1330)	Admitted to a ward (*n* = 1263)	Admitted to the ICU (*n* = 232)	Died in ED (*n* = 22)
Median	5	3	6	9	11.5
Range	0-20	0-15	0-20	0-20	8-17
Mean±SD	5.4±3.9	3.7±2.9	6.3±3.8	9.4±4.0	11.7±2.9

NEWS: National Early Warning Score

ED: emergency department

ICU: intensive care unit

SD: standard deviation

TRIPOD Checklist: Prediction Model Validation

Section/Topic	Item	Checklist Item	Page
Title and abstract			
Title	1	Identify the study as developing and/or validating a multivariable prediction model, the target population, and the outcome to be predicted.	P1
Abstract	2	Provide a summary of objectives, study design, setting, participants, sample size, predictors, outcome, statistical analysis, results, and conclusions.	P4
Introduction			
Background and objectives	3a	Explain the medical context (including whether diagnostic or prognostic) and rationale for developing or validating the multivariable prediction model, including references to existing models.	P6
	3b	Specify the objectives, including whether the study describes the development or validation of the model or both.	P6-7
Methods			
Source of data	4a	Describe the study design or source of data (e.g., randomized trial, cohort, or registry data), separately for the development and validation data sets, if applicable.	P7-8
	4b	Specify the key study dates, including start of accrual; end of accrual; and, if applicable, end of follow-up.	P7
Participants	5a	Specify key elements of the study setting (e.g., primary care, secondary care, general population) including number and location of centres.	P7
	5b	Describe eligibility criteria for participants.	P7
	5c	Give details of treatments received, if relevant.	None
Outcome	6a	Clearly define the outcome that is predicted by the prediction model, including how and when assessed.	P8-9
	6b	Report any actions to blind assessment of the outcome to be predicted.	None
Predictors	7a	Clearly define all predictors used in developing or validating the multivariable prediction model, including how and when they were measured.	P8-9
	7b	Report any actions to blind assessment of predictors for the outcome and other predictors.	P8-9
Sample size	8	Explain how the study size was arrived at.	P7
Missing data	9	Describe how missing data were handled (e.g., complete-case analysis, single imputation, multiple imputation) with details of any imputation method.	P11
Statistical analysis methods	10c	For validation, describe how the predictions were calculated.	P8-9
	10d	Specify all measures used to assess model performance and, if relevant, to compare multiple models.	P8-9
	10e	Describe any model updating (e.g., recalibration) arising from the validation, if done.	P8-9
Risk groups	11	Provide details on how risk groups were created, if done.	P8-9
Development vs. validation	12	For validation, identify any differences from the development data in setting, eligibility criteria, outcome, and predictors.	P8-9
Results			
Participants	13a	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful.	P9
	13b	Describe the characteristics of the participants (basic demographics, clinical features, available predictors), including the number of participants with missing data for predictors and outcome.	P9
	13c	For validation, show a comparison with the development data of the distribution of important variables (demographics, predictors and outcome).	P9-10
Model performance	16	Report performance measures (with CIs) for the prediction model.	P10-11
Model-updating	17	If done, report the results from any model updating (i.e., model specification, model performance).	None
Discussion			
Limitations	18	Discuss any limitations of the study (such as nonrepresentative sample, few events per predictor, missing data).	P14
Interpretation	19a	For validation, discuss the results with reference to performance in the development data, and any other validation data.	P11-12
	19b	Give an overall interpretation of the results, considering objectives, limitations, results from similar studies, and other relevant evidence.	P11-13
Implications	20	Discuss the potential clinical use of the model and implications for future research.	P14
Other information			
Supplementary information	21	Provide information about the availability of supplementary resources, such as study protocol, Web calculator, and data sets.	P15
Funding	22	Give the source of funding and the role of the funders for the present study.	P15

We recommend using the TRIPOD Checklist in conjunction with the TRIPOD Explanation and Elaboration document.