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# BMJ Open

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

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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
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1 Takuro Endo; Prehospital NEWS in Japan  
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5 Original article  
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8 Title of the article  
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10 Prehospital national early warning score predicts outpatient disposition at the  
11 Emergency Department in a Japanese tertiary hospital  
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13  
14

15 Authors  
16

17  
18 Takuro Endo ([Takuroendo@gmail.com](mailto:Takuroendo@gmail.com))<sup>1</sup> First author  
19

20  
21 Toru Yoshida ([yoshidat@marianna-u.ac.jp](mailto:yoshidat@marianna-u.ac.jp))<sup>1</sup>  
22

23  
24 Tomohiro Shinozaki ([shinozaki@rs.tus.ac.jp](mailto:shinozaki@rs.tus.ac.jp))<sup>2</sup>  
25

26  
27 Takako Motohashi ([motohashi-takako@marianna-u.ac.jp](mailto:motohashi-takako@marianna-u.ac.jp))<sup>3</sup>  
28

29  
30 Hsiang-Chin Hsu ([i3593120@gmail.com](mailto:i3593120@gmail.com))<sup>4</sup>  
31

32  
33 Shunsuke Fukuda ([s0711732@hotmail.co.jp](mailto:s0711732@hotmail.co.jp))<sup>1</sup>  
34

35  
36 Jumpei Tsukuda ([jumpechan@yahoo.co.jp](mailto:jumpechan@yahoo.co.jp))<sup>1</sup>  
37

38  
39 Takaki Naito ([takaki.jc@gmail.com](mailto:takaki.jc@gmail.com))<sup>1</sup>  
40

41  
42 Kenichiro Morisawa ([kmori0079@yahoo.co.jp](mailto:kmori0079@yahoo.co.jp))<sup>1</sup>  
43

44  
45 Nobuhiko Shimozawa ([simozawa@marianna-u.ac.jp](mailto:simozawa@marianna-u.ac.jp))<sup>1</sup>  
46

47  
48 Yasuhiko Taira ([y2taira@marianna-u.ac.jp](mailto:y2taira@marianna-u.ac.jp))<sup>1</sup>  
49

50  
51 Shigeki Fujitani ([shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com))<sup>1</sup> Corresponding author  
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1 Takuro Endo; Prehospital NEWS in Japan  
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6 Author institution  
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8  
9 <sup>1</sup> Department of Emergency and Critical Care Medicine, St. Marianna University School  
10  
11  
12 of Medicine, 2-16-1, Sugao, Miyamae, Kawasaki, Kanagawa, 216-8511 Japan. Phone:  
13  
14  
15 +81-44-977-8111  
16

17  
18 <sup>2</sup> Department of Information and Computer Technology, Faculty of Engineering, Tokyo  
19  
20  
21 University of Science, Tokyo, Japan.  
22

23  
24 <sup>3</sup> Department of Preventive Medicine, St. Marianna University School of Medicine,  
25  
26  
27 Kawasaki, Kanagawa, Japan.  
28

29  
30 <sup>4</sup> Department of Emergency Medicine, College of medicine, National Cheng Kung  
31  
32 University, Tainan, Taiwan.  
33

34  
35  
36  
37 Corresponding author  
38

39 Shigeki Fujitani, MD, PhD  
40

41 Department of Emergency and Critical Care Medicine, St. Marianna University School of  
42  
43 Medicine  
44

45  
46 2-16-1, Sugao, Miyamae-ku, Kawasaki-shi, Kanagawa-ken, Japan  
47

48 Tel: 81-44-977-8111  
49

50 Fax: 81-44-979-1522  
51

52 E-mail: [shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com)  
53  
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55  
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30 Article summary

- 31 ➤ NEWS was developed for in-hospital patients in 2012 and has recently been verified  
32 for use in prehospital setting. As a result of prehospital NEWS verification in several  
33 countries such as the United Kingdom, it is known that prehospital NEWS predicts  
34 death and outpatient disposition (hospitalization or not) with high accuracy.  
35  
36 ➤ In Japan, in-hospital EWS is beginning to be used gradually, but there is no report  
37 about use or verification of out-of-hospital EWS. This retrospective study shows in  
38 Japan where the aging of the population is extremely advanced, outpatient  
39 disposition was predicted with high accuracy by NEWS calculated from vital signs in  
40 prehospital setting. This result strengthens universal value of prehospital NEWS not  
41 only in a specific country but also in different race and fast-aging countries.  
42  
43 ➤ This study has several limitations. It was a retrospective study conducted in a single  
44 center. Therefore, the findings may not be generalizable to all populations in Japan.  
45 judgment for deciding the outpatient disposition of each emergency physician is  
46 standardized referring to guidelines but does not match exactly.  
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5 Abstract  
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8 **Objectives**  
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10 The national early warning score (NEWS) was originally developed in the UK to assess  
11 hospitalized patients. We examined whether the NEWS can be applied to patients  
12 transported by an ambulance in Japan.  
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16 **Methods**  
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18 Patients transported to a Japanese tertiary hospital between April 2017 and March  
19 2018 were assessed. The NEWS from vital signs recorded by paramedics was  
20 calculated. The emergency department (ED) disposition data were categorized into the  
21 following groups: discharged from the ED, admitted to the ward, admitted to the  
22 intensive care unit (ICU), or died in the ED. The predictive performance of the NEWS  
23 for patient dispositions using receiver operating characteristics curves was assessed.  
24 Patient dispositions were compared among NEWS-based categories after adjusting for  
25 age, gender, and presence of traumatic injury.  
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31 **Results**  
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33 Of the 2,847 patients, the mean ( $\pm$  standard deviation) NEWS of patients who were  
34 discharged from the ED ( $n=1330$ ,  $3.7 \pm 2.9$ ), admitted to the ward ( $n=1263$ ,  $6.3 \pm 3.8$ ),  
35 admitted to the ICU ( $n=232$ ,  $9.4 \pm 4.0$ ), and died in the ED ( $n=22$ ,  $11.7 \pm 2.9$ ) were  
36 statistically different in each group ( $p<0.001$ ). Prehospital NEWS's C-statistics (95%  
37 confidence interval; CI) for admission to the ward, admission to the ICU, or death in the  
38 ED was 0.73 (0.72-0.75), admission to the ICU or death in the ED was 0.81 (0.78-  
39 0.83), and death in the ED was 0.90 (0.87-0.93). After adjusting for age, gender and  
40 trauma, the odds ratio (95% CI) of admission to the ICU or death in the ED for the high-  
41 risk category (NEWS  $\geq 7$ ) was 13.8 (8.9-21.6) and that for the medium-risk category  
42 (NEWS 5–6) was 4.2 (2.5-7.1).  
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49 **Conclusion**  
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51 Based on the findings from a Japanese tertiary hospital setting, our study shows that  
52 prehospital NEWS can identify patients at risk of adverse outcomes. The NEWS  
53 stratification had a strong correlation with patient dispositions.  
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5 Main text  
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8 **Introduction**  
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11 Early warning score (EWS) was developed as a guide for a quick assessment and  
12 early diagnosis of an acute illness in patients admitted to hospitals.<sup>1</sup> It was intended to  
13 serve as a track and trigger tool to make consistent assessments of illness severity as  
14 well as to provide useful baseline data to evaluate the patient's clinical progress.<sup>2</sup>  
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19 In 2012, The Royal College of Physicians developed the national early warning score  
20 (NEWS) to improve early detection rates of clinical deterioration. Initially, the NEWS  
21 was used to predict illness severity and deterioration in a hospital setting.<sup>3</sup> Since 2015,  
22 it has been implemented across counties in the West of England area, with the aim of  
23 computing the NEWS for all patients prior to a referral to an acute care facility.<sup>4</sup>  
24 Furthermore, in a previous study, in-depth qualitative interviews with healthcare  
25 professionals had been carried out to identify the barriers and facilitators to the  
26 implementation of NEWS in prehospital, primary care, and community settings.<sup>5</sup> In this  
27 study, participants described that NEWS could support clinical decision-making around  
28 the escalation of care, and provide a clear means of communicating clinical acuity  
29 between clinicians and across different healthcare organizations.  
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37 A recent review showed that very low and high EWS could distinguish between  
38 patients who were not likely and those who were likely to deteriorate in the prehospital  
39 setting.<sup>6</sup> Some studies have also begun to apply NEWS extensively in prehospital  
40 settings and emergency departments.<sup>7-13</sup> Most studies have used mortality as a primary  
41 outcome for evaluating prehospital setting NEWS<sup>8-13</sup>. Meanwhile, in 2017, Shaw et al.  
42 used subsequent discharge disposition as the primary outcome.<sup>7</sup>  
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48 It is not clear how factors, such as health care systems, geographical conditions, and  
49 race, affect EWS. Within Asia, three countries—Iran, Hong Kong, and China—have  
50 published reports on EWS in prehospital settings<sup>11-13</sup>; however, in Japan, this has never  
51 been reported.  
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55 While life expectancy in Japan is high, it also faces the problem of an aging society<sup>14</sup>.  
56 The proportions of populations aged 65 years and higher in Iran, China, Hong Kong,  
57 the UK, and Japan are 5.6%, 9.6%, .6%, 17.8%, and 26.3%, respectively.<sup>15</sup> Given the  
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6 rapidly aging society, an increasing number of ambulance deliveries for patients with  
7 multiple comorbidities is expected to become more common than before. However,  
8 studies evaluating NEWS in prehospital settings in aging countries are limited. Thus,  
9 the present study aimed to examine the use of NEWS in the aging society of Japan  
10 and its application to emergency transportation.  
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## 14 Method

### 15 Patient and public involvement

16 Patients or the public were not involved in the design of the study.  
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### 20 Setting and population

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

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

50 Prehospital data and hospital data were collected separately, after which they were  
51 integrated. Prehospital data were recorded on a paper by paramedics at the scene, and  
52 data on chief complaints and vital signs, including heart rate, respiratory rate, systolic  
53 blood pressure, arterial oxygen saturation, temperature, and conscious level, were  
54 collected.  
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58 Chief complaints were categorized based on the Advanced Medical Priority Dispatch  
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5 System (AMPDS) categories as in a previous study<sup>8</sup>. Patients were categorized into the  
6 following four groups depending on their disposition, based on a previous study<sup>7</sup>:  
7 discharge from the emergency department (ED), admission to the ward, intensive care  
8 unit (ICU) admission, or death in the ED.  
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### 13 NEWS

14 NEWS ranges from 0 to 20. Each vital sign is scored from 0 to 3. When a patient is given  
15 supplementary oxygen, two points are added to the total score (Supplementary Table  
16 1).<sup>3</sup> We calculated the total post hoc NEWS from the vital signs.  
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### 21 Statistical analyses

22 SPSS® Ver.25 (Chicago, IL, USA) was used for statistical analyses. A p-value <0.05 was  
23 considered statistically significance. Patients' age, gender, and the presence of traumatic  
24 injury were summarized by the four categories based on their ED disposition, and  
25 presented the chief complaints made during the ambulance call. Distributions of NEWS  
26 were compared between the ED disposition groups using the Kruskal–Wallis test.  
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31 We assessed the discriminatory ability of the continuous-scale NEWS to predict patient  
32 ED dispositions, using receiver operating characteristics (ROC) curves and the area  
33 under the curves (C-statistics). For the ordered nature of the ED disposition outcome  
34 (discharge from the ED, ward or ICU admission, or death in the ED), we combined the  
35 outcomes as follows: 1) ward or ICU admission, or death in the ED, 2) admission to the  
36 ICU or death in the ED and 3) death in the ED, which would provide more interpretable  
37 results than analysis of each disposition outcome.  
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43 From the ROC curves, we obtained sensitivity and specificity of possible cut-off points  
44 that served as coordinate points for the ROC curves, from which possible cut-off values  
45 for risk categorization were derived.  
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49 Finally, two combined outcomes (ICU admission or death in the ED and death in the ED)  
50 were compared among the NEWS-based categories, without and after adjusting for age,  
51 gender, and the presence of traumatic injury.  
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55 The study protocol was approved by the Institutional Review Board of St. Marianna  
56 University, School of Medicine.  
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## 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 ( $\pm$ standard deviation) age of the participants was 66.5  $\pm$ 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  $\pm$  20.3, 68.8  $\pm$  18.8, 68.5  $\pm$  18.7, and 72.6  $\pm$  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 ( $\pm$  standard deviation) NEWSs increased for groups discharged from the ED (3 and 3.7  $\pm$  3.9), admitted to the ward (6 and 6.3  $\pm$  3.8), admitted to ICU (9 and 9.4  $\pm$  4.0), and died in the ED (11.5 and 11.7  $\pm$  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

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5 **Figure 3** shows the ROCs for patient disposition combined outcomes by continuous-  
6 scale NEWS. The area under the receiver-operating characteristics (AUROCs) (95%  
7 confidence interval [CI]) for prehospital NEWS for ward/ICU admission or death in the  
8 ED, ICU admission or death in the ED, and death in the ED were 0.73 (0.72–0.75),  
9 0.81 (0.78–0.83), and 0.90 (0.87–0.93), respectively.  
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14 **Supplementary Figure 1** also shows the ROCs of the prediction of each patient's  
15 disposition—discharged from the ED, admitted to the ward, admitted to the ICU, and  
16 died in the ED—using NEWS.  
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### 20 Cut-off NEWSs for clinical risk categories

21 Based on the coordinate points of the ROC curve (**Supplementary Table 8**), the “high  
22 risk” cut-off was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1-  
23 specificity of 0.30 for admission to the ICU or death in the ED), and the “low risk” cut-off  
24 was set between 4 and 5 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the  
25 ward/ICU admission or death in the ED). Accordingly, we adopted the categorization  
26 scheme for low-risk (NEWS $\leq$ 4), medium-risk (5 or 6), and high-risk ( $\geq$ 7).  
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### 32 Risk category by patient disposition group

33 **Table 2** shows that higher NEWS is associated with deteriorating patient disposition. In  
34 the low-risk group ( $n=1,327$ ), the highest proportion of patients were discharged from  
35 the ED ( $n=853$ , 64.3%), followed by those admitted to the ward ( $n=451$ , 34.0%),  
36 admitted to the ICU ( $n=23$ , 1.7%), and died in the ED ( $n=0$ , 0%). Conversely, patients  
37 in the high-risk group ( $n=979$ ) had a greater probability of being admitted to the ward  
38 ( $n=568$ , 58.0%), being admitted to the ICU ( $n=172$ , 17.6%), and dying in the ED ( $n=22$ ,  
39 0.8%). Focusing on those who died in the ED, 100% ( $n=22$ ) of the participants were  
40 categorized as high-risk participants.  
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### 49 The relationship between NEWS risk level and outcome

50 Binary logistic regression models were used to further examine the relationship  
51 between the NEWS risk category and the combined patient disposition outcomes  
52 (**Table 3**; note that death in the ED occurred only in the high-risk group, and we did not  
53 perform the logistic analysis for death in the ED). ICU admission or death in the ED in  
54 the medium-risk group (odds ratio: 4.2, 95% CI: 2.5 to 7.1,  $p<0.001$ ) and the high risk  
55 group (odds ratio: 13.8; 95% CI: 8.9 to 21.6,  $p<0.001$ ) significantly increased in  
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6 comparison to the low-risk group even after adjusting for age, gender, and trauma.  
7 Similarly, admission to the ward/the ICU or death in the ED in the medium-risk group  
8 (odds ratio: 1.9; 95% CI: 1.6 to 2.4,  $p < 0.001$ ) and the high-risk group (odds ratio: 6.1;  
9 95% CI: 5.0 to 7.3,  $p < 0.001$ ) also increased comparison to the low-risk group.  
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### 13 Discussion 14 15

16 This study aimed to evaluate the efficacy of NEWS to predict patient disposition in  
17 prehospital settings. Our findings indicate that prehospital NEWS could identify critical  
18 patients and those at risk of adverse outcomes. In recent years, several studies have  
19 conducted on prehospital EWS, and four representative reports<sup>7-10</sup> of NEWS have been  
20 published. A 2018 study conducted in Finland<sup>10</sup> showed the highest for 12,426 cases  
21 in two hospitals using short-term mortality rate as the primary outcome. Only a recent  
22 previous study of 287 patients conducted in the UK used patient disposition as the  
23 primary outcome.<sup>7</sup> The present study examined 2,847 cases, which is by far largest  
24 among studies that used patient disposition as the primary outcome.  
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31 The present study found that prehospital NEWS predicted patient disposition in an ED in  
32 Japan. Once the patient was categorized as high-risk or medium-risk based on their  
33 NEWS, the probability of ICU admission or death in the ED increased. We demonstrated  
34 the usefulness of prehospital NEWS in predicting the severity of an illness among  
35 participants with different demographic characteristics. Our findings indicate the  
36 usefulness of NEWS even for the older population.  
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41 Previous studies have used risk category with odds ratios to calculate early death  
42 within 24 or 48 hours after hospitalization<sup>8,10</sup>. Our study is the first = in which outpatient  
43 clinical outcomes were calculated by risk category with odds ratio. In 2017, a study  
44 showed that high-risk patients (those with NEWS  $\geq 7$ ) demonstrated a relatively higher  
45 risk for a one-day mortality rate of 101.5 compared to the low-risk group ( $\leq 4$ ).  
46 Moreover, for medium-risk patients (NEWS 5,6), a greater risk for one-day mortality  
47 rate of 4.4 was seen compared to low-risk patients, without adjusting for age, gender  
48 and trauma. In our research, the rate of ICU admission or death in the ED in the  
49 medium-risk group (odds ratio: 4.2, 95% CI: 2.5 to 7.1,  $p < 0.001$ ) and the high-risk  
50 group (odds ratio: 14.0; 95% CI: 9.0 to 21.8,  $p < 0.001$ ) significantly increased in  
51 comparison to the low-risk group, without adjusting for age, gender and trauma  
52 (Table3).  
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7 In a previous study conducted in the UK in 2016, patients who died or were admitted to  
8 the ICU had higher NEWS than those admitted to the ward or discharged from the ED.  
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10 <sup>7</sup> On the other hand, the present study found differences in the mean NEWSs on all  
11 segments (Figure 2 and Supplementary Table 7). The higher average NEWSs than  
12 those in the previous study for all groups could be explained by the fact that data were  
13 collected at a tertiary medical institution. Thus, it is appropriate to use an objective  
14 scoring system such as NEWS to compare the attributes of patients transported by  
15 ambulances.  
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20 Further, it is worth noting that the cut-off NEWS in the prehospital setting did not differ  
21 from cut-off value for NEWS in the hospital setting.<sup>3</sup> A few studies have reported the  
22 validity of the cut-off values for the NEWS in out-hospital settings. In the previous four  
23 studies<sup>7-10</sup>, patients were categorized into low-, medium-, and high-risk groups, according  
24 to the guidelines by the Royal College of Physicians.<sup>3</sup>  
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28 According to the definition of NEWS based on in-hospital patients, validation was  
29 considered necessary to confirm risk classification for out-of-hospital patients. Thus,  
30 ROC curve and specified coordinate points were evaluated. The cut-off NEWSs for  
31 prehospital assessment was in line with the definition for in-hospital NEWS prediction  
32 (Supplementary Table 8). As medical interventions are not applied in the prehospital  
33 environment, cut-off scores for the risk categories will differ from those in an in-hospital  
34 environment. Thus, future studies should use larger datasets to confirm this finding.  
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40 In Japan, some studies have confirmed the usefulness of EWS in the hospital and  
41 triage.<sup>19-22</sup> However, several countries require nationwide in-hospital EWS  
42 implementation, and in the UK it has been widely used in prehospital settings, outpatients  
43 and emergency services.<sup>4</sup> The paramedics in Japan should directly request the hospital  
44 for ambulance acceptance on the scene. In fact, it is often difficult to obtain hospital  
45 acceptance for transportation, because the number of transportation has been  
46 increasing each year.<sup>17</sup> Furthermore, the duration of making an ambulance call until  
47 arrival at the hospital is also gradually increasing.<sup>23 24</sup> This might delay crucial emergency  
48 treatments, which in turn might worsen the patient's outcomes. NEWS-based risk  
49 stratification helps paramedics understand the severity of the patient's condition and  
50 communicate it accurately with a healthcare professional at the hospital. Earlier  
51 identification of critical patients might facilitate earlier resuscitation and appropriate  
52 critical care.<sup>8</sup>  
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7 We used outpatient disposition as the primary outcome in this study. Most previous  
8 reports have considered short-term mortality as the primary outcome to assess the  
9 usefulness of prehospital NEWS.<sup>6 9 10</sup> As it predicts outpatient outcomes in addition to  
10 short-term mortality, the NEWS is a very useful tool. We are also currently analyzing  
11 the relationship between prehospital NEWS and mortality rate with more extensive  
12 data and exploring the possibility of predicting death more accurately by integrating  
13 other factors (chief complaints etc.).  
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19 The strengths of this study are as follows. This study is the first in Japan to show that  
20 the NEWS can be used in a prehospital setting to predict patient disposition in Japan.  
21 Our dataset was much larger compared to those used in previous study<sup>7</sup>, which  
22 indicates higher reliability. It is noteworthy that the result obtained by calculating the  
23 cut-off values for the out-hospital setting is the same as that obtained in the in-hospital  
24 setting.  
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### 29 Limitations

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

39 Our study suggests the usefulness of NEWS to categorize ED cases at patient's arrival  
40 by ambulance. The study also found that elevated NEWS among unselected prehospital  
41 patients could predict patient disposition at the ED in Japan. The NEWS has a wide  
42 range of uses in prehospital settings. A prospective multicenter study is needed to  
43 validate the usefulness of NEWS in the prehospital setting.  
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7 our department paramedic Mr. Daigo Ando for their help in collecting the data.  
8  
9

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11 TE, KM, SiF and YT conceived the research idea and designed the study. TE, ShF, TN  
12 DA and AH collected the data. TE, MT, JT, TN, NS and TS provided statistical advice  
13 on study design and analysed the data. TE, AH and SiF chaired the data oversight  
14 committee. TE, HCH and TY drafted the first version of the manuscript. TE, SiF and YT  
15 takes public responsibility of the contents of this paper.  
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25  
26  
27

#### 28 **Competing interests**

29 None declared.  
30  
31

#### 32 **Patient consent**

33 Not required.  
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#### 37 **Ethics approval**

38 The research protocol received approval from the ethics committee of the Institutional  
39 Review Board of St Marianna University School of Medicine, No 4325.  
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#### 43 **Provenance and peer review**

44 Not commissioned; externally peer reviewed.  
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#### 48 **Data sharing statement**

49 No additional data are available.  
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#### 52 **Open Access**

53 This is an Open Access article distributed in accordance with the Creative Commons  
54 Attribution Non Commercial (CC BY-NC 4.0) license,  
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## Takuro Endo; Prehospital NEWS in Japan

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 $\pm$ SD	66.5 $\pm$ 19.6	63.9 $\pm$ 20.3	68.8 $\pm$ 18.8	68.5 $\pm$ 18.7	72.6 $\pm$ 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

Takuro Endo; Prehospital NEWS in Japan

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

NEWS clinical risk level	Patient disposition				All
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	
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

Takuro Endo; Prehospital NEWS in Japan

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
<b>Event 1. Admission to the ICU or death in the ED</b>							
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
<b>Event 2. Admission to the Ward or ICU or death in the ED</b>							
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

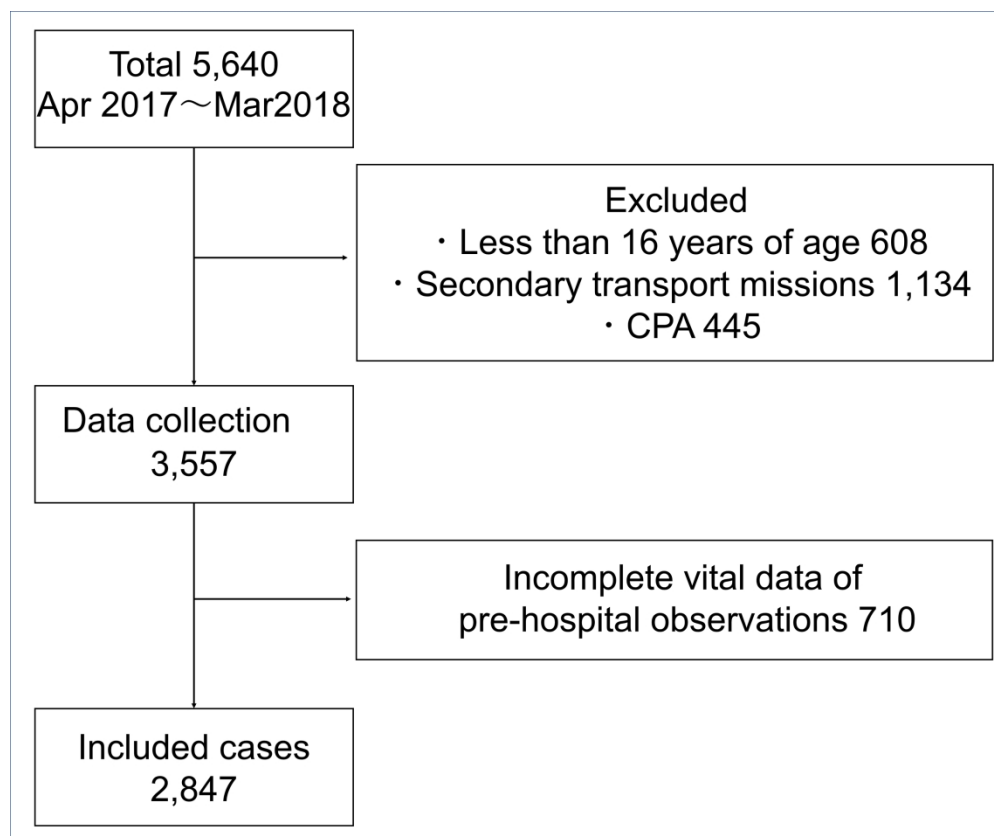


Figure 1. Flow diagram of cases included in the analysis.  
CPA: cardio-pulmonary arrest

259x215mm (300 x 300 DPI)



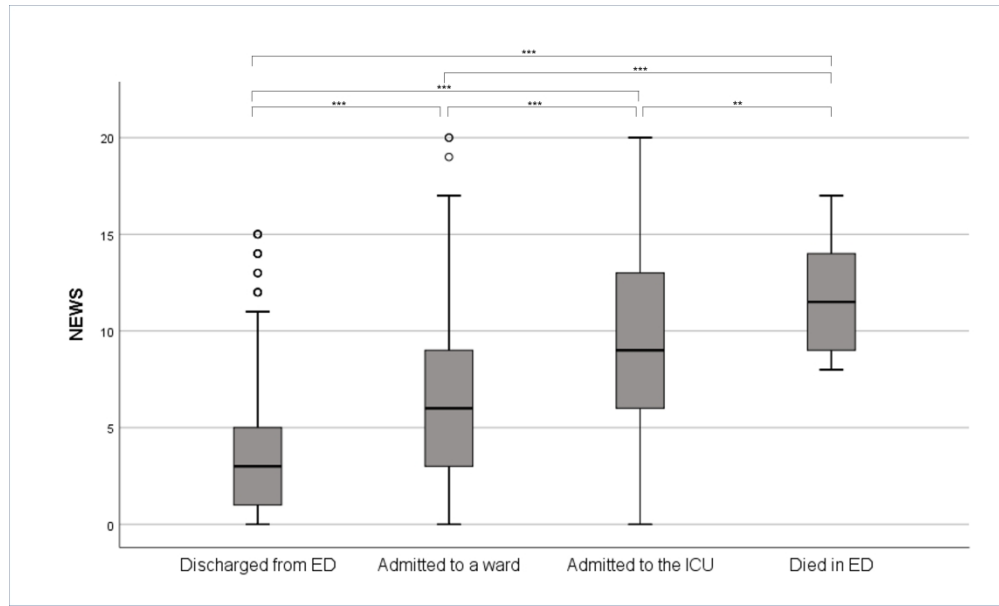


Figure2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxon tests.

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

479x287mm (300 x 300 DPI)

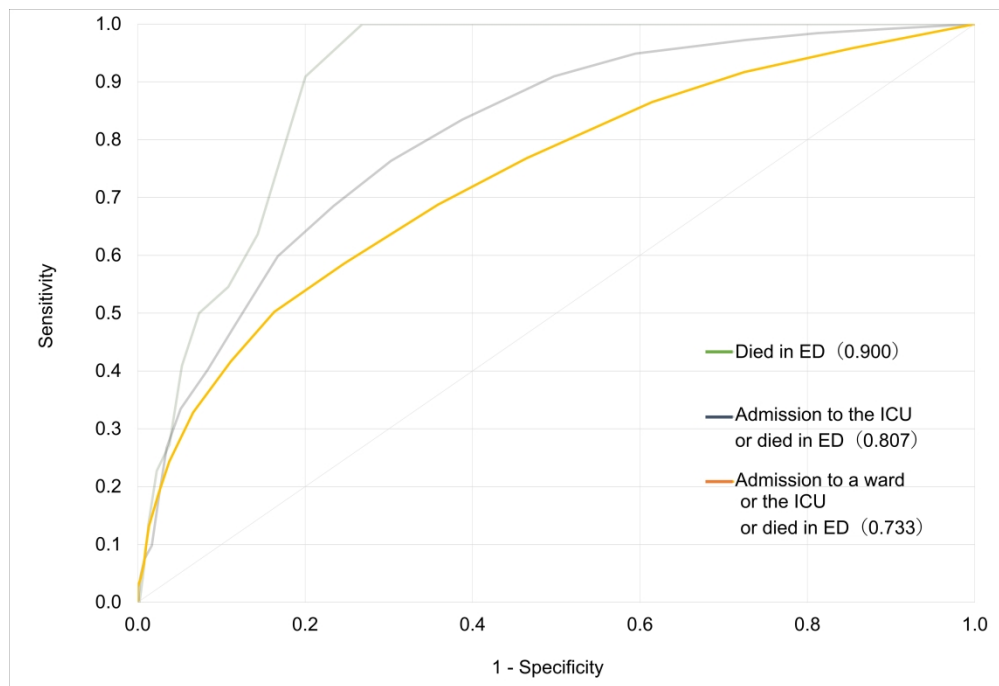


Figure 3.  
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.

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

400x273mm (300 x 300 DPI)

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Supplementary Table 1. Scoring system of NEWS.

Physiological parameters	+3	+2	+1	0	+1	+2	+3
Respiration Rate	$\leq 8$		9~11	12~ 20		21~24	25 $\leq$
Oxygen Saturations	$\leq 91$	92~93	94~95	$\geq 96$			
Any Supplemental Oxygen		Yes		No			
Temperature	$\leq 35.0$		35.1~ 36.0	36.1~ 38.0	38.1~ 39.0		39.1 $\leq$
Systolic Blood Pressure	$\leq 90$	91~ 100	101~ 110	111~ 219			220 $\leq$
Heart rate	$\leq 40$		41~50	51~ 90	91~ 110	111~ 130	131 $\leq$
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. 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
<b>Total</b>	<b>100</b>	<b>2,847</b>

AMPDS: advanced medical priority dispatch system

Takuro Endo; Prehospital NEWS in Japan

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

Takuro Endo; Prehospital NEWS in Japan

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
<b>Total</b>	<b>100</b>	<b>1,263</b>

AMPDS: advanced medical priority dispatch system

Takuro Endo; Prehospital NEWS in Japan

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
<b>Total</b>	<b>100</b>	<b>232</b>

ICU: intensive care unit

AMPDS: advanced medical priority dispatch system

Takuro Endo; Prehospital NEWS in Japan

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



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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

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4	15.50	0.026	0.000	0.075	0.008	0.136	0.013
5	16.50	0.013	0.000	0.043	0.003	0.045	0.006
6	17.50	0.004	0.000	0.012	0.001	0.000	0.002
7	18.50	0.003	0.000	0.004	0.001	0.000	0.001
8	19.50	0.002	0.000	0.004	0.001	0.000	0.001
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13 ROC: receiver operating characteristics

14 ED: emergency department

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16 ICU: intensive care unit  
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1 Takuro Endo; Prehospital NEWS in Japan  
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6 Supplementary legend:  
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9 Supplementary Figure 1. The ROC curves of the prediction of NEWS for each patient  
10 disposition. Each area under the curve (C-statistic) is depicted in the parenthesis in the  
11 graph.  
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14 Vertical line: sensitivity

15 Horizontal line: 1-specificity  
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19 ROC: receiver operating characteristic

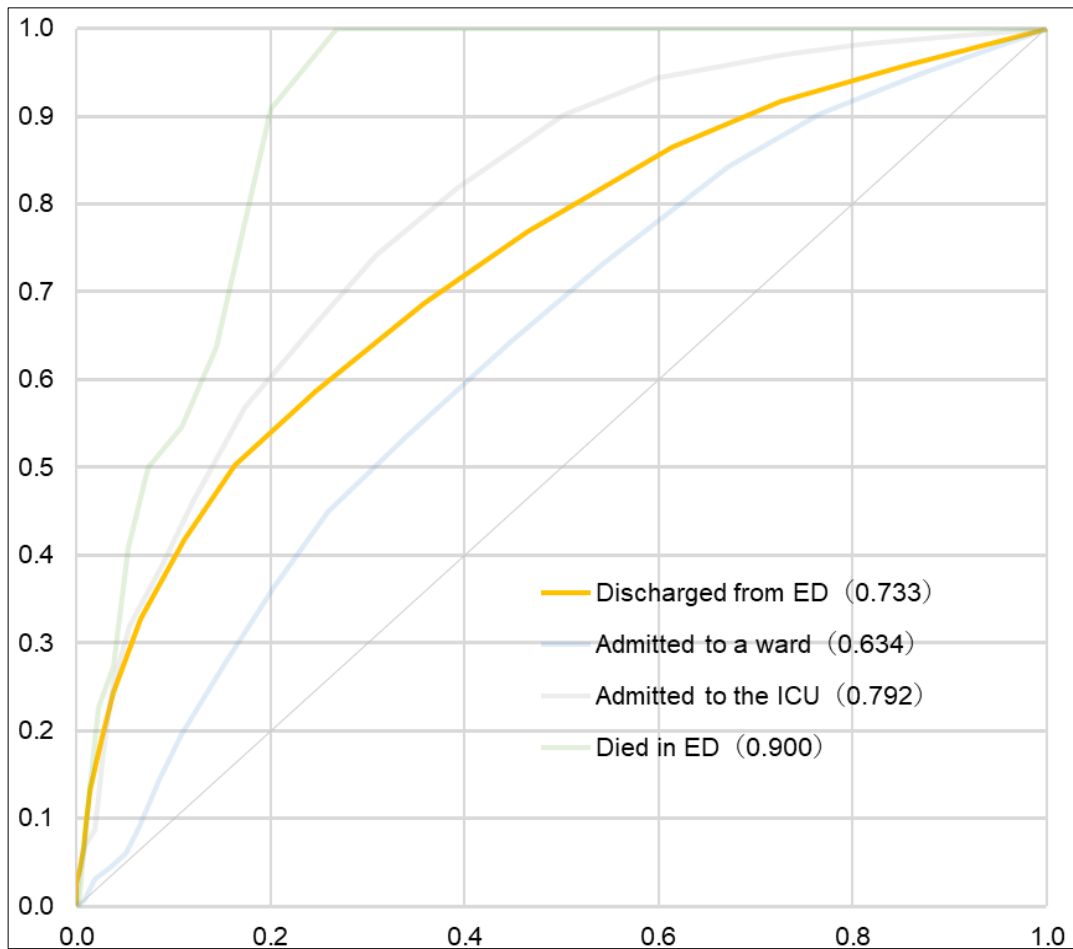
20 NEWS: national early warning score

21 ED: emergency department

22 ICU: intensive care unit  
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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.

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<b>Primary Subject Heading</b>:	Emergency medicine
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1 Takuro Endo; Prehospital NEWS in Japan  
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5 Original article  
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8 Title of the article  
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10 A retrospective study to evaluate the efficacy of prehospital National Early Warning  
11 Score to predict outpatient disposition at the Emergency Department in a Japanese  
12 tertiary hospital.  
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16 Authors  
17

18 Takuro Endo ([Takuroendo@gmail.com](mailto:Takuroendo@gmail.com))<sup>1</sup> First author  
19

20 Toru Yoshida ([yoshidat@marianna-u.ac.jp](mailto:yoshidat@marianna-u.ac.jp))<sup>1</sup>  
21

22 Tomohiro Shinozaki ([shinozaki@rs.tus.ac.jp](mailto:shinozaki@rs.tus.ac.jp))<sup>2</sup>  
23

24 Takako Motohashi ([motohashi-takako@marianna-u.ac.jp](mailto:motohashi-takako@marianna-u.ac.jp))<sup>3</sup>  
25

26 Hsiang-Chin Hsu ([i3593120@gmail.com](mailto:i3593120@gmail.com))<sup>4</sup>  
27

28 Shunsuke Fukuda ([s0711732@hotmail.co.jp](mailto:s0711732@hotmail.co.jp))<sup>1</sup>  
29

30 Jumpei Tsukuda ([jumpechan@yahoo.co.jp](mailto:jumpechan@yahoo.co.jp))<sup>1</sup>  
31

32 Takaki Naito ([takaki.jc@gmail.com](mailto:takaki.jc@gmail.com))<sup>1</sup>  
33

34 Kenichiro Morisawa ([kmori0079@yahoo.co.jp](mailto:kmori0079@yahoo.co.jp))<sup>1</sup>  
35

36 Nobuhiko Shimosawa ([simozawa@marianna-u.ac.jp](mailto:simosawa@marianna-u.ac.jp))<sup>1</sup>  
37

38 Yasuhiko Taira ([y2taira@marianna-u.ac.jp](mailto:y2taira@marianna-u.ac.jp))<sup>1</sup>  
39

40 Shigeki Fujitani ([shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com))<sup>1</sup> Corresponding author  
41  
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1 Takuro Endo; Prehospital NEWS in Japan  
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9 Author institution  
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11  
12 <sup>1</sup> Department of Emergency and Critical Care Medicine, St. Marianna University School  
13  
14 of Medicine, 2-16-1, Sugao, Miyamae, Kawasaki, Kanagawa, 216-8511 Japan. Phone:  
15  
16  
17  
18 +81-44-977-8111  
19

20  
21 <sup>2</sup> Department of Information and Computer Technology, Faculty of Engineering, Tokyo  
22  
23 University of Science, Tokyo, Japan.  
24

25  
26  
27 <sup>3</sup> Department of Preventive Medicine, St. Marianna University School of Medicine,  
28  
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40 Corresponding author  
41

42 Shigeki Fujitani, MD, PhD  
43

44 Department of Emergency and Critical Care Medicine, St. Marianna University School of  
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2-16-1, Sugao, Miyamae-ku, Kawasaki-shi, Kanagawa-ken, Japan

Tel: 81-44-977-8111

Fax: 81-44-979-1522

E-mail: [shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com)

1 Takuro Endo; Prehospital NEWS in Japan  
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1 Takuro Endo; Prehospital NEWS in Japan  
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5 Abstract  
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8 **Objectives**  
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10 The National Early Warning Score (NEWS) was originally developed in the United  
11 Kingdom to assess hospitalized patients. We examined whether the NEWS can be  
12 applied to patients transported by an ambulance in Japan.  
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16 **Methods**  
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18 Patients transported to a Japanese tertiary hospital between April 2017 and March  
19 2018 were assessed. The NEWS from vital signs recorded by paramedics was  
20 calculated. The emergency department (ED) disposition data were categorized into the  
21 following groups: discharged from the ED, admitted to the ward, admitted to the  
22 intensive care unit (ICU), or died in the ED. The predictive performance of the NEWS  
23 for patient dispositions using receiver operating characteristics curves was assessed.  
24 Patient dispositions were compared among NEWS-based categories after adjusting for  
25 age, gender, and presence of traumatic injury.  
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31 **Results**  
32

33 Of the 2,847 patients, the mean ( $\pm$  standard deviation) NEWS of patients who were  
34 discharged from the ED ( $n=1330$ ,  $3.7 \pm 2.9$ ), admitted to the ward ( $n=1263$ ,  $6.3 \pm 3.8$ ),  
35 admitted to the ICU ( $n=232$ ,  $9.4 \pm 4.0$ ), and died in the ED ( $n=22$ ,  $11.7 \pm 2.9$ ) were  
36 statistically different in each group ( $p<0.001$ ). Prehospital NEWS's C-statistics (95%  
37 confidence interval; CI) for admission to the ward, admission to the ICU, or death in the  
38 ED was 0.73 (0.72-0.75), admission to the ICU or death in the ED was 0.81 (0.78-  
39 0.83), and death in the ED was 0.90 (0.87-0.93). After adjusting for age, gender and  
40 trauma, the odds ratio (95% CI) of admission to the ICU or death in the ED for the high-  
41 risk category (NEWS  $\geq 7$ ) was 13.8 (8.9-21.6) and that for the medium-risk category  
42 (NEWS 5–6) was 4.2 (2.5-7.1).  
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49 **Conclusion**  
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51 Based on the findings from a Japanese tertiary hospital setting, our study shows that  
52 prehospital NEWS can identify patients at risk of adverse outcomes. The NEWS  
53 stratification had a strong correlation with patient dispositions.  
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6 Strengths and limitations

- 7 ➤ This study is a first retrospective study to evaluate the efficacy of prehospital  
8 National Early Warning Score (NEWS) calculated from vital signs described by  
9 paramedics in Japan.  
10  
11 ➤ Sample number of this study is larger than the prior study; therefore it works as  
12 external validation of prehospital NEWS for predicting outpatient disposition at the  
13 Emergency Department.  
14  
15 ➤ This study was conducted in an aging society Japan, the result will be helpful when  
16 other countries become an aging society.  
17  
18 ➤ This study also examined how adjustment for age, gender, and trauma changed the  
19 association between the NEWS risk score and outcomes.  
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21 ➤ It was conducted in a single center; therefore, the findings may not be generalizable  
22 to all populations in Japan.  
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5 Main text  
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8 Introduction  
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10  
11 Early warning score (EWS) was developed as a guide for a quick assessment and  
12 early diagnosis of an acute illness in patients admitted to hospitals.<sup>1</sup> It was intended to  
13 serve as a track and trigger tool to make consistent assessments of illness severity as  
14 well as to provide useful baseline data to evaluate the patient's clinical progress.<sup>2</sup>  
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18  
19 In 2012, The Royal College of Physicians developed the National Early Warning Score  
20 (NEWS) to improve early detection rates of clinical deterioration. Initially, the NEWS  
21 was used to predict illness severity and deterioration in a hospital setting.<sup>3</sup> Since 2015,  
22 it has been implemented across counties in the West of England area, with the aim of  
23 computing the NEWS for all patients prior to a referral to an acute care facility.<sup>4</sup>  
24 Furthermore, in a previous study, in-depth qualitative interviews with healthcare  
25 professionals had been carried out to identify the barriers and facilitators to the  
26 implementation of NEWS in prehospital, primary care, and community settings.<sup>5</sup> In this  
27 study, participants described that NEWS could support clinical decision-making around  
28 the escalation of care, and provide a clear means of communicating clinical acuity  
29 between clinicians and across different healthcare organizations.  
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37 A recent review showed that very low and high EWS could distinguish between  
38 patients who were not likely and those who were likely to deteriorate in the prehospital  
39 setting.<sup>6</sup> Some studies have also begun to apply NEWS extensively in prehospital  
40 settings and emergency departments.<sup>7-13</sup> Most studies have used mortality as a primary  
41 outcome for evaluating prehospital setting NEWS<sup>8-13</sup>. Meanwhile, in 2017, Shaw et al.  
42 used subsequent discharge disposition as the primary outcome.<sup>7</sup>  
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48 It is not clear how factors, such as health care systems, geographical conditions, and  
49 race, affect EWS. Within Asia, three countries—Iran, Hong Kong, and China—have  
50 published reports on EWS in prehospital settings<sup>11-13</sup>; however, in Japan, this has never  
51 been reported.  
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55 While life expectancy in Japan is high, it also faces the problem of an aging society<sup>14</sup>.  
56 The proportions of populations aged 65 years and higher in Iran, China, Hong Kong,  
57 the United Kingdom (UK), and Japan are 5.6%, 9.6%, 15.1%, 17.8%, and 26.3%,  
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6 respectively.<sup>15</sup> Given the rapidly aging society, an increasing number of ambulance  
7 deliveries for patients with multiple comorbidities is expected to become more common  
8 than before. However, studies evaluating NEWS in prehospital settings in aging  
9 countries are limited. Thus, the present study aimed to examine the use of NEWS in  
10 the aging society of Japan and its application to emergency transportation.  
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## 14 Method

### 15 Patient and public involvement

16 Patients or the public were not involved in the design of the study.  
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### 20 Setting and population

21 This observational cohort study was conducted at St Marianna University School of  
22 Medicine, a 1,200-bed tertiary teaching hospital in Kawasaki city, Kanagawa prefecture.  
23 The Kawasaki city covers a geographical area of 144 km<sup>2</sup> and has a population of 1.5  
24 million people. The number of emergency ambulance transportations in this city is  
25 estimated to be 72,000 incidents per year.<sup>16</sup> There are 25 emergency hospitals in the  
26 city, of which St. Marianna Medical University Hospital is the biggest one.<sup>17</sup> Between  
27 April 2016 and March 2017, the number of patients conveyed by ambulance was 5,640  
28 and the number of walk-in patients was 16,922.  
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35 In principle, it is up to the paramedics to decide which hospital they should transport the  
36 patient to, based on the severity of the patient's condition and the distance to the  
37 hospital.<sup>18</sup>  
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### 41 Participants

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

56 Prehospital data and hospital data were collected separately, after which they were  
57 integrated. Prehospital data were recorded on a paper by paramedics at the scene, and  
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5 data on chief complaints and vital signs, including heart rate, respiratory rate, systolic  
6 blood pressure, arterial oxygen saturation, temperature, and conscious level, were  
7 collected.  
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10  
11 Chief complaints were categorized based on the Advanced Medical Priority Dispatch  
12 System (AMPDS) categories as in a previous study<sup>8</sup>. However, in Japan, this code was  
13 not used in practice. The appropriate code number was added using the chief complaint  
14 item of the paper written by the paramedics after transport.  
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19 Patients were categorized into the following four groups depending on their disposition,  
20 based on a previous study<sup>7</sup>: discharge from the emergency department (ED), admission  
21 to the ward, intensive care unit (ICU) admission, or death in the ED.  
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### 25 NEWS

26 NEWS ranges from 0 to 20. Each vital sign is scored from 0 to 3. When a patient is given  
27 supplementary oxygen, two points are added to the total score (Supplementary Table  
28 1).<sup>3</sup> We calculated the total post hoc NEWS from the vital signs.  
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### 32 Statistical analyses

33 SPSS® Ver.25 (Chicago, IL, USA) was used for statistical analyses. A p-value <0.05 was  
34 considered statistically significance. Patients' age, gender, and the presence of traumatic  
35 injury were summarized by the four categories based on their ED disposition, and  
36 presented the chief complaints made during the ambulance call. Distributions of NEWS  
37 were compared between the ED disposition groups using the Kruskal–Wallis test.  
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43 We assessed the discriminatory ability of the continuous-scale NEWS to predict patient  
44 ED dispositions, using receiver operating characteristics (ROC) curves and the area  
45 under the curves (C-statistics). For the ordered nature of the ED disposition outcome  
46 (discharge from the ED, ward or ICU admission, or death in the ED), we combined the  
47 outcomes as follows: 1) ward or ICU admission, or death in the ED, 2) admission to the  
48 ICU or death in the ED and 3) death in the ED, which would provide more interpretable  
49 results than analysis of each disposition outcome.  
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55 To obtain candidate cut-off values for hospital disposition, we started with Youden's index  
56 (sensitivity + specificity - 1). Among the range, we carefully chose high/middle-risk and  
57 middle/low-risk cut points that appropriately reflect clinical requirement. Details are  
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5 described in the Supplement Table 2.

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8 Finally, two combined outcomes (ICU admission or death in the ED and death in the ED)  
9 were compared among the NEWS-based categories, without and after adjusting for age,  
10 gender, and the presence of traumatic injury.  
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13  
14 The study protocol was approved by the Institutional Review Board of St. Marianna  
15 University, School of Medicine.  
16

## 17 18 19 Results

### 20 21 22 Participants' baseline characteristics

23 The total number of emergency ambulance transportation to the hospital was 5,640  
24 during this study period. After exclusions, 2,847 cases were selected for analyses  
25 (Figure 1).  
26  
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28  
29 Of the 2,847 cases, 1,330 (46.7%) were discharged from the ED, 1,263 (44.4%) were  
30 admitted to the ward, 232 (8.1%) were admitted to the ICU, and 22 (0.8%) died in the  
31 ED. The mean ( $\pm$ standard deviation) age of the participants was  $66.5 \pm 19.6$  years,  
32 median age is 73 years (lower to upper quartile: 53-82), with a bimodal (modes around 44  
33 and 82) and asymmetric instead of unimodal, symmetric distribution, and the proportion of  
34 male participants was 53.5%. The mean ages of patients who were discharged from the  
35 ED, admitted to the ward, admitted to the ICU, and those who died in the ED were  $63.9$   
36  $\pm 20.3$ ,  $68.8 \pm 18.8$ ,  $68.5 \pm 18.7$ , and  $72.6 \pm 20.2$ , respectively. ( $p < 0.001$ ; Table 1)  
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43 Patients' chief complaints at the time of calling an ambulance were sick person  
44 (19.8%), unconsciousness (13.8%), and breathing difficulty (13.3%) in Table 1. Other  
45 chief complaints of the patients at the time of calling an ambulance (Supplementary  
46 Table 3) included traumatic injury (8.3%), stroke (7.4%), abdominal pain (6.6%),  
47 hemorrhage (5.9%), chest pain (5.9%), headache (4.1%), back pain (3.3%), and drug  
48 overdose (3.1%). Furthermore, the chief complaints of each patient disposition group  
49 are presented in Table 1 and Supplementary Table 3.  
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### 56 57 NEWS for each patient disposition group

58 The boxplots in Figure 2 illustrates the distribution of prehospital NEWSs for each  
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6 disposition group. As shown in Supplementary Table 4, the median and mean ( $\pm$   
7 standard deviation) NEWSs increased for groups discharged from the ED (3 and  $3.7 \pm$   
8  $3.9$ ), admitted to the ward (6 and  $6.3 \pm 3.8$ ), admitted to ICU (9 and  $9.4 \pm 4.0$ ), and died  
9 in the ED (11.5 and  $11.7 \pm 2.9$ ). The distributions significantly differed between patient  
10 disposition groups according to the Kruskal-Wallis test ( $p < 0.001$ ).  
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#### 14 Discriminative performance of NEWS in the prehospital setting

15 Figure 3 shows the ROC curves for patient disposition combined outcomes by  
16 continuous-scale NEWS. The area under the receiver-operating characteristics  
17 (AUROCs) (95% confidence interval; CI) for prehospital NEWS for ward/ICU admission  
18 or death in the ED, ICU admission or death in the ED, and death in the ED were 0.73  
19 (0.72–0.75), 0.81 (0.78–0.83), and 0.90 (0.87–0.93), respectively.  
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#### 25 Cut-off NEWSs for clinical risk categories

26 Based on the coordinate points of the ROC curve (Supplementary Table 2), the “high  
27 risk” cut-off was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1-  
28 specificity of 0.30 for admission to the ICU or death in the ED), and the “low risk” cut-off  
29 was set between 4 and 5 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the  
30 ward/ICU admission or death in the ED). How to choose these values is described in  
31 Supplementary Table 2.  
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36 Accordingly, we adopted the categorization scheme for low-risk ( $NEWS \leq 4$ ), medium-  
37 risk (5 or 6), and high-risk ( $\geq 7$ ).  
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#### 42 Risk category by patient disposition group

43 Table 2 shows that higher NEWS is associated with deteriorating patient disposition. In  
44 the low-risk group ( $n=1,327$ ), the highest proportion of patients were discharged from  
45 the ED ( $n=853$ , 64.3%), followed by those admitted to the ward ( $n=451$ , 34.0%),  
46 admitted to the ICU ( $n=23$ , 1.7%), and died in the ED ( $n=0$ , 0%). Conversely, patients  
47 in the high-risk group ( $n=979$ ) had a greater probability of being admitted to the ward  
48 ( $n=568$ , 58.0%), being admitted to the ICU ( $n=172$ , 17.6%), and dying in the ED ( $n=22$ ,  
49 0.8%). Focusing on those who died in the ED, 100% ( $n=22$ ) of the participants were  
50 categorized as high-risk participants.  
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#### 56 The relationship between NEWS risk level and outcome

57 Binary logistic regression models were used to further examine the relationship  
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6 between the NEWS risk category and the combined patient disposition outcomes  
7 (Table 3; note that death in the ED occurred only in the high-risk group, and we did not  
8 perform the logistic analysis for death in the ED). ICU admission or death in the ED in  
9 the medium-risk group (odds ratio: 4.2, 95% CI: 2.5 to 7.1,  $p<0.001$ ) and the high risk  
10 group (odds ratio: 13.8; 95% CI: 8.9 to 21.6,  $p<0.001$ ) significantly increased in  
11 comparison to the low-risk group even after adjusting for age, gender, and trauma.  
12 Similarly, admission to the ward/the ICU or death in the ED in the medium-risk group  
13 (odds ratio: 1.9; 95% CI: 1.6 to 2.4,  $p<0.001$ ) and the high-risk group (odds ratio: 6.1;  
14 95% CI: 5.0 to 7.3,  $p<0.001$ ) also increased comparison to the low-risk group.  
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## 20 Discussion 21

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23 This study aimed to evaluate the efficacy of NEWS to predict patient disposition in  
24 prehospital settings. Our findings indicate that prehospital NEWS could identify critical  
25 patients and those at risk of adverse outcomes. The aim of this study was not to clarify  
26 when to use NEWS to predict outcomes more accurately, but to verify whether the  
27 paramedics could determine the severity from vital sign scores at the time of patient  
28 contact.  
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34 In recent years, several studies have conducted on prehospital EWS, and four  
35 representative reports<sup>7-10</sup> of NEWS have been published. A 2018 study conducted in  
36 Finland<sup>10</sup> showed the highest for 12,426 cases in two hospitals using short-term  
37 mortality rate as the primary outcome. Only a recent previous study of 287 patients  
38 conducted in the UK used patient disposition as the primary outcome.<sup>7</sup> The present  
39 study examined 2,847 cases, which is by far largest among studies that used patient  
40 disposition as the primary outcome.  
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46 In this case, there is 20% incomplete data for which no vital signs were obtained. Vital  
47 signs of patients transported from Kawasaki City were written on paper by paramedics  
48 and we got it. On the other hand, vital signs of patients transported from other areas  
49 (Tokyo, Yokohama next to Kawasaki) were not written on the report after transportation.  
50 These data could not be allowed to access for the personal privacy. Definitely we  
51 excluded 20% of the data for which no vital signs were obtained but the only difference  
52 is the area that has been transported and it is presumed to be essentially the same as  
53 the other 80% of patients.  
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6 The present study found that prehospital NEWS predicted patient disposition in an ED in  
7 Japan. Once the patient was categorized as high-risk or medium-risk based on their  
8 NEWS, the probability of ICU admission or death in the ED increased. We demonstrated  
9 the usefulness of prehospital NEWS in predicting the severity of an illness among  
10 participants with different demographic characteristics. Our findings indicate the  
11 usefulness of NEWS even for the older population.  
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16 It has been confirmed that prehospital NEWS fully predicts outpatient disposition even  
17 in an aging society, such as in Japan. Addition to our result and following the results of  
18 previous studies predicting outpatient disposition in the UK and other countries, these  
19 results suggest that prehospital NEWS might be available globally. It suggests that  
20 NEWS could be used when countries become an aging society like Japan in the future.  
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25 Previous studies have used risk category with odds ratios to calculate early death  
26 within 24 or 48 hours after hospitalization<sup>8 10</sup>. Our study is the first study in which  
27 outpatient clinical outcomes were calculated by risk category with odds ratio. In 2017, a  
28 study<sup>7</sup> showed that high-risk patients (those with NEWS  $\geq 7$ ) demonstrated a relatively  
29 higher risk for a one-day mortality rate of 101.5 compared to the low-risk group ( $\leq 4$ ).  
30 Moreover, for medium-risk patients (NEWS 5,6), a greater risk for one-day mortality  
31 rate of 4.4 was seen compared to low-risk patients, without adjusting for age, gender  
32 and trauma.  
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39 In our research, the rate of ICU admission or death in the ED in the medium-risk group  
40 (odds ratio: 4.2, 95% CI: 2.5 to 7.1,  $p < 0.001$ ) and the high-risk group (odds ratio: 14.0,  
41 95% CI: 9.0 to 21.8,  $p < 0.001$ ) significantly increased in comparison to the low-risk  
42 group, without adjusting for age, gender and trauma (Table3).  
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46 This study also examined how adjustment for age, gender, and trauma changed the  
47 association between the NEWS risk score and outcomes. The results of the analysis  
48 shown in Table 3 suggest that the use of the NEWS risk score with or without considering  
49 age, gender and trauma was clinically useful.  
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54 In a previous study conducted in the UK in 2016, patients who died or were admitted to  
55 the ICU had higher NEWS than those admitted to the ward or discharged from the ED.  
56 <sup>7</sup> On the other hand, the present study found differences in the mean NEWSs on all  
57 segments (Figure2 and Supplementary Table 4). The higher average NEWSs than  
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5 those in the previous study for all groups could be explained by the fact that data were  
6 collected at a tertiary medical institution. Thus, it is appropriate to use an objective  
7 scoring system such as NEWS to compare the attributes of patients transported by  
8 ambulances.  
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13 Further it is worth noting that the cut-off NEWS in the prehospital setting did not differ  
14 from cut-off value for NEWS in the hospital setting.<sup>3</sup> A few studies have reported the  
15 validity of the cut-off values for the NEWS in out-hospital settings. In the previous four  
16 studies<sup>7-10</sup>, patients were categorized into low-, medium-, and high-risk groups, according  
17 to the guidelines by the Royal College of Physicians.<sup>3</sup>  
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22 According to the definition of NEWS based on in-hospital patients, validation was  
23 considered necessary to confirm risk classification for out-of-hospital patients. Thus,  
24 ROC curve and specified coordinate points were evaluated. The cut-off NEWSs for  
25 prehospital assessment was in line with the definition for in-hospital NEWS prediction  
26 (Supplementary Table 2). As medical interventions are not applied in the prehospital  
27 environment, cut-off scores for the risk categories will differ from those in an in-hospital  
28 environment. Thus, future studies should use larger datasets to confirm this finding.  
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34 In Japan, some studies have confirmed the usefulness of EWS in the hospital and  
35 triage.<sup>19-22</sup> However, several countries require nationwide in-hospital EWS  
36 implementation, and in the UK it has been widely used in prehospital settings, outpatients  
37 and emergency services.<sup>4</sup> The paramedics in Japan should directly request the hospital  
38 for ambulance acceptance on the scene. In fact, it is often difficult to obtain hospital  
39 acceptance for transportation, because the number of transportation has been  
40 increasing each year.<sup>17</sup> Furthermore, the duration of making an ambulance call until  
41 arrival at the hospital is also gradually increasing.<sup>23 24</sup> This might delay crucial emergency  
42 treatments, which in turn might worsen the patient's outcomes. NEWS-based risk  
43 stratification helps paramedics understand the severity of the patient's condition and  
44 communicate it accurately with a healthcare professional at the hospital. Earlier  
45 identification of critical patients might facilitate earlier resuscitation and appropriate  
46 critical care.<sup>8</sup>  
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55 We used outpatient disposition as the primary outcome in this study. Most previous  
56 reports have considered short-term mortality as the primary outcome to assess the  
57 usefulness of prehospital NEWS.<sup>6 9 10</sup> As it predicts outpatient outcomes in addition to  
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5 short-term mortality, the NEWS is a very useful tool.  
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8 We are also currently analyzing the relationship between prehospital NEWS and  
9 mortality rate with more extensive data and exploring the possibility of predicting death  
10 more accurately by integrating other factors (chief complaints etc.). This study is the  
11 first step towards implementation of prehospital NEWS as a prehospital triage tool. In  
12 Japan there is no triage tool in the prehospital setting. The Japan Triage and Acuity  
13 Scale (JTAS) is currently used in the outpatient setting but it does not assume an  
14 emergency site. Aiming for using prehospital NEWS as a triage tool, additional analysis  
15 of "false positive" and "false negative" would be required. It is necessary to clarify what  
16 kind of cases are "Go home despite high score" and "ICU hospitalization despite low  
17 score". Next step we will analyze these data.  
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25 The strengths of this study are as follows. This study is the first in Japan to show that  
26 the NEWS can be used in a prehospital setting to predict patient disposition in Japan.  
27 Our dataset was much larger compared to those used in previous study<sup>7</sup>, which  
28 indicates higher reliability. It is noteworthy that the result obtained by calculating the  
29 cut-off values for the out-hospital setting is the same as that obtained in the in-hospital  
30 setting.  
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### 34 35 **Limitations**

36 This study has several limitations. It was a retrospective study conducted in a single  
37 center. Therefore, the findings may not be generalizable to all populations in Japan.  
38 Second, judgment for deciding the outpatient disposition of each emergency physician  
39 is standardized referring to guidelines but does not match exactly.  
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### 44 45 **Conclusion**

46 Our study suggests the usefulness of NEWS to categorize ED cases at patient's arrival  
47 by ambulance. The study also found that elevated NEWS among unselected prehospital  
48 patients could predict patient disposition at the ED in Japan. The NEWS has a wide  
49 range of uses in prehospital settings. A prospective multicenter study is needed to  
50 validate the usefulness of NEWS in the prehospital setting.  
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9

#### 10 **Contributors** 11

12 TE, KM, SiF and YT conceived the research idea and designed the study. TE, ShF, TN  
13 collected the data. TE, MT, JT, TN, NS and TS provided statistical advice on study  
14 design and analysed the data. TE and SiF chaired the data oversight committee. TE,  
15 HCH and TY drafted the first version of the manuscript. TE, SiF and YT takes public  
16 responsibility of the contents of this paper.  
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26  
27

#### 28 **Competing interests** 29

30 None declared.  
31

#### 32 **Patient consent** 33

34 Not required.  
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#### 37 **Ethics approval** 38

39 The research protocol received approval from the ethics committee of the Institutional  
40 Review Board of St Marianna University School of Medicine, No 4325.  
41  
42

#### 43 **Provenance and peer review** 44

45 Not commissioned; externally peer reviewed.  
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#### 48 **Data sharing statement** 49

50 No additional data are available.  
51

#### 52 **Open Access** 53

54 This is an Open Access article distributed in accordance with the Creative Commons  
55 Attribution Non Commercial (CC BY-NC 4.0) license,  
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## Takuro Endo; Prehospital NEWS in Japan

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

Takuro Endo; Prehospital NEWS in Japan

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

NEWS clinical risk level	Patient disposition				All
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	
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

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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
<b>Event 1. Admission to the ICU or death in the ED</b>							
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
<b>Event 2. Admission to the Ward or ICU or death in the ED</b>							
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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5 Figure legend/caption  
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8 Figure 1.

9 Flow diagram of cases included in the analysis.  
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13 CPA: cardio-pulmonary arrest  
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16 Figure2.

17 Boxplots of NEWS by patient disposition outcomes, with the results of the  
18 pairwise Wilcoxon tests.  
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22 NEWS: National Early Warning Score

23 ED: emergency department

24 ICU: intensive care unit

25 \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$   
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30 Figure 3.

31 The receiver operating characteristic (ROC) curves of the prediction of  
32 NEWS for patient combined  
33 disposition.  
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37 NEWS: National Early Warning Score

38 ED: emergency department

39 ICU: intensive care unit  
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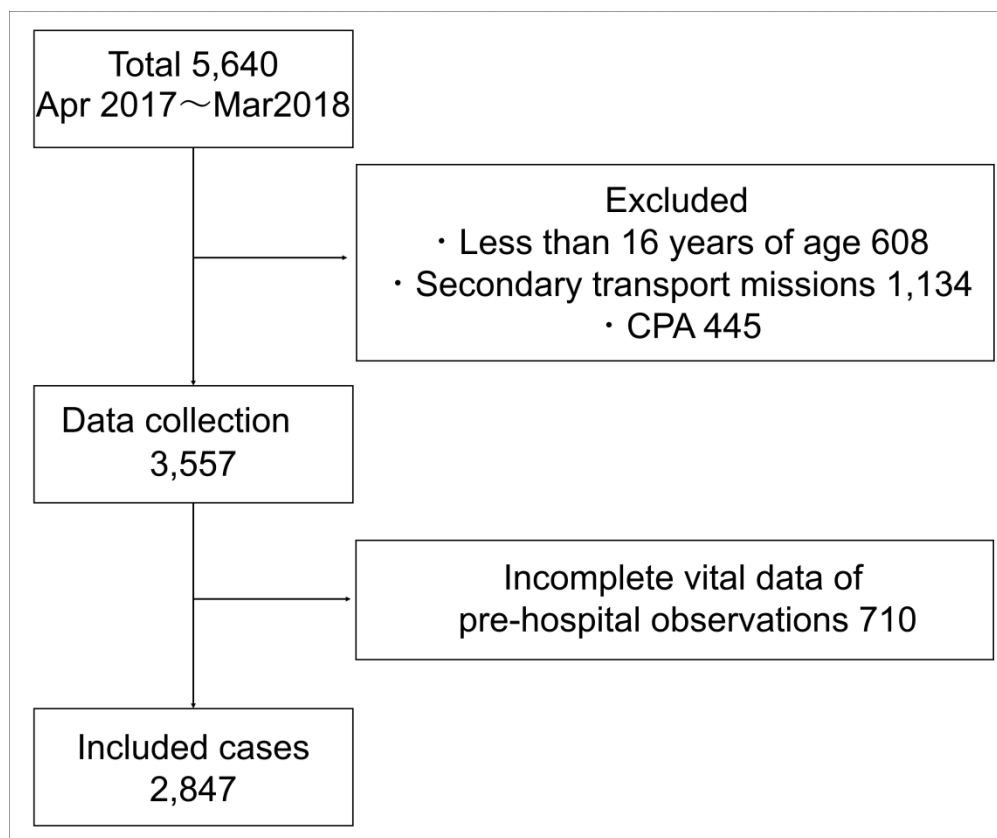


Figure 1. Flow diagram of cases included in the analysis.  
CPA: cardio-pulmonary arrest

259x215mm (350 x 350 DPI)

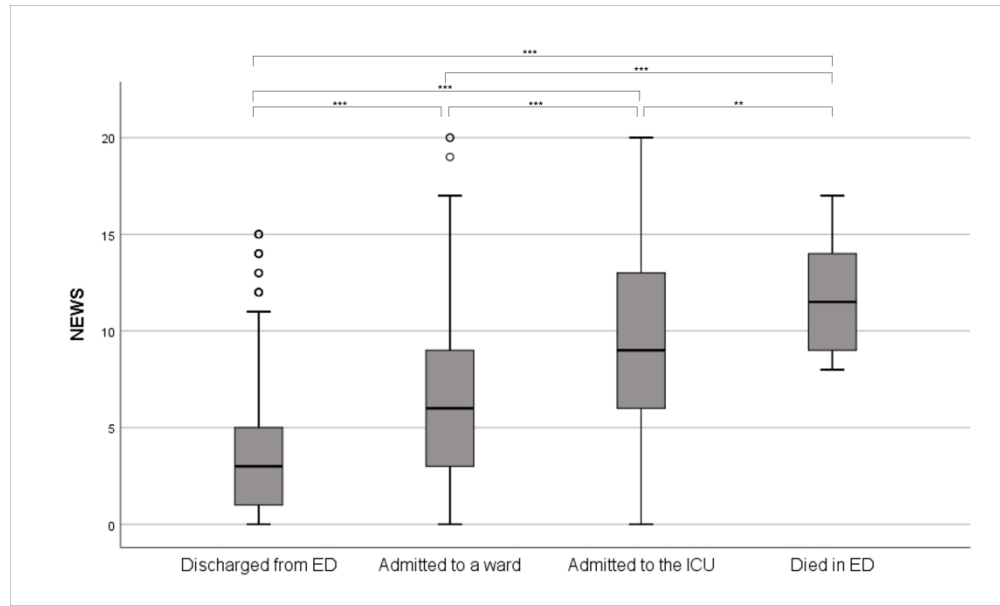


Figure2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxon tests.

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

479x287mm (350 x 350 DPI)



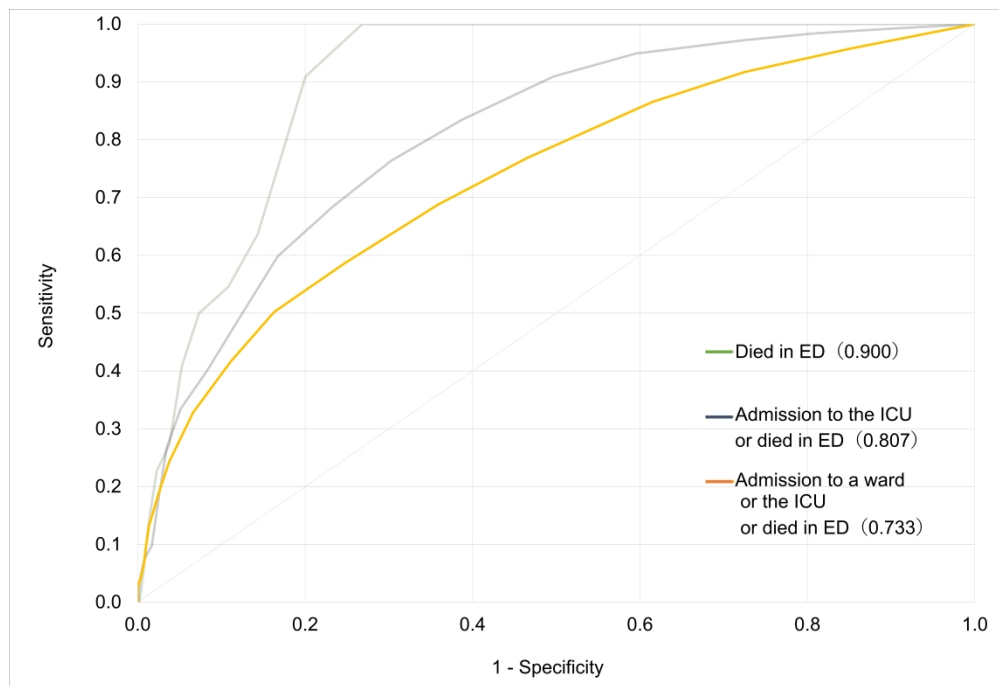


Figure 3.  
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.

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

400x273mm (350 x 350 DPI)

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Supplementary Table 1. Scoring system of NEWS.

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

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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:

Cut point	Youden's index		
	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

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6 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  
7 death), we chose a value 6.5 because relatively higher sensitivity of ICU admission or death (about 3/4, or 75%).  
8  
9

10 Next, we considered that a "middle/low-risk" cut point should have had high sensitivity for a ward admission and minimal degree of  
11 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  
12 for ICU admission, too.  
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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	-	-	-

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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

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

	All (n=2,847)	Patient disposition			
		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
<b>Title and abstract</b>			
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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			
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
<b>Discussion</b>			
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
<b>Other information</b>			
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:	<i>BMJ Open</i>
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
<b>Primary Subject Heading</b>:	Emergency medicine
Secondary Subject Heading:	Emergency medicine, Medical management
Keywords:	Early warning scores, Ambulance, Prehospital

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1 Takuro Endo; Prehospital NEWS in Japan  
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5 Original article  
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8 Title of the article  
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10 A retrospective study to evaluate the efficacy of prehospital National Early Warning  
11 Score to predict outpatient disposition at the Emergency Department in a Japanese  
12 tertiary hospital  
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16 Authors  
17

18 <sup>1</sup>Takuro Endo ([Takuroendo@gmail.com](mailto:Takuroendo@gmail.com)), first author  
19  
20  
21

22 <sup>1</sup>Toru Yoshida ([yoshidat@marianna-u.ac.jp](mailto:yoshidat@marianna-u.ac.jp))  
23  
24

25 <sup>2</sup>Tomohiro Shinozaki ([shinozaki@rs.tus.ac.jp](mailto:shinozaki@rs.tus.ac.jp))  
26  
27

28 <sup>3</sup>Takako Motohashi ([motohashi-takako@marianna-u.ac.jp](mailto:motohashi-takako@marianna-u.ac.jp))  
29  
30

31 <sup>4</sup>Hsiang-Chin Hsu ([i3593120@gmail.com](mailto:i3593120@gmail.com))  
32  
33

34 <sup>1</sup>Shunsuke Fukuda ([s0711732@hotmail.co.jp](mailto:s0711732@hotmail.co.jp))  
35  
36

37 <sup>1</sup>Jumpei Tsukuda ([jumpechan@yahoo.co.jp](mailto:jumpechan@yahoo.co.jp))  
38  
39

40 <sup>1</sup>Takaki Naito ([takaki.jc@gmail.com](mailto:takaki.jc@gmail.com))  
41  
42

43 <sup>1</sup>Kenichiro Morisawa ([kmori0079@yahoo.co.jp](mailto:kmori0079@yahoo.co.jp))  
44  
45

46 <sup>1</sup>Nobuhiko Shimozawa ([simozawa@marianna-u.ac.jp](mailto:simozawa@marianna-u.ac.jp))  
47  
48

49 <sup>1</sup>Yasuhiko Taira ([y2taira@marianna-u.ac.jp](mailto:y2taira@marianna-u.ac.jp))  
50  
51

52 <sup>1</sup>Shigeki Fujitani ([shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com)), corresponding author  
53  
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1 Takuro Endo; Prehospital NEWS in Japan  
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9 Author institution  
10

11  
12 <sup>1</sup>Department of Emergency and Critical Care Medicine, St. Marianna University School  
13

14  
15 of Medicine, 2-16-1, Sugao, Miyamae, Kawasaki, Kanagawa, 216-8511 Japan  
16

17  
18 Tel.: +81-44-977-8111  
19

20  
21 <sup>2</sup>Department of Information and Computer Technology, Faculty of Engineering, Tokyo  
22

23  
24 University of Science, Tokyo, Japan  
25

26  
27 <sup>3</sup>Department of Preventive Medicine, St. Marianna University School of Medicine,  
28

29  
30 Kawasaki, Kanagawa, Japan  
31

32  
33 <sup>4</sup>Department of Emergency Medicine, College of medicine, National Cheng Kung  
34

35  
36 University, Tainan, Taiwan  
37  
38  
39

40 Corresponding author  
41

42 Shigeki Fujitani, MD, PhD  
43

44 Department of Emergency and Critical Care Medicine,  
45

46 St. Marianna University School of Medicine,  
47

48 2-16-1, Sugao, Miyamae-ku, Kawasaki-shi, Kanagawa-ken, Japan  
49

50  
51 Tel.: 81-44-977-8111  
52

53 Fax: 81-44-979-1522  
54

55 E-mail: [shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com)  
56  
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8 Word count  
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10 Abstract: 299 Words

11 Key message box: 124 Words

12 Main text: 3,466 words

13 No. of Tables: 3

14 No. of Figures: 3

15 No. of Supplementary Tables: 4

16 No. of Supplementary Figures: 0

17 No. of References: 24  
18  
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20  
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23 Keywords: Emergency department, prehospital care, emergency ambulance systems,  
24 effectiveness, early warning score  
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1 Takuro Endo; Prehospital NEWS in Japan  
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5 Abstract  
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8 Objectives  
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10 The National Early Warning Score (NEWS) was originally developed in the United  
11 Kingdom to assess hospitalized patients. We examined whether the NEWS can be  
12 applied to patients transported by an ambulance in Japan.  
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16 Methods

17 Patients transported to a Japanese tertiary hospital between April 2017 and March  
18 2018 were assessed and the NEWS recorded by paramedics was calculated.  
19 Emergency department (ED) disposition data were categorized into the following  
20 groups: discharged from the ED, admitted to the ward, admitted to the intensive care  
21 unit (ICU), or died in the ED. The predictive performance of the NEWS for patient  
22 disposition using receiver operating characteristic curves was assessed. Patient  
23 dispositions were compared among NEWS-based categories after adjusting for age,  
24 gender, and presence of traumatic injury.  
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31 Results

32 Of the 2,847 patients, the mean ( $\pm$  standard deviation) NEWS of patients who were  
33 discharged from the ED ( $n=1,330$ ,  $3.7 \pm 2.9$ ), admitted to the ward ( $n=1,263$ ,  $6.3 \pm 3.8$ ),  
34 admitted to the ICU ( $n=232$ ,  $9.4 \pm 4.0$ ), and died in the ED ( $n=22$ ,  $11.7 \pm 2.9$ ) were  
35 statistically different in each group ( $p < 0.001$ ). Prehospital NEWS's C-statistics (95%  
36 confidence interval ;CI) for admission to the ward, admission to the ICU, or death in the  
37 ED was 0.73 (0.72–0.75), admission to the ICU or death in the ED was 0.81 (0.78–  
38 0.83), and death in the ED was 0.90 (0.87–0.93). After adjusting for age, gender, and  
39 trauma, the odds ratio (95% CI) of admission to the ICU or death in the ED for the high-  
40 risk category (NEWS  $\geq 7$ ) was 13.8 (8.9–21.6), and that for the medium-risk category  
41 (NEWS 5–6) was 4.2 (2.5–7.1).  
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49 Conclusion

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

- 7 ➤ This study is the first retrospective study to evaluate the efficacy of the prehospital  
8 National Early Warning Score (NEWS) calculated from vital signs described by  
9 paramedics in Japan.  
10  
11 ➤ The sample number in this study was larger than that in the previous study; therefore,  
12 it functions as an external validation of prehospital NEWS for predicting outpatient  
13 disposition at the Emergency Department.  
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15 ➤ This study was conducted in an aging society in Japan, and the results will likely be  
16 generalizable to other aging societies.  
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18 ➤ This study also examined how adjustment for age, gender, and trauma changed the  
19 association between the NEWS and outcomes.  
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21 ➤ Since the study was conducted in a single center, the findings may not be  
22 generalizable to all Japanese populations.  
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5 Main text  
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7  
8 Introduction  
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10  
11 The early warning score (EWS) was developed as a guide for quick assessment and  
12 early diagnosis of an acute illness in patients admitted to hospitals.<sup>1</sup> It was intended to  
13 serve as a track and trigger tool to make consistent assessments of illness severity, as  
14 well as to provide useful baseline data to evaluate the patient's clinical progress.<sup>2</sup>  
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18  
19 In 2012, The Royal College of Physicians developed the National Early Warning Score  
20 (NEWS) to improve early detection rates of clinical deterioration. Initially, the NEWS  
21 was used to predict illness severity and deterioration in a hospital setting.<sup>3</sup> Since 2015,  
22 it has been implemented across counties in the West of England, with the aim of  
23 computing the NEWS for all patients prior to a referral to an acute care facility.<sup>4</sup>  
24 Furthermore, in a previous study, in-depth qualitative interviews with healthcare  
25 professionals were carried out to identify the barriers and facilitators of the  
26 implementation of NEWS in prehospital, primary care, and community settings.<sup>5</sup> In this  
27 study, participants described that the NEWS could support clinical decision-making  
28 around the escalation of care, and provide a clear means of communicating clinical  
29 acuity between clinicians and across different healthcare organizations.  
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37 A recent review showed that very low and high EWS could distinguish between  
38 patients who were unlikely and likely to deteriorate in the prehospital setting,  
39 respectively.<sup>6</sup> Some studies have also begun to apply NEWS extensively in  
40 prehospital settings and emergency departments, and the majority have used mortality  
41 as a primary outcome for evaluating prehospital setting NEWS.<sup>7-13</sup> Meanwhile, in 2017,  
42 Shaw et al. used subsequent discharge disposition as the primary outcome.<sup>7</sup>  
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48 It is not clear how factors such as health care systems, geographical conditions, and  
49 race, affect the EWS. Three countries within Asia, Iran, Hong Kong, and China, have  
50 published reports on EWS in prehospital settings<sup>11-13</sup>; however, this has not yet been  
51 reported in Japan.  
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54  
55 While life expectancy in Japan is high, it also faces the problem of an aging society<sup>14</sup>.  
56 The proportions of people aged 65 years and higher in Iran, China, Hong Kong, the  
57 United Kingdom (UK), and Japan are 5.6%, 9.6%, 15.1%, 17.8%, and 26.3%,  
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6 respectively.<sup>15</sup> Given the rapidly aging society, the number of ambulance deliveries for  
7 patients with multiple comorbidities are only expected to increase. However, studies  
8 evaluating the NEWS in prehospital settings in aging countries are limited. Thus, the  
9 present study aimed to examine the use of NEWS in the aging society of Japan and its  
10 application to emergency transportation.  
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## 14 Method

### 15 Patient and public involvement

16 Patients or the public were not involved in the design of the study.  
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### 20 Setting and population

21 This observational cohort study was conducted at St Marianna University School of  
22 Medicine, a 1,200-bed tertiary teaching hospital in Kawasaki city, Kanagawa prefecture.  
23 Kawasaki city covers a geographical area of 144 km<sup>2</sup> and has a population of 1.5 million  
24 people. The number of emergency ambulance transportations in this city is estimated to  
25 be 72,000 incidents per year.<sup>16</sup> There are 25 emergency hospitals in the city, of which  
26 St. Marianna Medical University Hospital is the largest.<sup>17</sup> Between April 2016 and March  
27 2017, the number of patients transported by ambulance was 5,640, and the number of  
28 walk-in patients was 16,922.  
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35 In principle, it is up to the paramedics to decide which hospital they should transport the  
36 patient to, based on the severity of the patient's condition and the distance to the  
37 hospital.<sup>18</sup>  
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### 41 Participants

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

55 Prehospital and hospital data were collected separately and integrated. Prehospital data  
56 were recorded on paper by paramedics at the scene, and data on chief complaints and  
57 vital signs, including heart rate, respiratory rate, systolic blood pressure, arterial oxygen  
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5 saturation, temperature, and consciousness were collected.  
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8 Chief complaints were categorized based on the Advanced Medical Priority Dispatch  
9 System (AMPDS) categories as described in a previous study<sup>8</sup>. However, in Japan, this  
10 code has not been used in practice. The appropriate code number was added using the  
11 chief complaint item of the paper written by the paramedics after transport.  
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16 Patients were categorized into the following four groups based on their disposition, in  
17 accordance with a previous study<sup>7</sup>: discharge from the emergency department (ED),  
18 admission to the ward, intensive care unit (ICU) admission, or death in the ED.  
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## 22 NEWS

23 The NEWS ranges from 0 to 20, and each vital sign is scored from 0 to 3. When a patient  
24 is given supplementary oxygen, two points are added to the total score (Supplementary  
25 Table 1).<sup>3</sup> We calculated the total post hoc NEWS from the vital signs.  
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## 30 Statistical analysis

31 SPSS® Ver.25 (Chicago, IL, USA) was used for statistical analysis. A p-value < 0.05 was  
32 considered statistically significant. Patients' age, gender, and the presence of traumatic  
33 injury were summarized by the four categories based on their ED disposition and chief  
34 complaints made during the ambulance call. The distribution of NEWS were compared  
35 between the ED disposition groups using the Kruskal-Wallis test.  
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40 We assessed the discriminatory ability of the continuous-scale NEWS to predict patient  
41 ED dispositions, using receiver operating characteristic (ROC) curves and the area under  
42 the curves (C-statistics). For the ordered nature of ED disposition outcomes (discharge  
43 from the ED, ward or ICU admission, or death in the ED), we combined the outcomes as  
44 follows: 1) ward or ICU admission, or death in the ED; 2) admission to the ICU or death  
45 in the ED; and 3) death in the ED. These classifications were considered to provide more  
46 interpretable results than analysis of each disposition outcome alone.  
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52 To obtain candidate cut-off values for hospital disposition, we started with Youden's  
53 index (sensitivity + specificity - 1). Among these ranges, we carefully chose  
54 high/middle-risk and middle/low-risk cut-off points that appropriately reflected clinical  
55 requirements (Supplementary Table 2).  
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5 Finally, two combined outcomes (ICU admission or death in the ED and death in the ED)  
6 were compared among the NEWS-based categories, without and after adjusting for age,  
7 gender, and the presence of traumatic injury.  
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10  
11 The study protocol was approved by the Institutional Review Board of St. Marianna  
12 University, School of Medicine.  
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## 15 16 Results

### 17 18 Participants' baseline characteristics.

19 The total number of patients who were transported to the hospital by emergency  
20 ambulance was 5,640 during the study period. After exclusion, 2,847 cases were  
21 selected for analysis (Figure 1).  
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25  
26 In the current study, there were 20% incomplete data for which no vital signs were  
27 obtained. The vital signs of patients transported from Kawasaki City were written on  
28 paper by paramedics and given to hospital staff. On the other hand, the vital signs of  
29 patients transported from other areas (Tokyo, Yokohama next to Kawasaki) were not  
30 written on the report after transportation. These data could not be accessed due to  
31 privacy regulations. We excluded 20% of the data for which no vital signs were obtained,  
32 but the only difference was the area that the patients were transported from; thus, we  
33 assume that there would be no significant differences in the baseline characteristics  
34 between these patients and the other 80%.  
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41 Of the 2,847 cases, 1,330 (46.7%) were discharged from the ED, 1,263 (44.4%) were  
42 admitted to the ward, 232 (8.1%) were admitted to the ICU, and 22 (0.8%) died in the  
43 ED. The mean ( $\pm$  standard deviation) age of the participants was  $66.5 \pm 19.6$  years and  
44 the median age was 73 years (lower to upper quartile: 53–82), with bimodal (modes  
45 around 44 and 82) and asymmetric, instead of unimodal and symmetric distributions. The  
46 proportion of male participants was 53.5%. The mean ages of the patients who were  
47 discharged from the ED, admitted to the ward, admitted to the ICU, and those who died  
48 in the ED were  $63.9 \pm 20.3$ ,  $68.8 \pm 18.8$ ,  $68.5 \pm 18.7$ , and  $72.6 \pm 20.2$ , respectively ( $p <$   
49  $0.001$ ) (Table 1).  
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58 The main chief complaints of the patients at the time of calling an ambulance were a  
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5 sick person (19.8%), unconsciousness (13.8%), and breathing difficulty (13.3%) (Table  
6 1). Other chief complaints included traumatic injury (8.3%), stroke (7.4%), abdominal  
7 pain (6.6%), hemorrhage (5.9%), chest pain (5.9%), headache (4.1%), back pain  
8 (3.3%), and drug overdose (3.1%). The chief complaints of each patient disposition  
9 group are presented in Table 1 and Supplementary Table 3.  
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#### 16 NEWS for each patient disposition group

17 The boxplots in Figure 2 illustrate the distribution of prehospital NEWSs for each  
18 disposition group. As shown in Supplementary Table 4, the median and mean ( $\pm$   
19 standard deviation) NEWSs increased for groups discharged from the ED (3 and  $3.7 \pm$   
20  $3.9$ ), admitted to the ward (6 and  $6.3 \pm 3.8$ ), admitted to ICU (9 and  $9.4 \pm 4.0$ ), and died  
21 in the ED (11.5 and  $11.7 \pm 2.9$ ). The distributions significantly differed between patient  
22 disposition groups according to the Kruskal-Wallis test ( $p < 0.001$ ).  
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#### 28 Discriminative performance of the NEWS in the prehospital setting

29 Figure 3 shows the ROC curves for patient disposition combined outcomes using a  
30 continuous-scale NEWS. The area under the receiver-operating characteristics  
31 (AUROCs) (95% confidence interval [CI]) for prehospital NEWS for ward/ICU  
32 admission or death in the ED, ICU admission or death in the ED, and death in the ED  
33 were 0.73 (0.72-0.75), 0.81 (0.78-0.83), and 0.90 (0.87-0.93), respectively.  
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#### 39 Cut-off NEWSs for clinical risk categories

40 Based on the coordinate points of the ROC curve (Supplementary Table 2), the “high  
41 risk” cut-off was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1-  
42 specificity of 0.30 for admission to the ICU or death in the ED), and the “low risk” cut-off  
43 was set between 4 and 5 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the  
44 ward/ICU admission or death in the ED). The selection of these values is described in  
45 Supplementary Table 2.  
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50 Accordingly, we adopted the categorization scheme for low-risk (NEWS  $\leq 4$ ), medium-  
51 risk (5 or 6), and high-risk ( $\geq 7$ ).  
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#### 55 Risk category by patient disposition group

56 Table 2 shows that a higher NEWS was associated with deteriorating patient  
57 disposition. In the low-risk group ( $n = 1,327$ ), the highest proportion of patients were  
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6 discharged from the ED (n = 853, 64.3%), followed by those admitted to the ward (n =  
7 451, 34.0%), admitted to the ICU (n = 23, 1.7%), and died in the ED (n = 0, 0%).

8 Conversely, patients in the high-risk group (n = 979) had a greater probability of being  
9 admitted to the ward (n = 568, 58.0%), being admitted to the ICU (n = 172, 17.6%), and  
10 dying in the ED (n = 22, 0.8%). Focusing on those who died in the ED, 100% (n = 22)  
11 of the participants were categorized as high-risk participants.  
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### 16 Relationship between NEWS risk level and outcome

17 Binary logistic regression models were used to further examine the relationship  
18 between the NEWS risk category and the combined patient disposition outcomes  
19 (Table 3; note that death in the ED occurred only in the high-risk group, and we did not  
20 perform logistic analysis for death in the ED). ICU admission or death in the ED in the  
21 medium-risk group (odds ratio: 4.2, 95% CI: 2.5, 7.1, p < 0.001) and the high-risk group  
22 (odds ratio: 13.8; 95% CI: 8.9, 21.6, p < 0.001) increased significantly compared to the  
23 low-risk group even after adjusting for age, gender, and trauma. Similarly, admission to  
24 the ward, ICU, or death in the ED in the medium-risk group (odds ratio: 1.9; 95% CI:  
25 1.6, 2.4, p < 0.001) and the high-risk group (odds ratio: 6.1; 95% CI: 5.0, 7.3, p <  
26 0.001) also increased significantly compared to the low-risk group.  
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### 34 Discussion

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37 This study aimed to evaluate the efficacy of NEWS in predicting patient disposition in  
38 prehospital settings. Our findings indicate that prehospital NEWS could identify critical  
39 patients and those at risk of adverse outcomes. The aim of this study was not to clarify  
40 when to use NEWS to predict outcomes more accurately, but to verify whether the  
41 paramedics could determine the severity from vital sign scores at the time of patient  
42 contact.  
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48 In recent years, several studies have been conducted on prehospital EWS, and four  
49 representative reports<sup>7-10</sup> of NEWS have been published. A 2018 study conducted in  
50 Finland<sup>10</sup> showed the highest for 12,426 cases in two hospitals using short-term  
51 mortality rate as the primary outcome. Only a recent study of 287 patients conducted in  
52 the UK used patient disposition as the primary outcome.<sup>7</sup> The present study examined  
53 2,847 cases, which is by far the largest among the previous studies to have used  
54 patient disposition as the primary outcome.  
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6 The present study found that prehospital NEWS predicted patient disposition in an ED in  
7 Japan. Once the patient was categorized as high-risk or medium-risk based on their  
8 NEWS, the probability of ICU admission or death in the ED increased. We demonstrated  
9 the usefulness of prehospital NEWS in predicting the severity of an illness among  
10 participants with different demographic characteristics. Our findings indicate the  
11 usefulness of NEWS, even for the older population.  
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16 It has been confirmed that prehospital NEWS fully predicts outpatient disposition, even  
17 in an aging society, such as in Japan. Our results and those of previous studies  
18 predicting outpatient disposition in the UK and other countries, suggest that prehospital  
19 NEWS might be available globally. This suggests that NEWS could be used when  
20 other countries become aging societies in the future.  
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25 Previous studies have used risk categories with odds ratios to calculate early death  
26 within 24 or 48 hours of hospitalization<sup>8 10</sup>. Our study is the first study in which the  
27 outpatient clinical outcomes were calculated by risk category with odds ratio. In 2017, a  
28 study<sup>7</sup> showed that high-risk patients (those with a NEWS  $\geq 7$ ) demonstrated a  
29 relatively higher risk for a one-day mortality rate of 101.5 compared to the low-risk  
30 group ( $\leq 4$ ). Moreover, for medium-risk patients (NEWS, 5,6), a greater risk for one-day  
31 mortality rate of 4.4 was seen compared to low-risk patients, without adjusting for age,  
32 gender, and trauma.  
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39 In our research, the rate of ICU admission or death in the ED in the medium-risk group  
40 (odds ratio: 4.2, 95% CI: 2.5. 7.1,  $p < 0.001$ ) and the high-risk group (odds ratio: 14.0,  
41 95% CI: 9.0. 21.8,  $p < 0.001$ ) increased significantly compared to the low-risk group,  
42 without adjusting for age, gender, and trauma (Table 3).  
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46 This study also examined how adjustment for age, gender, and trauma changed the  
47 association between the NEWS risk score and outcomes. The results of the analysis  
48 shown in Table 3 suggest that the use of the NEWS risk score, with or without  
49 considering age, gender, and trauma, was clinically useful.  
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54 In a previous study conducted in the UK in 2016, patients who died or were admitted to  
55 the ICU had a higher NEWS than those admitted to the ward or discharged from the  
56 ED.<sup>7</sup> On the other hand, the present study found differences in the mean NEWSs for all  
57 segments (Figure 2 and Supplementary Table 4). The higher average NEWSs in all  
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6 groups compared to those observed in the previous study could be explained by the  
7 fact that data were collected at a tertiary medical institution. Thus, it is appropriate to  
8 use an objective scoring system such as NEWS to compare the attributes of patients  
9 transported by ambulances. Furthermore, it is worth noting that the cut-off NEWS in the  
10 prehospital setting did not differ from that in the hospital setting.<sup>3</sup> A few studies have  
11 reported the validity of the cut-off values for the NEWS in outpatient settings. In the  
12 previous four studies<sup>7-10</sup>, patients were categorized into low-, medium-, and high-risk  
13 groups, according to the guidelines of the Royal College of Physicians.<sup>3</sup> After  
14 examining the cut-off value in our data, we divided the risk categories into three  
15 categories. This classification based on our results is the same as the conventional in-  
16 hospital NEWS category.  
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23 According to the definition of NEWS based on in-hospital patients, validation was  
24 considered necessary to confirm the risk classification for out-of-hospital patients. Thus,  
25 the ROC curve and specified coordinate points were evaluated. The cut-off NEWSs for  
26 prehospital assessment were in line with the definition for in-hospital NEWS prediction  
27 (Supplementary Table 2). As medical interventions are not applied in the prehospital  
28 environment, the cut-off scores for the risk categories will differ from those in the in-  
29 hospital environment. Thus, future studies should use larger datasets to confirm this  
30 finding.  
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37 In Japan, some studies have confirmed the usefulness of EWS in the hospital and  
38 triage.<sup>19-22</sup> However, several countries require nationwide in-hospital EWS  
39 implementation, and in the UK this has been widely used in prehospital settings,  
40 outpatients, and emergency services.<sup>4</sup> Paramedics in Japan should directly request the  
41 hospital for ambulance acceptance on the scene. In fact, it is often difficult to obtain  
42 hospital acceptance for transportation because the number of transportations has  
43 increased each year.<sup>17</sup> Furthermore, the time from making the ambulance call until arrival  
44 at the hospital is also gradually increasing.<sup>23 24</sup> This might delay crucial emergency  
45 treatments, which in turn might worsen the patient's outcomes. NEWS-based risk  
46 stratification helps paramedics understand the severity of the patient's condition and  
47 communicate it accurately with a healthcare professional at the hospital. Earlier  
48 identification of critical patients might facilitate earlier resuscitation and appropriate  
49 critical care.<sup>8</sup>  
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58 We used outpatient disposition as the primary outcome in this study. Most previous  
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5 reports have considered short-term mortality as the primary outcome to assess the  
6 usefulness of prehospital NEWS.<sup>6 9 10</sup> As it predicts outpatient outcomes in addition to  
7 short-term mortality, the NEWS is a very useful tool.  
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11 We are also currently analyzing the relationship between prehospital NEWS and  
12 mortality rate with more extensive data and exploring the possibility of predicting death  
13 more accurately by integrating other factors (chief complaints, etc.). This study is the  
14 first step towards the implementation of prehospital NEWS as a prehospital triage tool.  
15 In Japan, there is no triage tool in the prehospital setting. The Japan Triage and Acuity  
16 Scale (JTAS) is currently used in the outpatient setting, but it does not assume an  
17 emergency site. To use prehospital NEWS as a triage tool, additional analysis of “false  
18 positive” and “false negative” is required. It is necessary to clarify what kind of cases  
19 are "Go home despite high score" and "ICU hospitalization despite low score". These  
20 data should be assessed in a future study.  
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28 The strengths of this study are as follows: This study is the first in Japan to show that  
29 the NEWS can be used in a prehospital setting to predict patient disposition in Japan.  
30 Our dataset was much larger than those used in a previous study<sup>7</sup>, which indicates  
31 higher reliability. It is noteworthy that the result obtained by calculating the cut-off  
32 values for the out-hospital setting is the same as that obtained in the in-hospital setting.  
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### 37 **Limitations**

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

47 Our study suggests the usefulness of NEWS in categorizing ED cases at patient's arrival  
48 by ambulance. The study also found that elevated NEWS among unselected prehospital  
49 patients could predict patient disposition at the ED in Japan. The NEWS has a wide  
50 range of uses in prehospital settings. A prospective multicenter study is needed to  
51 validate the usefulness of NEWS in the prehospital setting.  
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#### 10 11 **Contributors**

12 TE, KM, SiF, and YT conceived the research idea and designed the study. TE, ShF,  
13 and TN collected the data. TE, MT, JT, TN, NS, and TS provided statistical advice on  
14 study design and analyzed the data. TE and SiF chaired the data oversight committee.  
15 TE, HCH, and TY drafted the first version of the manuscript. TE, SiF, and YT take  
16 public responsibility for the contents of this paper.  
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26  
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#### 29 **Competing interests**

30 None declared.  
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#### 34 **Patient consent**

35 Not required.  
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#### 39 **Ethics approval**

40 The research protocol received approval from the ethics committee of the Institutional  
41 Review Board of St Marianna University School of Medicine, No. 4325.  
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#### 45 **Provenance and peer review**

46 Not commissioned; externally peer reviewed.  
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#### 49 **Data sharing statement**

50 No additional data were available.  
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#### 54 **Open Access**

55 This is an Open Access article distributed in accordance with the Creative Commons  
56 Attribution Non Commercial (CC BY-NC 4.0) license,  
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## Takuro Endo; Prehospital NEWS in Japan

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 $\pm$ SD	66.5 $\pm$ 19.6		63.9 $\pm$ 20.3		68.8 $\pm$ 18.8		68.5 $\pm$ 18.7		72.6 $\pm$ 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

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

NEWS clinical risk level	Patient disposition				All
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	
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

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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
<b>Event 1. Admission to the ICU or death in the ED</b>							
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
<b>Event 2. Admission to the Ward or ICU, or death in the ED</b>							
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

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5 Figure legend/caption

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8 Figure 1.

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10 Flow diagram of included cases

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13 CPA: Cardiopulmonary arrest

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16 Figure 2.

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

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21 NEWS: National Early Warning Score

22 ED: Emergency department

23 ICU: Intensive care unit

24 \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

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27 Figure 3.

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

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31 NEWS: National Early Warning Score

32 ED: Emergency department

33 ICU: Intensive care unit

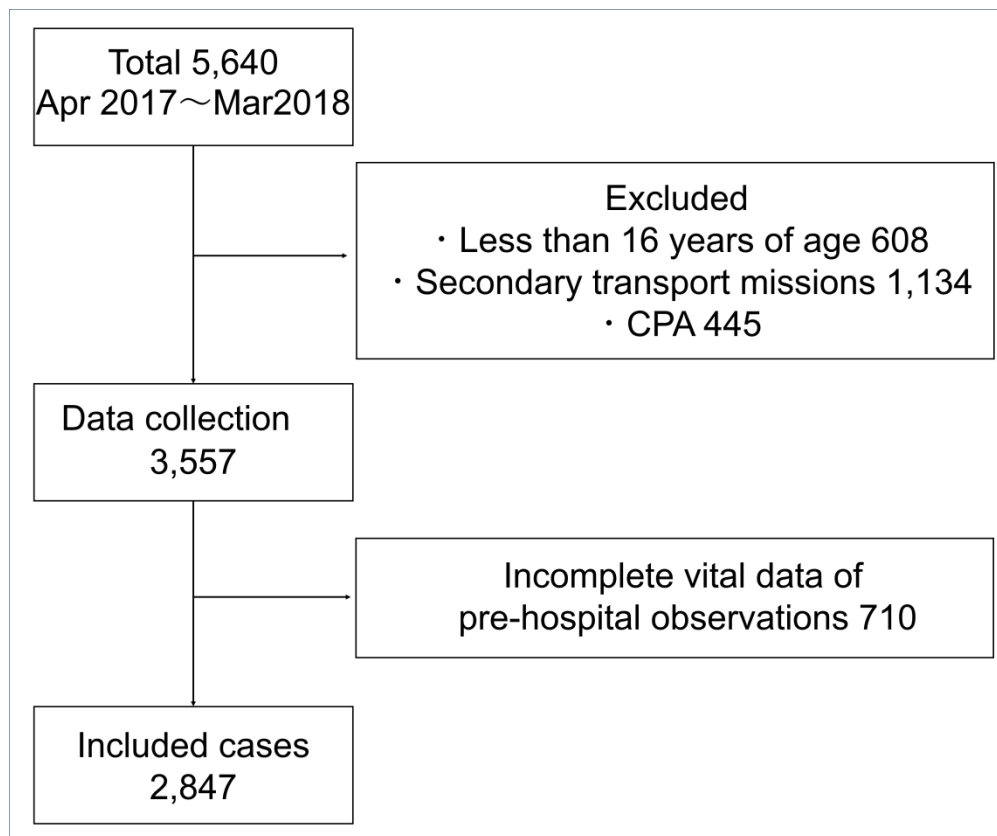


Figure 1. Flow diagram of cases included in the analysis.  
CPA: cardio-pulmonary arrest

259x215mm (350 x 350 DPI)

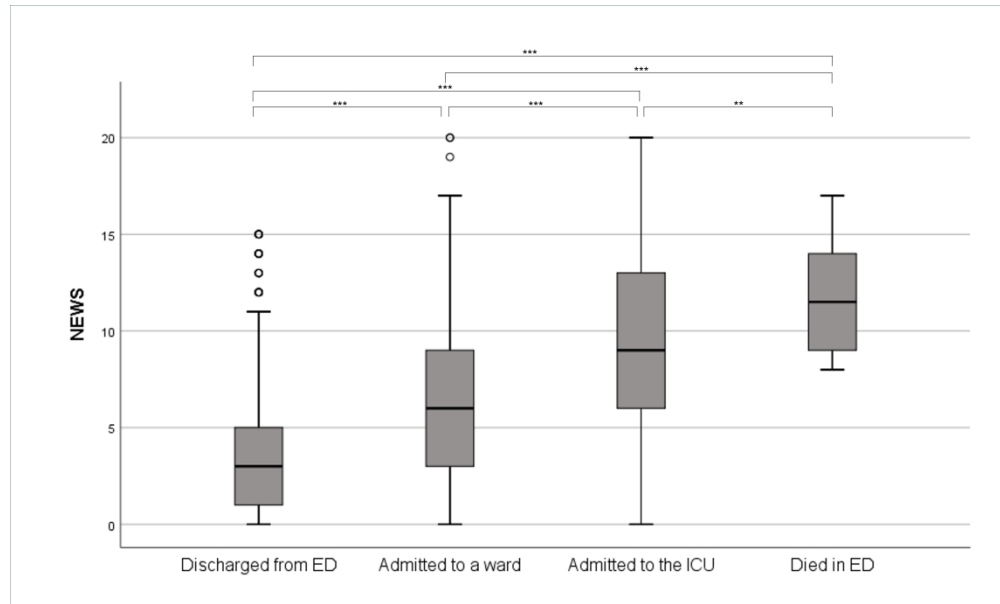


Figure2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxon tests.

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

479x287mm (350 x 350 DPI)

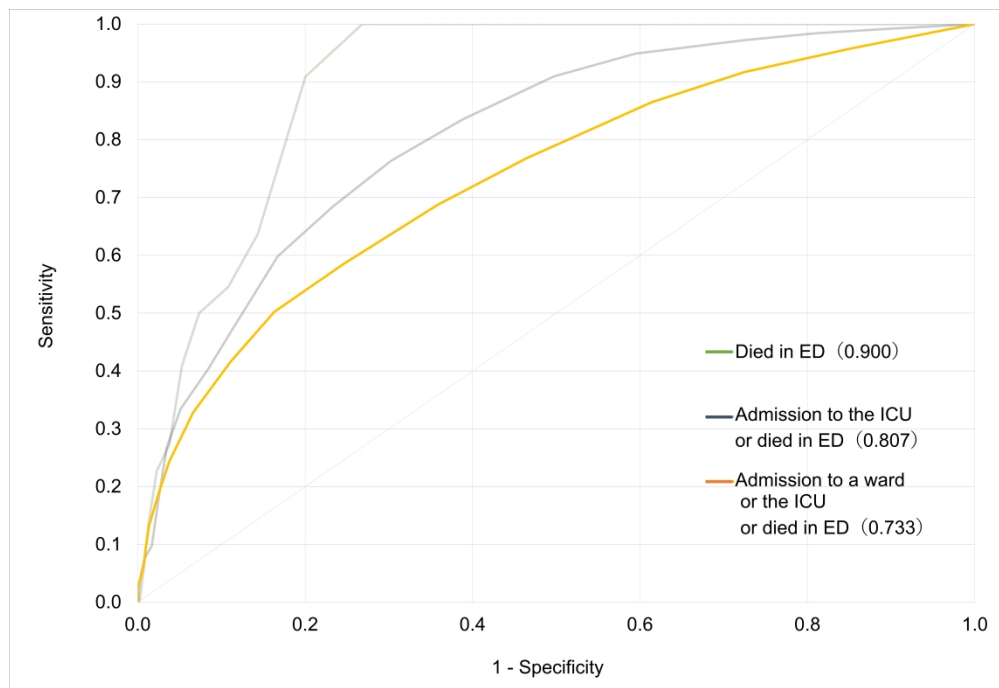


Figure 3.  
The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.

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

400x273mm (350 x 350 DPI)

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Supplementary Table 1. Scoring system of NEWS.

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

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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:

Cut point	Youden's index		
	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

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6 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  
7 death), we chose a value 6.5 because relatively higher sensitivity of ICU admission or death (about 3/4, or 75%).  
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10 Next, we considered that a "middle/low-risk" cut point should have had high sensitivity for a ward admission and minimal degree of  
11 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  
12 for ICU admission, too.  
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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	-	-	-

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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

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

	All (n=2,847)	Patient disposition			
		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
<b>Title and abstract</b>			
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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			
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
<b>Discussion</b>			
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
<b>Other information</b>			
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:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-034602.R3
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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
<b>Primary Subject Heading</b>:	Emergency medicine
Secondary Subject Heading:	Emergency medicine, Medical management
Keywords:	Early warning scores, Ambulance, Prehospital

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5 Original article  
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10 Title of the article

11 Efficacy of prehospital National Early Warning Score to predict outpatient disposition at an  
12 emergency department of a Japanese tertiary hospital: a retrospective study  
13  
14  
15  
16  
17

18 Authors

19  
20 <sup>1</sup>Takuro Endo ([Takuroendo@gmail.com](mailto:Takuroendo@gmail.com)), first author  
21

22 <sup>1</sup>Toru Yoshida ([yoshidat@marianna-u.ac.jp](mailto:yoshidat@marianna-u.ac.jp))  
23

24 <sup>2</sup>Tomohiro Shinozaki ([shinozaki@rs.tus.ac.jp](mailto:shinozaki@rs.tus.ac.jp))  
25

26 <sup>3</sup>Takako Motohashi ([motohashi-takako@marianna-u.ac.jp](mailto:motohashi-takako@marianna-u.ac.jp))  
27

28 <sup>4</sup>Hsiang-Chin Hsu ([i3593120@gmail.com](mailto:i3593120@gmail.com))  
29  
30  
31

32 <sup>1</sup>Shunsuke Fukuda ([s0711732@hotmail.co.jp](mailto:s0711732@hotmail.co.jp))  
33

34 <sup>1</sup>Jumpei Tsukuda ([jumpechan@yahoo.co.jp](mailto:jumpechan@yahoo.co.jp))  
35

36 <sup>1</sup>Takaki Naito ([takaki.jc@gmail.com](mailto:takaki.jc@gmail.com))  
37

38 <sup>1</sup>Kenichiro Morisawa ([kmori0079@yahoo.co.jp](mailto:kmori0079@yahoo.co.jp))  
39

40 <sup>1</sup>Nobuhiko Shimosawa ([simosawa@marianna-u.ac.jp](mailto:simosawa@marianna-u.ac.jp))  
41

42 <sup>1</sup>Yasuhiko Taira ([y2taira@marianna-u.ac.jp](mailto:y2taira@marianna-u.ac.jp))  
43

44 <sup>1</sup>Shigeki Fujitani ([shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com)), corresponding author  
45  
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51 Author institutions

52  
53 <sup>1</sup>Department of Emergency and Critical Care Medicine, St. Marianna University School of  
54 Medicine, 2-16-1, Sugao, Miyamae, Kawasaki, Kanagawa, 216-8511 Japan  
55

56 Tel.: +81-44-977-8111  
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2  
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5 <sup>2</sup>Department of Information and Computer Technology, Faculty of Engineering, Tokyo  
6 University of Science, Tokyo, Japan  
7  
8

9 <sup>3</sup>Department of Preventive Medicine, St. Marianna University School of Medicine, Kawasaki,  
10 Kanagawa, Japan  
11  
12

13 <sup>4</sup>Department of Emergency Medicine, College of Medicine, National Cheng Kung University,  
14 Tainan, Taiwan  
15  
16  
17  
18  
19

20 Corresponding author

21 Shigeki Fujitani, MD, PhD

22 Department of Emergency and Critical Care Medicine,  
23  
24

25 St. Marianna University School of Medicine,  
26  
27

28 2-16-1, Sugao, Miyamae-ku, Kawasaki-shi, Kanagawa-ken, Japan  
29  
30

31 Tel.: 81-44-977-8111

32 Fax: 81-44-979-1522

33 E-mail: [shigekifujitani@gmail.com](mailto:shigekifujitani@gmail.com)  
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5 **ABSTRACT**  
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9 Objectives

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

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

38 A tertiary hospital in Japan.  
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43 Participants

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

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

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5 **STRENGTHS AND LIMITATIONS**  
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- 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.



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5 Main text  
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## 9 **INTRODUCTION**

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14 The early warning score (EWS) was developed as a guide for the quick assessment and early  
15 diagnosis of acute illness in patients admitted to hospitals.<sup>1</sup> It was intended to serve as a track  
16 and trigger tool for consistent assessment of illness severity and to provide useful baseline data  
17 to evaluate a patient's clinical progress.<sup>2</sup>  
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24 In 2012, The Royal College of Physicians developed the National Early Warning Score  
25 (NEWS) to improve the early detection rates of clinical deterioration. The NEWS was initially  
26 used to predict illness severity and deterioration in a hospital setting.<sup>3</sup> Since 2015, it has been  
27 implemented across counties in the West of England to compute the NEWS for all patients  
28 before referral to acute care facilities.<sup>4</sup> Furthermore, a previous study performed in-depth  
29 qualitative interviews of healthcare professionals to identify barriers and facilitators of NEWS  
30 implementation in prehospital, primary care, and community settings.<sup>5</sup> In this study, participants  
31 indicated that the NEWS could support clinical decision-making for the escalation of care and  
32 provide a clear means of communicating clinical acuity among clinicians and different  
33 healthcare organizations.  
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48 A recent review showed that very low and high EWSs could distinguish among patients who  
49 were unlikely and likely to deteriorate in the prehospital setting, respectively.<sup>6</sup> Some studies  
50 have also begun to extensively apply the NEWS in prehospital settings and emergency  
51 departments, and most of these studies have used mortality as a primary outcome for evaluating  
52 prehospital NEWS.<sup>7-13</sup> In contrast, in 2017, Shaw et al. used subsequent discharge disposition as  
53 the primary outcome.<sup>7</sup>  
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8 It is not clear how factors such as health care systems, geographical conditions, and race affect  
9 the EWS. Three Asian countries—Iran, Hong Kong, and China—have published reports on the  
10 use of EWS in prehospital settings<sup>11-13</sup>; however, its use has not yet been reported in Japan.  
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16 While life expectancy in Japan is high, the country also faces the problem of an aging society.<sup>14</sup>  
17 The proportions of people aged 65 years and higher in Iran, China, Hong Kong, the UK, and  
18 Japan are 5.6%, 9.6%, 15.1%, 17.8%, and 26.3%, respectively.<sup>15</sup> Given the rapidly aging society  
19 in Japan, the number of ambulance deliveries for patients with multiple comorbidities is only  
20 expected to increase. However, studies evaluating the NEWS in prehospital settings in aging  
21 countries are limited. Thus, this study examined the use of NEWS in the aging society of Japan  
22 and its application during emergency transportation.  
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## 33 **METHODS**

### 34 **Patient and public involvement**

35 Patients or the public were not involved in the study design.  
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### 42 **Setting and population**

43 This observational cohort study was conducted at St. Marianna University School of Medicine, a  
44 1,200-bed tertiary teaching hospital in Kawasaki city, Kanagawa prefecture. Kawasaki city covers  
45 a geographical area of 144 km<sup>2</sup> and has a population of 1.5 million. The estimated number of  
46 emergency ambulance transportations in this city is 72,000 incidents per year.<sup>16</sup> There are 25  
47 emergency hospitals in the city, of which St. Marianna Medical University Hospital is the  
48 largest.<sup>17</sup> Between April 2016 and March 2017, 5,640 of patients were transported by ambulance,  
49 while 16,922 patients were walk-in.  
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5 In principle, paramedics decide which hospital they should transport the patient to, based on the  
6 severity of the patient's condition and the distance to the hospital.<sup>18</sup>  
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### 10 11 12 **Participants**

13 This study enrolled patients transported to our hospital by ambulance between April 2016 and  
14 March 2017. The requirement for obtaining patients' informed consent was waived because the  
15 data were anonymized. The following patients were excluded: 1) those aged <16 years; 2)  
16 pregnant patients; 3) patients transported from another hospital because it was not a prehospital  
17 setting (this rule was the same for a previous study<sup>10</sup>; and 4) cardiopulmonary arrest cases.  
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### 26 27 **Data sources**

28 Prehospital and hospital data were collected separately and integrated. Prehospital data were  
29 recorded on paper by paramedics at the scene and data on chief complaints and vital signs,  
30 including heart rate, respiratory rate, systolic blood pressure, arterial oxygen saturation,  
31 temperature, and consciousness, were collected.  
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39 Chief complaints were categorized based on the Advanced Medical Priority Dispatch System  
40 categories as previously described.<sup>8</sup> However, in Japan, these codes have not been used in practice.  
41 The appropriate code was added using the chief complaint item recorded on the paper by the  
42 paramedics after transportation.  
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49 The patients were categorized into the following four groups based on their disposition as  
50 described previously:<sup>7</sup> discharge from the emergency department (ED), admission to the ward,  
51 admission to the intensive care unit (ICU), or death in the ED.  
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### 58 **NEWS** 59 60

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5 The NEWS ranges from 0 to 20, with each vital sign scored from 0 to 3. When a patient is  
6 administered supplementary oxygen, two points are added to the total score (Supplementary Table  
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10 1).<sup>3</sup> We calculated the total post hoc NEWS based on the vital signs.  
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### 13 **Statistical analysis**

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16 IBM SPSS Statistics for Windows, version 25.0 (Armonk, NY, USA) was used for statistical  
17 analysis. A p-value <0.05 was considered statistically significant. Patients' age, sex, and presence  
18 of traumatic injury were summarized by four categories based on their ED disposition and chief  
19 complaints made during the ambulance call. The distributions of the NEWS were compared  
20 between the ED disposition groups using Kruskal–Wallis tests.  
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28 We assessed the discriminatory ability of the continuous-scale NEWS to predict patient ED  
29 dispositions using receiver operating characteristic (ROC) curves and the area under the curves  
30 (C-statistics). For the ordered nature of ED disposition outcomes (discharge from the ED, ward  
31 or ICU admission, or death in the ED), we combined the outcomes as follows: 1) ward or ICU  
32 admission or death in the ED; 2) admission to the ICU or death in the ED; and 3) death in the ED.  
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39 These classifications were considered to provide more interpretable results than the analysis of  
40 each disposition outcome alone.  
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45 To obtain candidate cut-off values for hospital disposition, we started with Youden's Index  
46 (sensitivity + specificity - 1). Among these ranges, we carefully chose high/middle-risk and  
47 middle/low-risk cut-off points that appropriately reflected clinical requirements (Supplementary  
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52 Table 2).  
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56 Finally, two combined outcomes (ICU admission or death in the ED and death in the ED) were  
57 compared among the NEWS-based categories without and after adjusting for age, sex, and the  
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5 presence of traumatic injury.  
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10 The study protocol was approved by the Institutional Review Board of St. Marianna University,  
11 School of Medicine.  
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## 16 **RESULTS**

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### 20 **Participants' baseline characteristics**

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22 Overall, 5,640 patients were transported to the hospital by emergency ambulances during the  
23 study period. After exclusion, 2,847 cases were selected for analysis (Figure 1).  
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29 In the current study, there were 20% incomplete data for which no vital signs were obtained. The  
30 vital signs of patients transported from Kawasaki City were written on paper by paramedics and  
31 given to hospital staff. However, the vital signs of patients transported from other areas (Tokyo,  
32 Yokohama next to Kawasaki) were not written on the report after transportation. These data could  
33 not be accessed owing to privacy regulations. We excluded 20% of the data for which no vital  
34 signs were obtained; however, the only difference was the area from which the patients were  
35 transported; thus, we assumed that there were no significant differences in baseline characteristics  
36 between these patients and the other 80% of patients.  
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48 Of 2,847 cases, 1,330 (46.7%) were discharged from the ED, 1,263 (44.4%) were admitted to  
49 the ward, 232 (8.1%) were admitted to the ICU, and 22 (0.8%) died in the ED. The mean ( $\pm$   
50 standard deviation) age of the participants was  $66.5 \pm 19.6$  years, and the median age was 73  
51 years (lower to upper quartile: 53–82), with bimodal (modes around 44 and 82) and asymmetric  
52 distributions rather than unimodal and symmetric distributions. Male patients comprised 53.5%  
53 of the participants. The mean ages of the patients discharged from the ED, admitted to the ward,  
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admitted to the ICU, and died in the ED were  $63.9 \pm 20.3$ ,  $68.8 \pm 18.8$ ,  $68.5 \pm 18.7$ , and  $72.6 \pm 20.2$  years, respectively ( $p < 0.001$ ) (Table 1).

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 $\pm$ SD	66.5 $\pm$ 19.6		63.9 $\pm$ 20.3		68.8 $\pm$ 18.8		68.5 $\pm$ 18.7		72.6 $\pm$ 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

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Chest pain	5.9	167	6.3	84	4.8	60	8.6	20	13.6	3
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\* 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 ( $\pm$  standard deviation) NEWSs increased for groups discharged from the ED (3 and  $3.7 \pm 3.9$ ), admitted to the ward (6 and  $6.3 \pm 3.8$ ), admitted to the ICU (9 and  $9.4 \pm 4.0$ ), and died in the ED (11.5 and  $11.7 \pm 2.9$ ). 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

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5 [CI]) for prehospital NEWS for ward/ICU admission or death in the ED, ICU admission or  
6 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  
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8 (0.87-0.93), respectively.  
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#### 14 **Cut-off NEWSs for clinical risk categories**

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16 Based on the coordinate points of the ROC curve (Supplementary Table 2), the high-risk cut-off  
17 was set between NEWS 6 and 7 (score 6.5: sensitivity of 0.76 and 1- specificity of 0.30 for  
18 admission to the ICU or death in the ED), and the low-risk cut-off was set between 4 and 5  
19 (score 4.5: sensitivity of 0.69 and 1- specificity of 0.36 for the ward/ICU admission or death in  
20 the ED). The selection of these values is described in Supplementary Table 2.  
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29 Accordingly, we adopted the categorization scheme for low (NEWS  $\leq$ 4), medium (5 or 6), and  
30 high ( $\geq$ 7) risks.  
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#### 35 **Risk category by patient disposition group**

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37 Table 2 shows that a higher NEWS was associated with deteriorating patient disposition. In the  
38 low-risk group (n = 1,327), the highest proportion of patients was discharged from the ED (n =  
39 853, 64.3%), followed by those admitted to the ward (n = 451, 34.0%), admitted to the ICU (n =  
40 23, 1.7%), and died in the ED (n = 0, 0%). Conversely, patients in the high-risk group (n = 979)  
41 had a greater probability of being admitted to the ward (n = 568, 58.0%), being admitted to the  
42 ICU (n = 172, 17.6%), and dying in the ED (n = 22, 2.2%). Among those who died in the ED,  
43 100% (n = 22) of the participants were categorized as high risk.  
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56 Table 2. Distributions of patient disposition outcomes by risk categories based on NEWS  
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NEWS clinical risk level	Patient disposition				All
	Discharged from the ED	Admitted to the ward	Admitted to the ICU	Died in the ED	
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 $\geq 7$ )	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;

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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
<b>Event 1. Admission to the ICU or death in the ED</b>							
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
<b>Event 2. Admission to the ward or ICU, or death in the ED</b>							
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

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5 ICU: Intensive care unit  
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7 ED: Emergency department  
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## 10 11 **DISCUSSION** 12

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16 This study aimed to evaluate the efficacy of NEWS in predicting patient disposition in prehospital  
17 settings. Our findings indicate that prehospital NEWS could identify critical patients and those at  
18 a risk of adverse outcomes. This study did not aim to clarify when to use NEWS to more  
19 accurately predict outcomes but rather to verify whether paramedics could determine the severity  
20 based on vital sign scores at the time of patient contact.  
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29 In recent years, several studies have been conducted on prehospital EWS, and four  
30 representative reports<sup>7-10</sup> of NEWS have been published. A 2018 study conducted in Finland<sup>10</sup>  
31 included the highest number of cases (n=12,426) in two hospitals but used short-term mortality  
32 rate as the primary outcome. Only a recent study of 287 patients conducted in the UK used  
33 patient disposition as the primary outcome.<sup>7</sup> The present study examined 2,847 cases, which is  
34 by far the largest among previous studies to have used patient disposition as the primary  
35 outcome.  
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45 We found that prehospital NEWS predicted patient disposition in an ED in Japan. Patients  
46 categorized as high or medium risk based on their NEWS had increased probabilities of ICU  
47 admission or death in the ED. We demonstrated the usefulness of prehospital NEWS in predicting  
48 illness severity among participants with different demographic characteristics. Our findings  
49 indicate the usefulness of NEWS even in an older population.  
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58 Prehospital NEWS has been confirmed to fully predict outpatient disposition, even in aging  
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5 societies such as those in Japan. Our results and those of previous studies predicting outpatient  
6 disposition in the UK and other countries suggest that prehospital NEWS might be available  
7 globally. These findings suggest that the NEWS could be used for aging societies in other  
8 countries in the future.  
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16 Previous studies have used risk categories with odds ratios to calculate early death within 24 or  
17 48 hours of hospitalization.<sup>8 10</sup> Our study is the first to assess outpatient clinical outcomes based  
18 on risk category with odds ratio. A 2017 study<sup>7</sup> showed that high-risk patients (NEWS  $\geq 7$ )  
19 demonstrated a relatively higher risk for a one-day mortality rate of 101.5 compared with the  
20 low-risk group (NEWS  $\leq 4$ ). Moreover, for medium-risk patients (NEWS, 5,6), we observed an  
21 increased risk of one-day mortality of 4.4 compared with that for low-risk patients, without  
22 adjusting for age, sex, and trauma.  
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33 In our study, the rate of ICU admission or death in the ED in the medium-risk (odds ratio: 4.2,  
34 95% CI: 2.5–7.1,  $p < 0.001$ ) and high-risk (odds ratio: 14.0, 95% CI: 9.0–21.8,  $p < 0.001$ )  
35 groups increased significantly compared with that in the low-risk group, without adjusting for  
36 age, sex, and trauma (Table 3).  
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43 This study also examined how adjustment for age, sex, and trauma changed the association  
44 between NEWS risk and outcomes. The results of the analysis (Table 3) suggest that the use of  
45 the NEWS was clinically useful regardless of age, sex, and trauma.  
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51 In a 2016 study conducted in the UK, patients who died or were admitted to the ICU had a  
52 higher NEWS than that of patients admitted to the ward or discharged from the ED.<sup>7</sup> However,  
53 we observed differences in the mean NEWSs for all segments (Figure 2 and Supplementary  
54 Table 4). The higher average NEWSs in all groups compared with those observed in a previous  
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5 study could be explained by the fact that the data were collected at a tertiary medical institution.  
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7 Thus, it is appropriate to use objective scoring systems such as NEWS to compare the attributes  
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9 of patients transported by ambulance. Furthermore, the cut-off NEWS in the prehospital setting  
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11 did not differ from that in the hospital setting.<sup>3</sup> Several studies have reported the validity of the  
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13 cut-off values for the NEWS in outpatient settings. Four previous studies<sup>7-10</sup> categorized patients  
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15 into low-, medium-, and high-risk groups according to Royal College of Physicians guidelines.<sup>3</sup>  
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17 After examining the cut-off value in our data, we developed three risk categories. This  
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19 classification based on our results is the same as that for conventional in-hospital NEWS  
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21 categories.  
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26 According to the definition of NEWS based on in-hospital patients, validation was necessary to  
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28 confirm the risk classification for out-of-hospital patients. Thus, we evaluated the ROC curves  
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30 and specified coordinate points. The cut-off NEWSs for prehospital assessment were consistent  
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32 with the definition for in-hospital NEWS prediction (Supplementary Table 2). As medical  
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34 interventions are not applied in the prehospital environment, the cut-off scores for the risk  
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36 categories will differ from those in the in-hospital environment. Thus, future studies should use  
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38 larger datasets to confirm this finding.  
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43 Some studies in Japan have confirmed the usefulness of EWS in hospital and triage settings.<sup>19-22</sup>  
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45 However, several countries require nationwide in-hospital EWS implementation, and in the UK,  
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47 this has been widely used in prehospital settings, outpatients, and emergency services.<sup>4</sup>  
48  
49 Paramedics in Japan should directly request the hospital for ambulance acceptance on the scene.  
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51 However, it is often difficult to obtain hospital acceptance for transportation because the number  
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53 of transportations has increased each year.<sup>17</sup> Furthermore, the time from making the ambulance  
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55 call until arrival at the hospital is also gradually increasing.<sup>23,24</sup> This might delay crucial  
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57 emergency treatments, which in turn might worsen patient outcomes. NEWS-based risk  
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5 stratification helps paramedics to understand the severity of the patient's condition and  
6 communicate it accurately to a healthcare professional at the hospital. Earlier identification of  
7 critical patients might facilitate earlier resuscitation and appropriate critical care.<sup>8</sup>  
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14 This study used outpatient disposition as the primary outcome. Most previous reports have  
15 considered short-term mortality as the primary outcome to assess the usefulness of prehospital  
16 NEWS.<sup>6,9,10</sup> As it predicts outpatient outcomes in addition to short-term mortality, the NEWS is  
17 a very useful tool.  
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24 We are also currently analyzing the relationship between prehospital NEWS and mortality rate  
25 with more extensive data and exploring the possibility of more accurately predicting death by  
26 integrating other factors (chief complaints, etc.). This study is the first step toward the  
27 implementation of prehospital NEWS as a prehospital triage tool. There is currently no triage  
28 tool in the prehospital setting in Japan. The Japan Triage and Acuity Scale is currently used in  
29 the outpatient setting, but it does not assume an emergency site. To use prehospital NEWS as a  
30 triage tool, additional analysis of "false-positive" and "false-negative" rates is required. It is  
31 necessary to clarify what kind of cases are "Go home despite high score" and "ICU  
32 hospitalization despite low score." These data should be assessed in a future study.  
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45 The strengths of this study are as follows. This study is the first in Japan to show that the NEWS  
46 can be used in a prehospital setting to predict patient disposition. Our dataset was much larger  
47 than that used in a previous study<sup>7</sup>, which suggests higher reliability. It is noteworthy that the  
48 results obtained by calculating the cut-off values for the out-hospital setting were the same as  
49 those obtained for the in-hospital setting.  
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## 58 **Limitations**

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

17 The results of our study suggest the usefulness of NEWS for categorizing ED cases on patient  
18 arrival by ambulance. The study also showed that elevated NEWS among unselected prehospital  
19 patients could be used to predict patient disposition at the ED in Japan. The NEWS has a wide  
20 range of uses in prehospital settings. A prospective multicenter study is needed to validate the  
21 usefulness of the NEWS in the prehospital setting.  
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#### 5 **ACKNOWLEDGEMENTS** 6

7 We thank our department research assistant, Ms. Akiko Hosoyama, and our department  
8 paramedic, Mr. Daigo Ando, for their help in collecting the data.  
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#### 13 **CONTRIBUTORS** 14

15 TE, KM, SiF, and YT conceived the research idea and designed the study. TE, ShF, and TN  
16 collected the data. TE, MT, JT, TN, NS, and TS provided statistical advice on the study design  
17 and analyzed the data. TE and SiF chaired the data oversight committee. TE, HCH, and TY  
18 drafted the first version of the manuscript. TE, SiF, and YT take public responsibility for the  
19 contents of this paper.  
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31 Grant 2018 and the Yuumi Memorial Foundation for Home Health Care Grant 2017.  
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#### 37 **COMPETING INTERESTS** 38

39 None declared.  
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#### 43 **PATIENT CONSENT** 44

45 Not required.  
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#### 49 **ETHICS APPROVAL** 50

51 The research protocol received approval from the ethics committee of the Institutional Review  
52 Board of St Marianna University School of Medicine (No. 4325).  
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#### 58 **PROVENANCE AND PEER REVIEW** 59 60



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5 Not commissioned; externally peer-reviewed.  
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10 **DATA SHARING STATEMENT**

11 No additional data were available.  
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16 **OPEN ACCESS**

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For peer review only

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5 **FIGURE LEGENDS**  
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7 Figure 1.

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9 Flow diagram of the included cases  
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14 CPA: Cardiopulmonary arrest  
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18 Figure 2.

19  
20 Boxplots of NEWS by patient disposition outcomes, and results of pairwise Wilcoxon tests  
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24 NEWS: National Early Warning Score

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26 ED: Emergency department

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28 ICU: Intensive care unit

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30 \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$   
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35 Figure 3.

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37 Receiver operating characteristic (ROC) curves of the prediction of NEWS for combined patient  
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43 NEWS: National Early Warning Score

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45 ED: Emergency department

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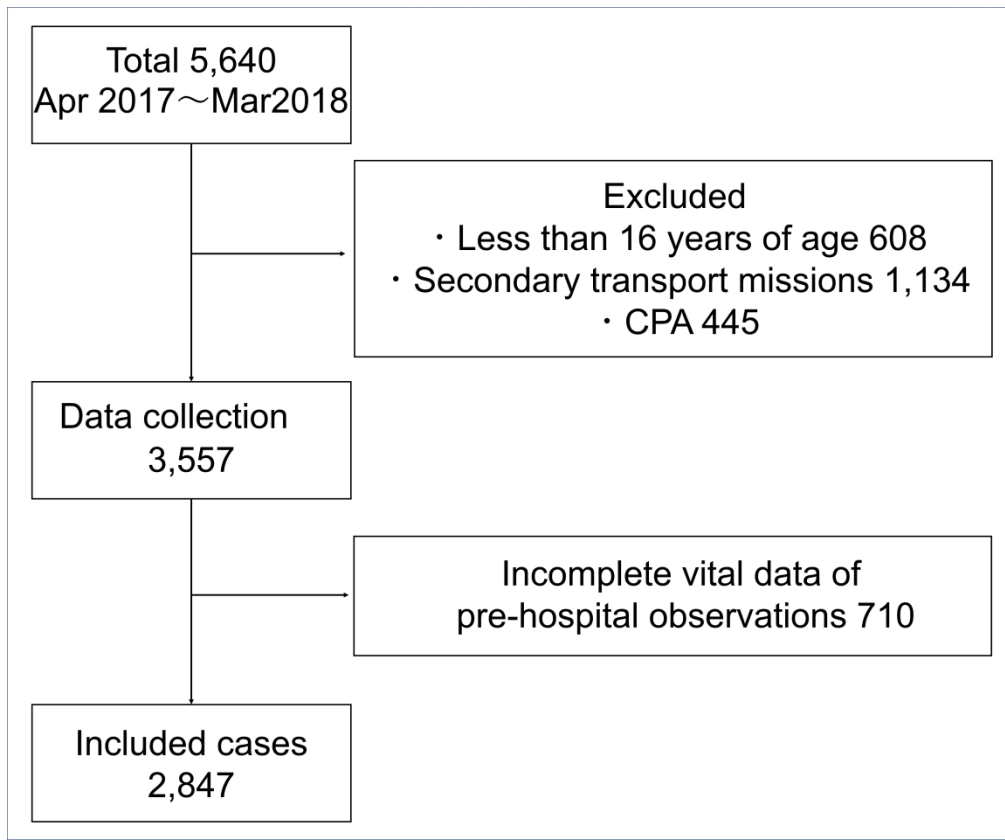


Figure 1. Flow diagram of cases included in the analysis.  
CPA: cardio-pulmonary arrest

259x215mm (350 x 350 DPI)

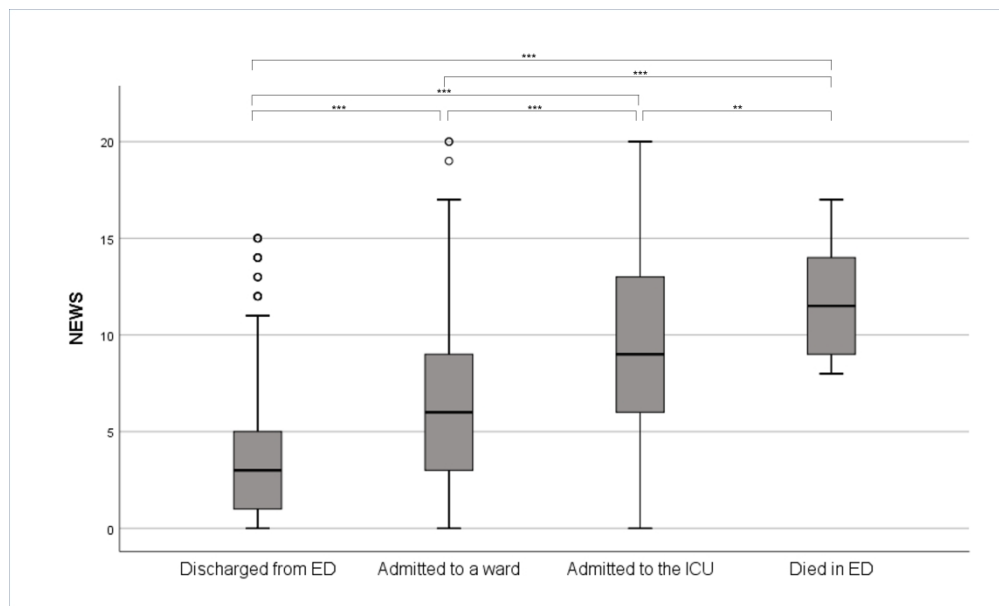


Figure 2 Boxplots of NEWS by patient disposition outcomes, with the results of the pairwise Wilcoxon tests.

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

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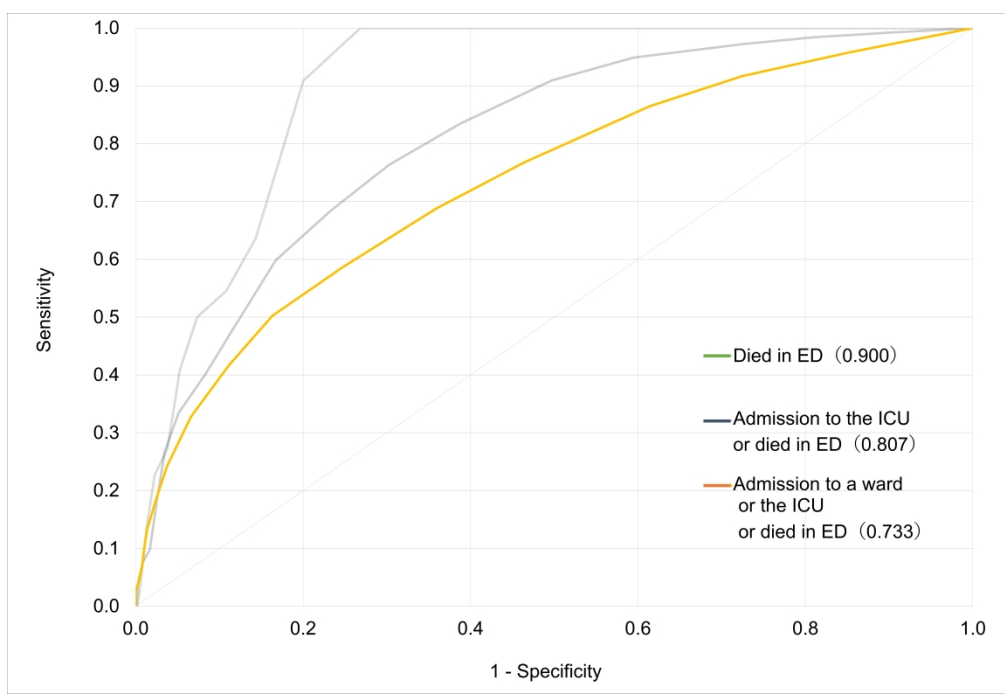


Figure 3.  
 The receiver operating characteristic (ROC) curves of the prediction of NEWS for patient combined disposition.  
 NEWS: national early warning score  
 ED: emergency department  
 ICU: intensive care unit  
 400x273mm (350 x 350 DPI)



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Supplementary Table 1. Scoring system of NEWS.

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

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4	16.50	0.013	0.000	0.043	0.003	0.045	0.006
5	17.50	0.004	0.000	0.012	0.001	0.000	0.002
6	18.50	0.003	0.000	0.004	0.001	0.000	0.001
7	19.50	0.002	0.000	0.004	0.001	0.000	0.001
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12 ROC: receiver operating characteristics

13 ED: emergency department

14 ICU: intensive care unit  
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18 Because there is no principled statistical criterion for selecting an optimal cutoff point without information on "cost", we carefully chose  
19 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  
20 clinical practice viewpoint. As a starting point, we calculated Youden's index, which is defined as a difference between sensitivity and 1 -  
21 specificity, or "sensitivity + specificity - 1"; we found the following values to be considered as candidate cut points for NEWS:  
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	Youden's index		
Cut point	Ward/ICU/Death	ICU/Death	Death
25 3.5	0.303	0.354	0.377
26 4.5	0.329	0.412	0.47
27 5.5	0.339	0.447	0.577
28 6.5	0.339	0.461	0.661
29 7.5	0.306	0.451	0.732
30 8.5	0.262	0.431	0.709

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6 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  
7 death), we chose a value 6.5 because relatively higher sensitivity of ICU admission or death (about 3/4, or 75%).  
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10 Next, we considered that a "middle/low-risk" cut point should have had high sensitivity for a ward admission and minimal degree of  
11 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  
12 for ICU admission, too.  
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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	-	-	-

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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

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

	All (n=2,847)	Patient disposition			
		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
<b>Title and abstract</b>			
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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			
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
<b>Discussion</b>			
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
<b>Other information</b>			
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.