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Analysis of the early warning score to detect critical or high-risk patients in the prehospital setting

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Abstract
The early warning score can help to prevent, recognize and act at the first signs of clinical and physiological deterioration. The objective of this study is to evaluate different scales for use in the prehospital setting and to select the most relevant one by applicability and capacity to predict mortality in the first 48 h. A prospective longitudinal observational study was conducted in patients over 18 years of age who were treated by the advanced life support unit and transferred to the emergency department between April and July 2018. We analyzed demographic variables as well as the physiological parameters and clinical observations necessary to complement the EWS. Subsequently, each patient was followed up, considering their final diagnosis and mortality data. A total of 349 patients were included in our study. Early mortality before the first 48 h affected 27 patients (7.7%). The scale with the best capacity to predict early mortality was the National Early Warning Score 2, with an area under the curve of 0.896 (95% CI 0.82–0.97). The score with the lowest global classification error was 10 points with sensitivity of 81.5% (95% CI 62.7–92.1) and specificity of 88.5% (95% CI 84.5–91.6). The early warning score studied (except modified early warning score) shows no statistically significant differences between them; however, the National Early Warning Score 2 is the most used score internationally, validated at the prehospital scope and with a wide scientific literature that supports its use. The Prehospital Emergency Medical Services should include this scale among their operative elements to complement the structured and objective evaluation of the critical patient.

Keywords Prehospital care · Early warning score · Prognosis · Early mortality · Clinical research

Introduction

The professionals of the Prehospital Emergency Medical Services (PhEMS) often have to face situations with complex patients (pluripathology, comorbidity, contexts of violence, use of personal protection equipment, etc.) in a critical situation, which require accurate and rapid handling [1].

One priority of health systems is the early identification of high-risk patients, and especially in time-dependent pathologies [2, 3]. With recent technological advances, we can apply portable analytical systems at bedside [4], imaging methods like point-of-care ultrasound (POCUS) [5], etc., that in combination with standardized care should guarantee adequate attention to patients in critical state. However, in many cases, parameters that indicate a situation of imminent risk are not taken into account or identified in the decision-making process.

For the identification of these patients, different Early Warning Scores (EWS) emerged a few years ago that provide a reliable, fast, easy-to-apply and validated tool [6, 7]. EWS enable the identification of critical patients, as well as those with potential for deterioration [8, 9], while also allowing to assess the severity of the process in a simple and pragmatic way, through early detection, rapid and timely response and precise professional competence [10, 11].

Since the development of the first EWS, more than 100 different scales have been developed [12], all providing a standardized score based on different physiological parameters (such as heart and respiratory rate, systolic blood pressure, temperature, oxygen saturation) and observations (level of awareness, use of supplementary oxygen). These variables provide information about the severity of the patient, help in

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making clinical decisions, and also guarantee a standardized means of identifying and responding to the same physiopathological processes in different situations [13–15].

EWS can identify subtle signs of deterioration 6–8 h before a serious adverse event [16], and are used routinely in the hospital setting. The score can, thus, guide the appropriate clinical response to the potentially changing pathophysiological situation of these patients.

Currently, different EWS are used internationally in the prehospital setting [6, 7, 9, 12, 17, 18], but with limited empirical evidence about their effectiveness. We have a heterogeneity of scales, developed for specific purposes (such as cardiac arrest, trauma, or sepsis) and with the inclusion of different parameters or different weights for the same parameter between some scales and others [19–21].

A systematic review about the use of EWS in the prehospital setting [12] discovered reports that the early identification of signs of deterioration can be very useful in time-dependent pathologies such as sepsis. All the EWS included in the review have a high sensitivity, so they adequately identify high-risk patients. The importance of pre-hospital alert was stressed. In fact, the pre-alert situation (calculated by EWS) decreased the time of treatment by half [22].

PhEMS should have some of the scales in their care protocols, which together with the standardized clinical evaluation and other diagnostic tools such as electrocardiogram, capillary glucose, capillary lactate or POCUS would optimize the care chain. However, it is currently unknown which EWS have better prognostic performance in the prehospital setting as studies on the subject have not been conducted.

In the prehospital environment, professionals must face multiple challenges: danger, reduced time window, nonspecific signs and symptoms, limited diagnostic means, social pressure, etc. In these special circumstances, EWS can reliably assist in clinical decision-making [23], yet we must not lose sight of the fact that a high score is simply a numerical orientation towards practice. No EWS can replace an objective and structured evaluation and clinical judgment. Low scores, but concomitant with situations such as electrocardiographic alterations in the ST segment, shock, exacerbations of chronic diseases, etc., can represent critical situations for patients that are not clearly reflected by the scales.

Therefore, the main objective of this study is to evaluate the different EWS for use in the prehospital setting and determine the most appropriate one in terms of their ability to predict early mortality of patients.

Methods

Study design

We conducted a prospective longitudinal observational study in patients above 18 years who were attended by the advanced life support unit (ALSU), and transferred to the emergency department (ED) between April and July 2018.

Study setting and population

The study was conducted in the city of Valladolid (Spain). The PhEMS provides coverage in the metropolitan area to a population of 449,834 inhabitants, distributed over 7210 km^2, with three ALSU, integrated by two paramedics, an emergency nurse and a medical doctor.

The gateway to PhEMS is through the telephone number 112, operating 24 h a day, 365 days a year. The call is received by a non-health technician. If the reason for the call is to request medical attention, once affiliation and location have been gathered as accurately as possible, the call is immediately transferred to an emergency medical doctor, who determines the seriousness of the situation and sends the most appropriate response for that medical emergency.

Participants in the study were treated and transferred by the ALSU to the two public reference hospitals in the city: Río Hortega University Hospital and the University Clinic of Valladolid. Both hospitals have a wide surgical capacity and intensive care unit (ICU), with the door of entry being the ED.

The criteria for including a patient in the study were having been transferred in ALSU to the reference hospital, and not meeting any exclusion criteria, which were: age below 18 years, cardiorespiratory arrest or exitus prior to the arrival of the hospital, pregnancy, psychiatric pathology, diagnosis of end-stage disease (in treatment by palliative care units), time of arrival of ALSU greater than 45 min and transfer by other transport vectors or discharge in situ (Fig. 1).

Early warning scales inclusion

Since the birth of the Early Warning Score (EWS) and its validation until today, more than 100 scales have been developed on the basis of the original [12]. These scales are composed of simple parameter systems, multiple parameters or aggregate weighting systems, the latter being the most reliable [17, 24]. For this study, we selected six EWS that can be used in the prehospital setting: Early Warning Score (EWS) [14], National Early Warning Score 2 (NEWS 2) [13], Modified Early Warning Score (MEWS) [1], VitalPAC Early Warning Score (ViEWS) [25], Hamilton Early

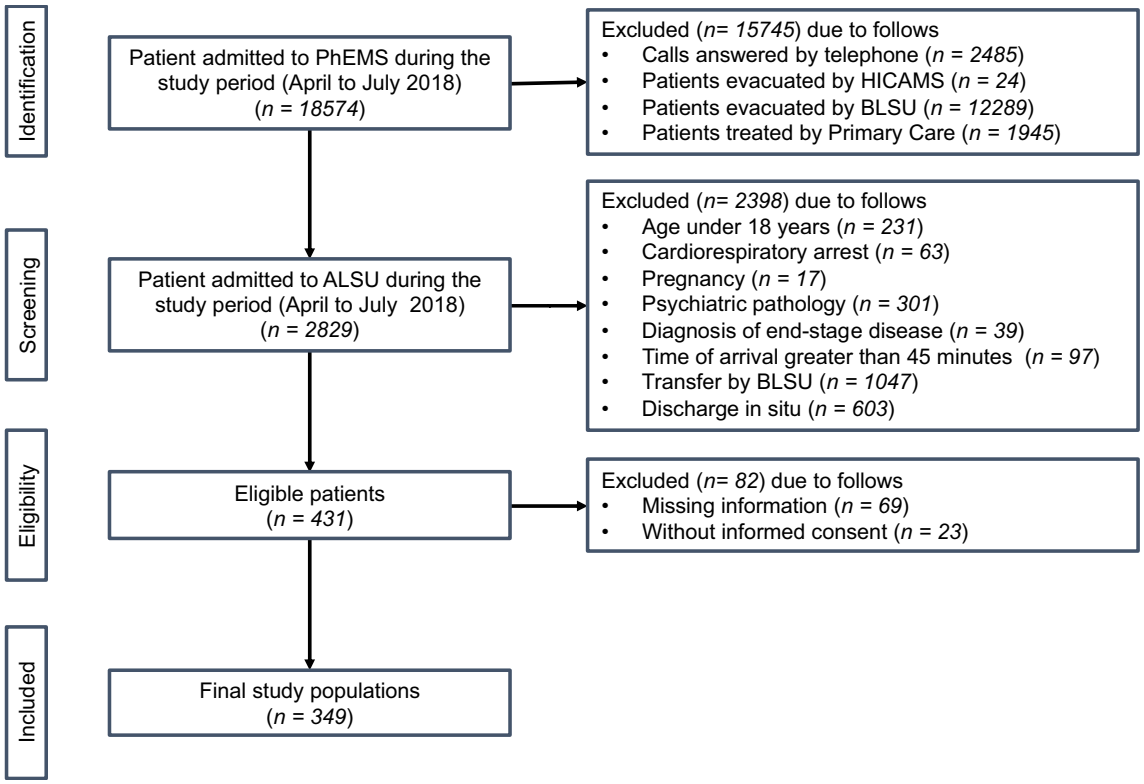

Fig. 1 Flow chart enrolled patients. *PhEMS* Prehospital Emergency Medical Services, *HICAMS* Helicopter Intensive Care Advanced Medical Service, *ALSU* advanced life support unit, *BLSU* basic life support unit

Warning Score (HEWS) [26], and Scottish Early Warning Score (SEWS) [27] (Table 1 shows the different early warning scales used in the study and the parameters that make them up).

We discarded scales that consider the use of age, analytical parameters, diuresis, or that due to their complexity are not agile in their application, such as the Rapid Acute Physiology Score (RAPS), Rapid Emergency Medicine Score (REMS), Acute Physiology and Chronic Health Evaluation (APACHE) or Simplified Acute Physiology Score (SAPS) [28].

Data measures and analysis

At the time of assistance, demographic variables and those related to the times of healthcare were collected, as well as

Table 1 Early warning score evaluated in the study and physiological parameters that make up each scale

	EWS	MEWS	HEWS	ViEWS	SEWS	NEWS 2
References	[14]	[1]	[26]	[25]	[27]	[13]
Breathing rate (bpm)	X	X	X	X	X	X
Oxygen saturation %	X		X	X	X	X
Air oxygen				X		X
FiO_2			X			
Pulse (hpm)	X	X	X	X	X	X
SBP (mmHg)	X	X	X	X	X	X
Temperature (°C)	X	X	X	X	X	X
AVPU (scale)	X	X	X	X	X	X
Total score (points)	18	14	21	21	18	20

EWS Early Warning Score, *MEWS* Modified Early Warning Score, *HEWS* Hamilton Early Warning Score, *ViEWS* VitalPAC Early Warning Score, *SEWS* Scotish Early Warning Score, *NEWS-2* National Early Warning Score-2, *FiO2* fraction of inspired oxygen, *SBP* Systolic blood pressure, *AVPU* alert, verbal, pain, unresponsive

physiological parameters and clinical observations necessary to complement the EWS. Subsequently, a follow-up of each patient was carried out, analyzing the variables related to the patient's care at the hospital level, considering their final diagnosis and classifying the patients according to the following diagnostic groups: cardiovascular, neurological, respiratory, trauma and injuries due to external agents and other types of pathologies (digestive, endocrine, infectious, genito-urinary, etc.). We also took into account requests for complementary tests or visits to other medical specialists, as well as their final destination in terms of admission into intensive care units or hospitalization and early mortality (less than 48 h).

For measuring tympanic temperature, we used a Braun Thermoscan Pro 6000 (Welch Allyn, Inc. New York, USA) with ExacTemp™ technology. Arterial blood pressure, heart rate, breathing frequency, rhythm monitoring and oxygen saturation were done with the multiparameter monitor LifePAK® 15 (Physio-Control, Inc. Redmond, WA, USA).

All data were collected and organized in a database designed for that purpose, with double data entry to reduce input errors. Prior to the applying statistical techniques, we checked the database by means of logical tests, range tests (for the detection of extreme values) and for data consistency. Subsequently, we checked for the presence and distribution of the unknown values ("missing") of all variables.

All data were stored in an XLSTAT® BioMED database for Microsoft Excel® (version 14.4.0.), and Statistical Product and Service Solutions (SPSS, version 20.0), with which the subsequent statistical analysis was carried out. A descriptive study of the samples was carried out. Continuous quantitative variables are described as mean ± standard deviation in case of normal distribution. If the distribution did not follow a normal distribution, data are presented as median and interquartile range, and the Kolmogorov–Smirnov test was used. Qualitative variables are described by absolute and relative frequencies (%). For comparing means of quantitative variables, we used Student's t test with normally distributed values and the Mann–Whitney U test if there was no normal distribution. The Chi-square test was used for 2 × 2 contingency tables and/or proportional contrast to stipulate the association or dependency relationship between qualitative variables if necessary (percentage of squares with expected values less than five, greater than 20%); Fisher's exact test was used.

The area under the curve (AUC) of the receiver operating characteristic (ROC) curve of each of the scales was calculated in terms of early mortality (less than 48 h). We determined the three scores of each scale that offered the highest sensitivity and specificity using the Youden index, calculating in each case: sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio. Finally, we proceeded to compare each of the AUC obtained from all the scales created by nonparametric tests.

In all tests, a confidence level of 95% and a p value of less than 0.05 were considered significant.

Results

From April to July 2018, a total of 349 patients were included in our study, the mean (± SD) age was 66 (± 17) years, 41.5% of the patients were women. Early mortality before the first 48 h affected 27 patients (7.7%).

The demands for care were mostly due to medical problems in 298 cases (85.3%), especially problems of cardiovascular origin in 152 cases (43.6%), neurological in 76 (21.8%), respiratory in 35 (10%) and other types of medical pathology in another 35 cases (10%). Trauma (deliberate self-harm is classified under overdose or injury as appropriate) and injury by external agents accounted for 51 cases (14.6%) (Table 2).

All patients underwent a systematized primary evaluation, with statistically significant differences between survivors and non-survivors in respiratory frequency, oxygen saturation, heart rate and Glasgow Coma Scale. Regarding the measures of advanced life support, 14 of 27 deceased patients previously required advanced maneuvers of the airway ($p < 0.001$) (Table 2).

The admission rate was 62.8% (219 patients). In 227 cases (65.1%), the interconsultation with specialists (different from those of the PhEMS or ED) was required; in 134 of them (38.3%), additional special tests were requested: imaging studies (computerized axial tomography and/or ultrasound), lumbar puncture, cultures, endoscopy, etc.), and in 15.4% (54 patients), surgical and/or interventional procedures were necessary.

The mean scores of the EWS showed statistically significant differences between survivors and non-survivors ($p < 0.001$). In the stratification by gender, these differences were maintained in all the scales studied ($p < 0.001$).

All AUC of the EWS obtained statistical significance for the prediction of early mortality (before the first 48 h) (Fig. 2). The EWS that obtained the best AUC are the NEWS2 and the ViEWS, with an AUC of 0.896 (95% CI 0.82–0.95) and 0.894 (95% CI 0.82–0.96), respectively. When comparing both scales, no statistically significant differences are observed ($p = 0.919$). The MEWS scale obtained the lowest AUC of 0.848 (95% CI 0.76–0.93) (Fig. 2 and Table 3).

Table 4 shows the three best cut-off points for the different scales in terms of sensitivity and specificity. The NEWS2 and the ViEWS presented the same sensitivity and specificity for scores of more than 8 and a positive likelihood ratio of 3.36 (95% CI 2.69–4.22) and 3.29 (95% CI 2.63–4.11),

Table 2 General characteristics of the patients

	Total	Survivors	Non-survivors	*p* value
Number [*n* (%)]	349 (100)	322 (92.3)	27 (7.7)	< 0.001
Gender				
Male [*n* (%)]	204 (58.5)	185 (90.7)	19 (9.3)	< 0.001
Female [*n* (%)]	145 (41.5)	137 (94.5)	8 (5.5)	< 0.001
Age (years old) [mean (± SD)]	66.4 (17.1)	65.5 (17.1)	77.4 (12.6)	0.002
Male	65.1 (16.5)	63.8 (16.4)	78.1 (10.2)	0.001
Female	68.2 (17.7)	67.7 (17.7)	80.5 (17.9)	< 0.001
Isochronous (min) [Mean (± SD)]				
Arrival time	11 (5)	11 (5)	12 (6)	0.302
Support time	30 (10)	30 (10)	33 (13)	0.238
Transfer time	11 (7)	10 (7)	13 (8)	0.073
Initial evaluation [Mean (± SD)]				
Breathing rate (bpm)	21.5 (8.8)	21.1 (8.3)	26.2 (12.9)	0.028
Oxygen saturation (%)	92.9 (9.7)	93.9 (8.3)	80.4 (13.3)	< 0.001
Heart rate (hpm)	90.9 (30.9)	90.4 (30.8)	97.4 (31.5)	0.048
SBP (mmHg)	137.8 (32.5)	138.9 (31.1)	125.1 (45.1)	0.075
Tympanic temperature (°C)	36.3 (0.9)	36.3 (0.8)	36.1 (1.1)	0.230
GCS (3–15 points)	13.7 (2.8)	14.1 (2.3)	9.9 (4.9)	< 0.001
Prehospital support [*n* (%)]				
Supplemental oxygen	84 (24.1)	73 (22.7)	11 (40.7)	0.035
Advanced airway support	30 (8.9)	17 (5.3)	13 (48.1)	< 0.001
Intravenous medication	289 (82.8)	262 (82.6)	23 (85.2)	0.734
Pacemaker or cardioversion	21 (6.1)	17 (5.3)	4 (14.8)	0.046
Prehospital diagnostic [*n* (%)]				
Cardiac pathology	152 (43.4)	138 (42.9)	14 (51.9)	< 0.001
Neurological pathology	76 (21.8)	71 (22.1)	5 (18.5)	< 0.001
Respiratory pathology	35 (10.1)	30 (9.3)	5 (18.5)	< 0.001
Injuries and external agents	51 (14.6)	49 (15.1)	2 (7.4)	< 0.001
Other pathology	35 (10.1)	34 (10.6)	1 (3.7)	< 0.001
Hospital department [*n* (%)]				
ED/hospitalization	219 (62.8)	192 (59.6)	27 (100)	< 0.001
ICU	77 (22.1)	60 (18.6)	17 (63.1)	< 0.001
Hospitalization days [Median (25th–75th percentile)]	2 (0–7)	2 (0–7.25)	1 (0–1)	0.003

Mortality data refer to early mortality rate (≤ 48 h)

SD standard deviation, *SBP* systolic blood pressure, *GCS* Glasgow coma scale, *ED* emergency department, *ICU* intensive care unit

respectively. For scores greater than or equal to 10, the specificity increases d to 0.88 (95% CI 0.84–0.91) in the NEWS2 and 0.87 (95% CI 0.83–0.90) in the ViEWS with a probability ratio of 7.09 and 6.85, respectively.

Discussion

We present the first prospective study that compares the prognostic performance of different EWS in PhEMS.

All the EWS analyzed represent tools that can be used where the patient is, and are, therefore, ideal in the prehospital context, with a high capacity to discriminate critical patients and the appearance of serious adverse effects and to initiate an appropriate response by qualified personnel.

Our analysis demonstrates that all scales have a high capacity to predict short-term mortality. Of all the scales evaluated, only the MEWS behaved significantly worse than the rest; so, it would not be the best option in the analysis of these patients outside the hospital setting. The other five scales obtained similar AUC, with NEWS2 and ViEWS slightly larger, although without significant differences [6, 12, 23, 29].

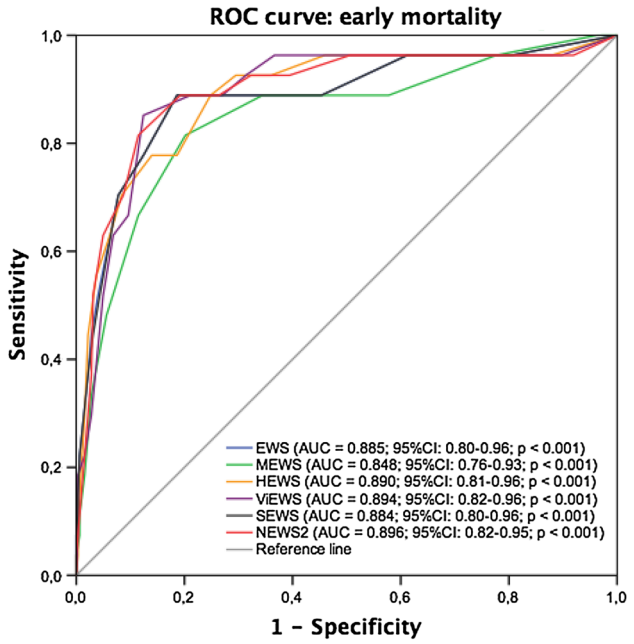

Fig. 2 Diagnostic performance curves and areas under the curve with 95% confidence intervals for the different scales. Analysis of early mortality. *EWS* Early Warning Score, *MEWS* Modified Early Warning Score, *HEWS* Hamilton Early Warning Score, *ViEWS* VitalPAC Early Warning Score, *SEWS* Scottish Early Warning Score, *NEWS2* National Early Warning Score-2

Table 3 Comparison of the different AUROC of the EWS with statistical significance (*p* value)

	MEWS	HEWS	ViEWS	SEWS	NEWS2
EWS	**0.022**	0.709	0.533	0.968	0.468
MEWS		**0.008**	**0.004**	**0.024**	**0.003**
HEWS			0.802	0.679	0.725
ViEWS				0.507	0.919
SEWS					0.444

EWS Early Warning Score, *MEWS* Modified Early Warning Score, *HEWS* Hamilton Early Warning Score, *ViEWS* VitalPAC Early Warning Score, *SEWS* Scottish Early Warning Score, *NEWS2* National Early Warning Score-2

Studies such as those of Mosseson et al. [28] and Alam et al. [30] present AUROC similar to the data presented in our study, despite using the EWS in a hospital context (APACHE II and III, SAPS II, MEWS, REMS, Prince of Wales Emergency Department Score: PEDS). In a study developed specifically for the prehospital setting, Silcock et al. [6] obtained an AUROC of 0.871 for the validation of the NEWS, a figure slightly lower than that obtained in our analysis but in line with our results. In a recently published systematic review, Patel et al. [31] aimed at evaluating the effectiveness and predictive accuracy of different scales in the prehospital setting (NEWS, MEWS, ViEWS, etc.). The review concludes that there is no evidence that either scale was used in the prehospital setting, and that more prospective studies are required.

It is crucial to determine which score on each of the scales should trigger alarms, to initiate hospital pre-alert measures to start care early and ensure continuity of care [32, 33]. The high sensitivity of these systems can lead to labeling of non-critical patients as critical; however, we will avoid the loss or delay in the treatment of critical patients who need therapeutic measures or response to the appearance of serious adverse effects [34]. Other studies [7, 15, 30, 35] have established the cut-off point for receiving hospital notice or the need to activate intensive care services within the hospital at seven points. In our series, the average score on all scales is much higher among those who died in the first 48 h, corroborating other analyzes, such as the one carried out for the NEWS by Shaw et al. [9].

A high score on any of the scales studied at the time of initial care means a higher probability of early mortality [22, 36]. Hence, we believe it is appropriate to establish a cut-off point in the NEWS2 score of eight points to determine that patients should be evacuated in the ALSU and ten points to give hospital notice. With these scores, specificity is lost but sensitivity is gained.

PhEMS differ in terms of personnel, equipment, operating protocols and activation; so, each health system should assess the limiting scores that activate one or the other response. As we have seen in the results, all the scales studied (except the MEWS) can be used to screen for early mortality.

The early detection is an element that can make a difference. Yet we may not forget that no EWS can substitute an objective and structured clinical evaluation, since these scales can underestimate severity in time-dependent pathologies (ictus, sepsis, etc.) or in the presence of concomitant findings (alterations in the ST segment, shock in the compensation phase, etc.).

PhEMS have few diagnostic resources, so any help that can guide clinical decision-making is a very useful tool. The early warning score studied (except MEWS) shows no statistically significant differences between them. The authors think that any of them can be used, but if the PhEMS is going to implement its use in the system, we are inclined to use the NEWS-2, not for statistical power with respect to the others, but for specific valuation in the prehospital scope, by the international diffusion and by the multitude of studies that reaffirm this score.

Limitations

Our study has several limitations. First, the multiplicity of EWS present in the literature: after a deep review, six scales were selected for applicability in the prehospital context,

Table 4 Cut-off points of sensitivity and specificity combined with best score (Youden test) for the different scales analyzed

Cut-offs (points)		Se % [95% CI]	Sp % [95% CI]	PPV [95% CI]	NPV [95% CI]	LR (+) [95% CI]	LR (−) [95% CI]
EWS	5[a]	0.88 (0.70–0.96)	0.81 (0.76–0.85)	0.28 (0.20–0.39)	0.98 (0.96–0.99)	4.77 (3.66–6.21)	0.13 (0.05–0.40)
	6	0.77 (0.58–0.89)	0.87 0.83–0.90)	0.34 (0.23–0.47)	0.97 (0.95–0.99)	6.26 (4.40–8.91)	0.25 (0.12–0.52)
	7	0.70 (0.51–0.84)	0.92 (0.88–0.94)	0.43 (0.29–0.57)	0.97 (0.94–0.98)	9.06 (5.78–14.20)	0.32 (0.18–0.58)
MEWS	5[a]	0.81 (0.62–0.92)	0.79 (0.75–0.83)	0.25 (0.17–0.35)	0.98 (0.95–0.99)	4.03 (3.04–5.35)	0.23 (0.10–0.52)
	6	0.66 (0.47–0.81)	0.88 (0.84–0.91)	0.32 (0.21–0.45)	0.96 (0.94–0.98)	5.80 (3.87–8.69)	0.37 (0.22–0.65)
	7	0.48 (0.30–0.66)	0.94 (0.91–0.96)	0.41 (0.26–0.59)	0.95 (0.92–0.97)	8.61 (4.75–15.63)	0.54 (0.38–0.80)
HEWS	6	0.92 (0.75–0.98)	0.70 (0.65–0.75)	0.20 (0.14–0.28)	0.99 (0.96–0.99)	3.13 (2.57–3.83)	0.10 (0.03–0.40)
	7[a]	0.88 (0.70–0.96)	0.75 (0.70–0.79)	0.23 (0.16–0.32)	0.98 (0.96–0.99)	3.57 (2.84–4.51)	0.14 (0.05–0.43)
	8	0.77 (0.58-0.89)	0.81 (0.76-0.85)	0.25 (0.17-0.36)	0.97 (0.95-0.99)	4.17 (3.08-5.66)	0.27 (0.13-0.56)
ViEWS	8	0.88 (0.70-0.96)	0.73 (0.67–0.77)	0.21 (0.15-0.30)	0.98 (0.96-0.99)	3.29 (2.63-4.11)	0.15 (0.05-0.45)
	9	0.88 (0,70-0.96)	0.78 (0.74-0.83)	0.26 (0.18-0.35)	0.98 (0.96-0.99)	4.20 (3.28-5.40)	0.14 (0.05-0.41)
	10[a]	0.85 (0.66–0.94)	0.87 (0.83–0.90)	0.36 (0.25–0.48)	0.98 (0.96–0.99)	6.85 (4.93–9.54)	0.16 (0.07–0.42)
SEWS	5[a]	0.88 (0.70-0.96)	0.81 (0.76-0.85)	0.28 (0.20-0.39)	0.98 (0.96-0.99)	4.77 (3.66-6.21)	0.13 (0.05-0.40)
	6	0.77 (0.58-0.89)	0.87 (0.83–0.90)	0.34 (0.23–0.47)	0.97 (0.95–0.99)	6.26 (4.40–8.91)	0.25 (0.12–0.52)
	7	0.70 (0.51–0.84)	0.92 (0.88–0.94)	0.43 (0.29–0.57)	0.97 (0.94–0.98)	9.06 (5.78–14.20)	0.32 (0.18–0.58)
NEWS2	8	0.88 (0.70–0.96)	0.73 (0.68–0.78)	0.22 (0.15–0.30)	0.98 (0.96–0.99)	3.36 (2.69–4.22)	0.15 (0.05–0.44)
	9	0.88 (0.70–0.96)	0.80 (0.76–0.84)	0.27 (0.19–0.38)	0.98 (0.96–0.99)	4.61 (3.56–5.99)	0.13 (0.05–0.40)
	10[a]	0.81 (0.62–0.92)	0.88 (0.84–0.91)	0.37 (0.26–0.50)	0.98 (0.96–0.99)	7.09 (4.98–10.09)	0.20 (0.09–0.46)

CI confidence interval, *Se* sensitivity, *Sp* specificity, *PPV* positive predictive value, *NPV* negative predictive value, *LR* likelihood ratio, *EWS* Early Warning Score, *MEWS* Modified Early Warning Score, *HEWS* Hamilton Early Warning Score, *ViEWS* VitalPAC Early Warning Score, *SEWS* Scottish Early Warning Score, *NEWS2* National Early Warning Score-2

[a]Maximum (sensitivity + specificity − 1)

validation and use at an international level. The authors are aware that it is a partial selection, but we think that it is very appropriate to the current state of knowledge.

We have used early mortality (in less than 48 h), a patient-centered result, as the only measure of quality of care. We do not examine the deaths that occurred outside this time window, either in the hospital setting or in their own homes because these deaths are not attributable to prehospital care.

Finally, our analysis was conducted in a city with a limited sample. It is necessary to perform prospective multicenter studies with adequate power, using the same EWS to facilitate comparison and identify the best EWS for use in a prehospital context.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of human and animal rights "All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards." The study was approved by the Clinical Research Ethics Committee at the Río Hortega University Hospital, and the University Clinic Valladolid (Spain), with registration codes #PI 18-010 and #PI 18-895.

Informed consent Informed consent was obtained from all individual participants included in the study (in the case that the patient due to its seriousness could not grant the consent, a family member or tutor was spoken to, and in the latter case in the subsequent hospital follow-up, informed consent is made).

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