

ORIGINAL ARTICLE

Early detection of risk for clinical deterioration in emergency department patients: validation of a version of the National Early Warning Score 2 for use in Spain

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Objective. To determine the ability of a Spanish translation of the National Early Warning Score 2 (NEWS2) to predict hospitalizations and adverse events during triage in hospital emergency departments.

Methods. Prospective observational study in 2 phases. Phase 1 took place in October and November 2019 and phase 2 in January and February 2020. Phase 1 involved the translation and back translation process to produce an adapted Spanish version of the NEWS2 tool, the piloting of the adapted tool, and training sessions for nurses on how to use the scale. Phase 2 was a validation study of the translated scale for use in Spain. We analyzed its psychometric properties and capacity to predict adverse events and hospital admissions. Adult patients (over the age of 18 years) were recruited consecutively in a hospital emergency department in Spain.

Results. We evaluated 523 patients, 81 in phase 1 and 442 in phase 2. The validated Spanish language version of the NEWS2 tool achieved a Cronbach α score of 0.70. The intraclass correlation coefficients for intra- and inter-observer reliability, respectively, were 0.996 (95% CI, 0.995–0.997) and approaching 1 (95% CI, 0.999–1). The area under the receiver operating characteristic curve was 0.969 (95% CI, 0.938–1) for adverse events and 0.881 (95% CI, 0.819–0.943) for hospitalization.

Conclusion. The ability of the Spanish version of the NEWS2 scale to predict hospital admissions and adverse events is high when used during hospital emergency department triage.

Keywords: Clinical deterioration. Triage. Early-warning systems.

Validación en España de la escala National Early Warning Score 2 (NEWS-2) para la detección precoz en urgencias de pacientes en riesgo de deterioro

Objetivo. Conocer la capacidad predictiva en términos de ingresos hospitalarios y de aparición de eventos adversos de la escala de alerta temprana National Early Warning Score 2 (NEWS-2) en la consulta de triaje de los servicios de urgencias hospitalarios (SUH).

Método. Estudio observacional prospectivo dividido en dos fases: Fase I (octubre-noviembre 2019) y Fase II (enero-febrero 2020). En la Fase I se llevó a cabo un proceso de traducción-retrotraducción, se formó al personal de Enfermería en el manejo de la escala NEWS-2 adaptada al español, y se realizó un pilotaje de la escala. En la Fase II se procedió a la validación de la escala analizando sus propiedades psicométricas y predictivas en términos de aparición de eventos adversos e ingresos hospitalarios. Se incluyeron consecutivamente a los usuarios adultos (mayores de 18 años) de un SUH en España.

Resultados. Se valoraron 523 pacientes, 81 en la fase I y 442 en la fase II. La versión de la escala NEWS-2 en español obtenida tras el proceso de validación mostró un valor de alfa Cronbach de 0,70. El coeficiente de correlación intra-clase para la fiabilidad intra e interobservador fue de 0,996 (IC 95%: 0,995-0,997) y 1 (IC 95%: 0,999-1), respectivamente. El área bajo la curva de la característica operativa del receptor fue de 0,969 (IC 95%: 0,938-1) para eventos adversos y de 0,881 (IC 95%: 0,819-0,943) para ingreso hospitalario.

Conclusiones. La escala NEWS-2 tiene alta capacidad predictiva de ingresos hospitalarios y eventos adversos cuando se aplica en la consulta de triaje de los SUH.

Palabras clave: Deterioro clínico. Triage. Sistema de alerta temprana.

Introduction

The need for monitoring and alarm systems to detect patients at high risk of cardiorespiratory arrest (CRA) is contemplated in Spain within the National Cardiopulmonary Resuscitation (CPR) Plan and, specifically, in the various hospital care plans on CRA and vital

emergencies, the prevention of CRA is detailed as a main objective.¹

Early warning systems or early detection of signs of deterioration are simple tools that rely on the vital signs of the patient to determine the likelihood of deterioration in the patient's condition.² The first early warning scale was developed in 1997 by Morgan et al.³ This

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scale was a clinical milestone, improving communication between professionals, reducing the workload and increasing the quality of care provided to patients.³ Numerous such scales have subsequently emerged. In 2007 the Acute Medicine Task Force published a report in the United Kingdom indicating that there is no justification for the use of multiple scales in the same country for the assessment of patient severity and recommended the creation of a unified scale common to all hospitals.⁴ Thus, the National Early Warning Score (NEWS)⁵ scale was developed in 2012 by the Royal College of Physicians of London, with the intention of standardizing clinical practice throughout the country. Its three main aims were: 1) to assess hospitalized patients for severity criteria; 2) to detect clinical deterioration; and 3) to promptly trigger an appropriate clinical response. The NEWS scale was revised and updated in 2017 resulting in the National Early Warning Score 2 (NEWS-2) scale.⁶

The NEWS-2 scale consists of seven items [heart rate (HR), systolic blood pressure (SBP), temperature, oxygen saturation (SatO₂), oxygen delivery, respiratory rate (RF) and level of consciousness], differentiating between patients with respiratory disease in the item SatO₂.⁶

As far as is known today, there is no validated tool in Spain for the recognition of the risk of deterioration of patients during their hospital stay.⁷ Given the predictive capacity of early warning scales for patient deterioration, specifically in hospital emergency departments (ED),^{8,9} as well as the wide implementation and acceptance in various countries of the NEWS-2 scale,^{10,11} it was decided to carry out a translation and cultural adaptation of this scale to the Spanish setting. The general objective was to translate and adapt the NEWS-2 scale to the Spanish context and to determine its predictive capacity for patient deterioration in the ED triage consultation.

Methods

Prospective observational study, conducted in two phases. In Phase I, an English-Spanish-English back-translation process was carried out, with the participation of four bilingual, independent nursing professionals with experience in the use of the NEWS-2⁶ tool, who freely collaborated with the research team. Thus, the first version of the NEWS-2 scale adapted to Spanish was obtained, which was elaborated in order to assess the researchers' understanding of the wording of the translated items, as well as to study whether any of them should be eliminated or modified. To this end, the feasibility, reliability, and validity of the scale were studied. The opinions of the professionals who participated in this phase were also collected for evaluation and group discussion, and the second version of the scale, which presented structural and visual modifications with respect to the first version, was drafted. In Phase II, the second version of the scale was validated in Spanish. To this end, the psychometric properties of

the scale were studied (validity, reliability, and sensitivity to change), as well as its predictive power.

In both phases, data collection took place in the triage consultation room, where a researcher and an ED professional in charge of triage were present. When the user entered the room, the study was explained and consent was requested. Once accepted, triage was performed and vital signs were taken (RF, SatO₂, oxygen intake, HR, SBP, level of consciousness and temperature). Likewise, data derived from hospital care and sociodemographic data were recorded. The calculation of the early warning scale score was performed independently by the investigator and by the professional in charge of triage. Then, in the following 15 minutes, the investigator took another set of vital signs and proceeded to calculate the patient's NEWS-2 score adapted to Spanish.

The study population consisted of all adults over 18 years of age in the health area of a second level hospital in the south of Spain who attended the ED mentioned above, and of the nursing professionals who provided their services in the center and service referred to. Minors (under 18 years of age) and pregnant patients were excluded due to physiological changes in the vital signs of this group.

The data collection period for Phase I was from October 2019 to November 2019, and for Phase II from January 2020 to February 2020.

The sample size for Phase I was 81 patients, following the recommendations of Cea D'Ancona¹² and Iraossi.¹³ For Phase II, the sample size calculation was performed using the Granmo tool, with an alpha risk of 0.05 and a statistical power of 80% in a bilateral contrast, with a known proportion in the pilot study of 15.8% of patients with a NEWS-2 score > 5 points within the outpatient group. To detect a minimum odds ratio of 1.40 requires a total of 442 patients (n = 442). A loss-to-follow-up rate of 10% was estimated. Recruitment, in both phases, was carried out by including consecutively patients attending the ED. Days and times (morning or afternoon) were randomly selected (list of random numbers).

The variables collected during the two phases of the study were: (i) patient sociodemographic variables (age and sex); (ii) patient independent variables (reason for consultation, medical diagnosis, diagnostic category, admission time and priority level assigned by the SET-MAT® program); (iii) patient dependent variables [score on the Spanish-adapted NEWS-2 early warning scale on arrival at the ED and within 15 minutes of arrival at the ED, length of stay in the ED, patient discharge destination, in-hospital mortality, transfer to the intensive care unit (ICU), occurrence of adverse event (AE) (CRA, respiratory arrest), hospital admission, length of admission, department in charge of admission and discharge destination]; and independent variables of the professionals (age, gender, work shift, season of the year and observations of the professionals).

The descriptive analysis of the variables was performed using absolute and relative frequencies for cate-

gorical and ordinal variables. For numerical variables, measures of central tendency, dispersion and percentiles were used. The normality of the sample was tested using the Kolmogorov-Smirnov test for normality, and if they did not follow a distribution, nonparametric tests were used. The NEWS-2 scores obtained (mean, median and maximum) in patients who suffered an AE were compared with those who did not (using Pearson's chi-square test and the Wilcoxon test). We also studied the difference between the length of stay in the emergency department, hospital admission and priority level in the emergency department of patients with a score equal to or greater than 5 with respect to those with a score of less than 5 (using Pearson's chi-square test, Fisher's test and the Kruskal-Wallis test). The predictive capacity of the scale was obtained using the area under the receiver operating characteristic curve (AUC-ROC) and 95% confidence intervals (95% CI). The association between length of hospital stay and the early warning scale was determined with Spearman's correlation coefficient.

The psychometric properties of the scale were studied by means of: feasibility (in the pilot test, aspects related to the time employed, ease of use of the scale, clarity of the items or the interpretation of the results were taken into account); validity [validity of appearance, content-exploratory factor analysis, construct and criterion-Kaiser-Meyer-Olkin (KMO) of sampling adequacy; reliability (internal consistency, intraobserver and interobserver reliability) and sensitivity to change]. The SPSS version 23 statistical program was used. In addition, the optimal cut-off point for determining the risk of hospital admission and for the occurrence of an AE was calculated. The positive predictive value (PPV) and negative predictive value (NPV) were obtained. The "optimal cut point" package (version 1.1-5) of the R statistical software was used to determine the cut-off point.

A favorable report was obtained from the ethics committee of the reference research (the one attached to the Hospital Universitario Reina Sofía de Córdoba). An information and informed consent form was given to both the patients and the professionals who participated in the study. Although the NEWS-2⁶ scale is a free, non-copyrighted scale, permission was obtained from the Royal College of Physicians of London for its cultural adaptation and validation.

Results

Phase I

After the translation - retro-translation process, the first version of the NEWS-2 early warning scale adapted to Spanish was obtained. The scale was evaluated by means of a prospective observational study in which 81 patients were included (Table 1). More than half (54.3%; $n = 44$) of the patients were women, with a mean age of 58.9 years (SD: 20.4). The mean length of stay in the ED was 1:46 hours (SD: 1:24). For this version, Cronbach's alpha coefficient was 0.56 (95% CI:

0.43-0.69). Regarding intraobserver and interobserver reliability, the intraclass correlation coefficient (ICC) was 0.998 (95% CI: 0.998-0.999). After collecting all the opinions, it became clear that the scale was simple to understand and use and that it was presented in a structured and well-defined manner, although it required visual and structural modifications.

After Phase I, the second version of the NEWS-2 scale adapted to Spanish was obtained (Figure 1) with visual and structural corrections with respect to the first version.

Phase II

In this phase, the validation of the second version of the NEWS-2 scale adapted to Spanish was carried out. A total of 442 patients were included (Table 2), of whom 50.7% (224) were women; the mean age was 56.8 years (SD: 21.1). The mean length of stay of patients in the ED was 1:32 hours (SD: 1:09). For the purposes of work shift, age or sex, no significant differences were found in the NEWS-2 score obtained.

Regarding the psychometric properties of the scale, in the reliability analysis, Chronbach's alpha was 0.70. The ICC for intraobserver reliability was 0.996 (95% CI 0.995-0.997) and for interobserver reliability 1 (95% CI 0.999-1). In the validity analysis, a KMO of sampling adequacy of 0.661 was obtained and Bartlett's test of sphericity was significant ($p < .001$). An exploratory factor analysis was then carried out (Table 3) and three components with a value greater than 1 were extracted, which explained approximately 57.9% of the variance.

Table 1. Clinical and sociodemographic characteristics of the patients included in the pilot phase (phase I)

	Total N = 81 n (%)
Sex	
Female	44 (54.3)
Male	37 (45.7)
Age [mean (SD)]	58.9 (20.4)
P1	0 (0)
P2	13 (16)
P3	43 (53)
P4	24 (29)
P5	1 (2)
Emergency room time [mean (SD)]	1:46 (1:24)
	1
Diagnostic categories	
Infectious	15 (18.5)
Cardiology	11 (13.6)
Digestive	12 (14.8)
Neurology	4 (4.9)
Ophthalmology	6 (7.4)
Psychiatry	4 (4.9)
Traumatology	14 (17.3)
Others	15 (18.5)
Admission	
Yes	8 (9.9)
No	73 (90.1)

N: number; SD: standard deviation; P: priority.

Name:		Date:	
			Value***
A+B	Respiratory rate (Bpm)	≥ 25	3
		21-24	2
		12-20	0
		9-11	1
		≤ 8	3
	O ₂ Saturation (Scale 1) (%)	≥ 96	0
		94-95	1
		92-93	2
		≤ 91	3
	O ₂ Saturation (Scale 2) (%) COPD patients with SpO ₂ 88%-92% range	≥ 97 with O ₂	3
		95-96 with O ₂	2
		93-94 with O ₂	1
		≥ 93 with no O ₂	0
		88-92 with O ₂	0
86-87 with O ₂		1	
84-85 with O ₂		2	
Oxygen supply?	≤ 83 with O ₂	3	
	NO	0	
	YES	2	
Device*			
C	Systolic blood pressure (mmHg)	≥ 220	3
		111-219	0
		101-110	1
		91-100	2
		≤ 50-90	3
	Heart rate (beats per minut)	≥ 131	3
		111-130	2
		91-110	1
		51-90	0
D	Level of awareness	41-50	1
		≤ 30-40	3
		Alerta	0
		Confusion**	3
		Verbal	3
E	Temperature (°C)	Pain	3
		No response	3
		≥ 39,1	2
		38,1-39,0	1
		36,1-38,0	0
		35,1-36,0	1
		≤ 35,0	3
Final Score			

*Record type of oxygen therapy delivery device (e.g.: nasal goggles, reservoir...).

**Select confusion, only when it is of new onset.

*** Score value given to each vital constant.

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*** Score value given to each vital constant.

Figure 1. Second version of the NEWS-2 early warning scale. COPD: chronic obstructive pulmonary disease.

Predictive capacity

Of the total number of patients evaluated (442), a total of 42 were hospitalized. The mean age was 75.0 years (SD: 15.3), 45.2% were women. Significant differences were found between the median NEWS-2 for the

Table 2. Clinical and sociodemographic characteristics of the patients included in the validation phase

	Total N = 442 n (%)
Female	224 (50.7)
Male	218 (49.3)
Age [mean (SD)]	56.8 (21.1)
P1	1 (0.2)
P2	34 (7.7)
P3	183 (41.4)
P4	215 (48.6)
P5	9 (2)
ED time [mean (SD)]	1:32 (1:09)
Destination	1 (2.25)
Home	399 (90.3)
Conventional unit plant entry	22 (5)
Intensive care unit	3 (0.7)
Observation	17 (3.8)
Outpatient	1 (0.2)
Adverse event	
Yes	6 (1.4)
No	436 (98.6)

N: number; SD: standard deviation; CI: confidence interval, IQR: interquartile range; P: priority.

group of patients who were admitted [6 (IQR: 3.88-8.13)] and the median of those patients who were not admitted [1 (IQR: 0-2)] ($p < 0.001$) (Figure 2). The AU-ROC for hospitalization was 0.881 (95% CI: 0.819-0.943).

Six AEs were detected, which represented 1.3% of the patients. The mean NEWS-2 of the group that experienced an AE was higher than the group that did not experience an AE (8.83 vs. 1.64; $P = .003$). Patients who experienced an AE stayed in the ED longer than those who did not experience an AE (2:33 vs. 1:31 hours; $P = .033$). All patients who experienced an AE were admitted to the hospital; however, only 8.3% of patients who did not experience an AE were admitted. The AUC-ROC for AE was 0.969 (95% CI 0.938-1) (Figure 3).

The mean NEWS-2 for the 3 ICU admissions was 10.3 points (SD: 4.0) vs. 1.3 (SD: 1.7) ($p < .001$) for discharged patients. Finally, the AUC-ROC for hospital mortality was 0.955 (95% CI: 0.905-1).

The optimal cut-off point for determining the risk of admission was 3, with a PPV of 32% and NPV of 98%. For AE, the optimal cut-off point was 6, with a PPV of 14% and NPV of 99.7%.

Discussion

The present study has validated a scale for the early detection of patients at risk of deterioration in the triage consultation. To our knowledge, no similar studies have been carried out in Spain and, therefore, no comparisons can be made with other scales or series with the same purpose, although there are other similar scales developed in other countries.^{10,14}

The second version of the Spanish-adapted NEWS-2 scale obtained after the pilot phase presented structural

Table 3. Exploratory factor analysis. Total variance

Component	Initial eigenvalues			Extraction sums of squared loads			Rotational sums of squared loads		
	Total	% Variance	% Accumulated Variance	Total	% Variance	% Accumulated Variance	Total	% Variance	% Accumulated Variance
1	1.912	27.311	27.311	1.912	27.311	27.311	1.627	23.247	23.247
2	1.130	16.146	43.457	1.130	16.146	43.457	1.333	19.043	42.291
3	1.014	14.490	57.947	1.014	14.490	57.947	1.096	15.657	57.947
4	0.914	13.063	71.010						
5	0.744	10.633	81.644						
6	0.672	9.600	91.244						
7	0.613	8.756	100.000						

and visual differences with respect to the first version. For each item, values with the same score were grouped together, thus simplifying the completion of the scale and making it easier to use. These modifications were introduced following the opinions of the professionals who used the scale and resulted in an increase in the validity of the scale (increase in Chronbach's alpha from 0.56 to 0.70).

In the context of the present study, a systematic review and meta-analysis was carried out which revealed that the application of the early warning scales in the emergency department is a good predictive tool for AE in the hospital triage consultation.⁷ These findings have been corroborated in the present study where the mean NEWS-2 score of the group that suffered an AE was higher than that of the group that did not suffer an AE, although it is true that the size of the group of patients who suffered an AE was small ($n = 6$) compared to the group that did not suffer an AE ($n = 436$). Therefore, future studies are needed in which the sample size is larger.

After studying patient characteristics, it was observed that both patients who were admitted and those who suffered an AE were assigned a higher level of pri-

ority by the SET-MAT¹⁵ triage system upon arrival at the ED. Therefore the use of the NEWS-2 scale in the triage consultation together with a structured triage system would allow adequate and safe management of patient flows when demand and clinical needs exceed resources.¹⁶ In addition, it would provide the predictive capacity that this tool has been shown to have.

The ability of the NEWS-2 scale to predict hospital admission from the time of triage has been studied by other authors.^{9,17} Along the same lines as these, our study showed that the scale had a high AUC-ROC for hospital admission higher than those obtained by the group of Alam et al.¹⁸ which was 0.664 (95% CI: 0.599-0.728). On the other hand, other different models for predicting hospital admission, such as that developed by Parker et al.¹⁹ obtained results similar to those found for the NEWS scale, with an AUC-ROC of 0.825 (95% CI: 0.824-0.827).

In terms of hospital mortality, the predictive capacity of the NEWS-2 scale was described by Smith et al.²⁰

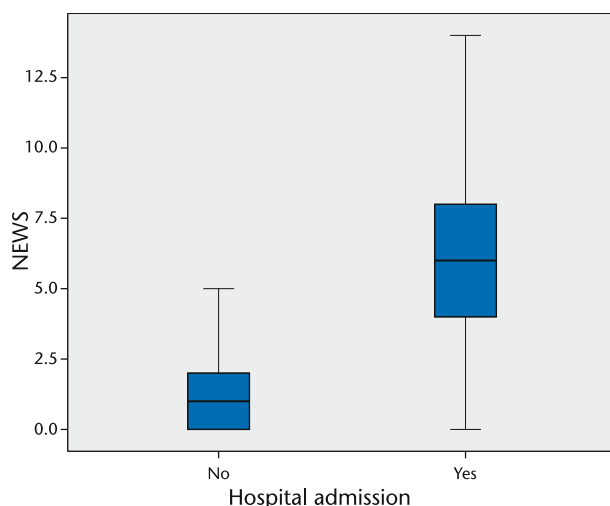
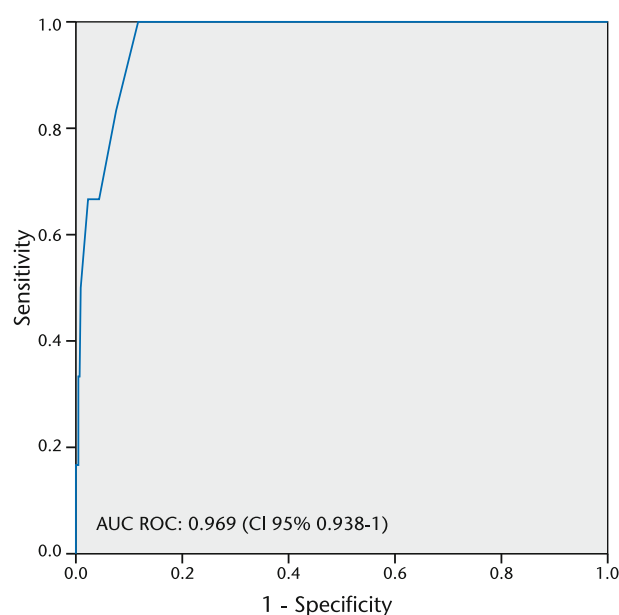


Figure 2. Box plot of NEWS-2 score at the beginning of the triage process, distinguishing between patients who were admitted to the hospital and those who were not. The boxes include 50% of the patients, between patients 25 and 75, and the central line the median.



Diagonal segments are generated by ties.

Figure 3. Predictive capacity of adverse events of the NEWS-2 scale. ABC COR: area under the receiver operating characteristic curve.

in an observational study where it presented an AUC-ROC of 0.894 (95% CI: 0.887-0.902). Similarly, the study by Brabrand et al.²¹ showed an AUC-ROC of 0.79 (95% CI: 0.73-0.86). The findings of the present study are along the same lines as these authors, adding evidence and extending the settings of the previous studies and, therefore, strengthening the idea that the NEWS-2 scale has the capacity to predict hospital mortality even if it is applied only in the triage consultation.

There are several limitations to the present study. Firstly, the difficulties in obtaining the sample, due to the pressure of care in the ED, which on some occasions may have made it difficult to complete the scale. In an attempt to speed up data collection, a specific, easy-to-understand sheet was prepared. Secondly, the scope and extent of the study, since it was carried out in a regional hospital. Furthermore, with regard to the second phase of the study (January-February 2020), we cannot ascertain whether there have been any alterations due to the influence of seasonal diseases (influenza) or to the then incipient COVID-19.

As conclusions of our study, we can say that, after the validation process, the NEWS-2 scale adapted to Spanish has been shown to be a valid tool for use in ED triage consultation. In terms of reliability, it has demonstrated acceptable internal consistency and a high degree of interobserver and intraobserver reliability. The items, in addition to having an adequate weight, were consistent with each other and three grouping factors were obtained. The scale showed an excellent predictive capacity for the appearance of AEs such as admission to the ICU, mortality or CRA in the ED, as well as hospital admission.

As implications for clinical practice, it should be noted that the validated scale facilitates the existence of a standardized and simple language that can provide information on patients and allow rapid recognition of patients at risk of deterioration. In this way, healthcare personnel could prevent the onset of AE. Furthermore, its use could facilitate an improvement in health outcomes and in the efficiency of healthcare and its organization. In particular, the emergency department population would benefit in terms of quality of care and safety.

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