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# Comorbidity-adjusted NEWS predicts mortality in suspected patients with COVID-19 from nursing homes: Multicentre retrospective cohort study

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## Abstract

**Aims:** To assess the prognostic accuracy of comorbidity-adjusted National Early Warning Score in suspected Coronavirus disease 2019 patients transferred from nursing homes by the Emergency Department.

**Design:** Multicentre retrospective cohort study.

**Methods:** Patients transferred by high-priority ambulances from nursing homes to Emergency Departments with suspected *severe acute respiratory syndrome coronavirus* 2 infection, from March 12 to July 31 2020, were considered. Included variables were: clinical covariates (respiratory rate, oxygen saturation, systolic blood pressure, heart rate, temperature, level of consciousness and supplemental oxygen use), the presence of comorbidities and confirmatory analytical diagnosis of *severe acute respiratory syndrome coronavirus* 2 infection. The primary outcome was a 2-day mortality rate. The discriminatory capability of the National Early Warning Score was assessed by the area under the receiver operating characteristic curve in two different cohorts, the validation and the revalidation, which were randomly selected from the main cohort.

**Results:** A total of 337 nursing homes, 10 advanced life support units, 51 basic life support units and 8 hospitals in Spain entailing 1,324 patients (median age 87 years) was involved in this study. Two-day mortality was 11.5% (152 cases), with a positivity rate of *severe acute respiratory syndrome coronavirus* 2 of 51.2%, 77.7% of hospitalization from whom 1% was of intensive care unit admission. The National Early Warning Score results for the revalidation cohort presented an AUC of 0.771, and of 0.885, 0.778 and 0.730 for the low-, medium- and high-level groups of comorbidities.

**Conclusion:** The comorbidity-adjusted National Early Warning Score provides a good short-term prognostic criterion, information that can help in the decision-making process to guide the best strategy for each older adult, under the current pandemic.

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**Impact:**

- What problem did the study address?

Under the current coronavirus disease 2019 pandemic, targeting older adults at high risk of deterioration in nursing homes remains challenging.

- What were the main findings?

Comorbidity-adjusted National Early Warning Score helps to forecast the risk of clinical deterioration more accurately.

- Where and on whom will the research have impact?

A high NEWS, with a low level of comorbidity is associated with optimal predictive performance, making these older adults likely to benefit from continued follow up and potentially hospital referral under the current coronavirus disease 2019 pandemic.

**KEYWORDS**

clinical decisions rules, comorbidity, COVID-19, nurse, nursing homes, older adults, risk scores

## 1 | INTRODUCTION

The current pandemic outbreak caused by the coronavirus disease 2019 (COVID-19), which has resulted in the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has led to a substantial increase in consultations, transfers, inpatients and admissions in intensive care units (ICU) due to pneumonia with multiorgan diseases. This has, directly and transversely, affected the quality of care the patients should receive in worldwide healthcare systems (Wiersinga et al., 2020). The unbalance between needs and resources has prompted to identify patients to whom the maximum level of care should be provided. In addition, at the initial stages of the pandemic, healthcare workers were faced with an unknown disease, with rudimentary detection tests and with an empirical treatment that was changing according to the scientific evidence available at that time. In short, COVID-19 represented a new paradigm for healthcare systems, with a degree of uncertainty and care burden hitherto unknown in non-combat situations.

In such situations of massive casualty incidents while hospitals capacities are overwhelmed, the healthcare system must plan their response in a strategic way with the objective of attending the largest possible number of patients under the best possible conditions. An accurate and fast triage should certainly be a central issue to optimize the available resources (Leclerc et al., 2020; Maves et al., 2020).

### 1.1 | Background

COVID-19 has had an especially important impact on frail older adults, a particularly vulnerable group (Graham et al., 2020). For instance, the greatest impact in terms of mortality has been in nursing homes (Davidson & Szanton, 2020) where patients with higher incidence of comorbidities are found (Imam et al., 2020; Quigley et al., 2020). The burden of comorbidities is linked to poor prognosis in the short and medium term. This is particularly true for older adults in whom many simultaneous comorbidities are more frequent (Aliberti et al., 2021; Pulok et al., 2020).

Under these circumstances, a dilemma for healthcare workers arises in nursing homes: (i) transferring patients to the Emergency Department (ED) or on the contrary, (ii) providing assistance at the nursing home. This is a challenging situation requiring appropriate tools to guide the professionals' decisions. Specifically, early warning scores have become easy tools to apply, with a very fast learning curve and a high predictive capacity; moreover, most of them are already validated; some examples included the National Early Warning Score (NEWS), the Modified Early Warning Score (MEWS), the VitalPAC early warning score (ViEWS) or the Rapid Emergency Medicine Score (REMS), among others (Downey et al., 2017). The use of scoring systems has been widely proven among older adults in different clinical settings, for example, prehospital care, ED and hospitalization (Covino et al., 2021; Dundar et al., 2016; Martín-Rodríguez et al., 2020). Indeed, early warning scores are increasingly being instituted in nursing homes (Barker et al., 2019; Russell et al., 2020).

Management of older adults presents specific problems such as the assessment of frailty or the identification of short-term risk of mortality (Cardona-Morrell & Hillman, 2015; Myers et al., 2018). These problems have become more evident under the current pandemic in which the discrimination of the risk of deterioration of older adults in the short term is mandatory. Because of that, specific scores have been developed to discriminate the risk of deterioration in patients with COVID-19 (Berenguer et al., 2020; Wynants & Sotgiu, 2021; Wynants et al., 2020). In addition, the prognostic accuracy of the already known early warning scores, such as the NEWS, in a patient with COVID-19 has also been recently studied (Carr et al., 2021; Kostakis et al., 2021; Myrstad et al., 2020).

Particularly interesting is the NEWS, a widely contrasted score under several clinical contexts (Pimentel et al., 2019), in particular when applied on older adults (Kemp et al., 2020; Romero-Ortuno et al., 2016), providing an early alert trigger in such cases. This tool was developed by the Royal College of Physicians of London in 2012 (Royal College of Physicians. National Early Warning Score (NEWS), 2012) and updated as NEWS2 in 2017 (Royal College of Physicians. National Early Warning Score (NEWS), 2017). The tool is

based on six physiological parameters easily obtainable: respiration rate, oxygen saturation, systolic blood pressure, pulse rate, level of consciousness or new confusion and temperature; additionally, and if the patient requires supplemental oxygen to maintain normal saturation levels, two points are assigned to the final score.

The main difference between NEWS2 (Royal College of Physicians. National Early Warning Score (NEWS), 2017) and NEWS is that the first one uses saturation scale 2 for those patients with hypercapnic respiratory insufficiency instead of using the normal scale which is used for the rest of the patients. In the present study, NEWS instead of NEWS2 has been used because the situation of hypercapnic respiratory insufficiency was impossible to know in many situations. Furthermore, recent studies suggest that the behaviour of NEWS is superior to NEWS2 in patients with COVID-19 (Kostakis et al., 2021; Richardson et al., 2021).

## 2 | THE STUDY

### 2.1 | Aims

The goal of this study was to test the prognostic accuracy of NEWS in suspected COVID-19 patients at risk of clinical deterioration, transferred from nursing homes to an ED, as well as to study the differences of that prognostic accuracy in relation to the three age-adjusted Charlson comorbidity index (ACCI) groups.

### 2.2 | Design

The present multicentre retrospective cohort study enrolled older patients aged more than 65 years, evacuated by high priority from nursing homes to ED, during the first season of COVID-19, between March 12 to July 31 2020.

The study was conducted in four provinces (Palencia, Salamanca, Segovia and Valladolid) of the Castilla y León Community, Spain, involving 337 nursing homes, 61 ambulances (10 advanced life support units and 51 basic life support units) and 8 hospitals (3 tertiary university hospital and 5 general district hospital), all of them operated by the Public Health System of Castilla y León (SACYL), the primary health authority with an overall reference population of 1,166,408 inhabitants.

The outcome was 2-day in-hospital mortality from any cause after the ambulance transfer. This specific time window was selected to evaluate the short-term prognostic accuracy of the NEWS, in such a way that the cause of death was linked to the condition that motivated the transfer, in line with similar studies (Abbott et al., 2018; Jo et al., 2016; Pimentel et al., 2019).

### 2.3 | Sample/participants

Adult patients (>65 years) from nursing homes with suspected COVID-19 infection were identified and only those evacuated by

high priority by EMS to ED were recruited. All patients were assessed by the physician or the registered nurse at the nursing homes.

Patients transferred to private hospitals, evacuated by other means of transport (e.g. private ambulance, walking), and cases in which it was impossible to calculate the NEWS or to know the co-morbidities (the absence of any parameter), were excluded.

### 2.4 | Data collection

The final outcome and predictors were compiled by independent investigators of each hospital, obtained from reviews of the patient's electronic medical record (EMR). Before starting the systematized data collection, investigators of each hospital attended a previous training on: (i) study variables with ranges and measurements; (ii) use of the electronic database designed for this purpose; and (iii) how to submit the anonymized data. The main outcome was blinded to the clinical investigators in charge of data collection.

Epidemiological variables (sex, age, rural or urban area) were extracted from the standardized clinical history used by the EMS professionals. Clinical covariates necessary to calculate the NEWS (respiratory rate, oxygen saturation, systolic blood pressure, heart rate, temperature, level of consciousness and use of supplemental oxygen) were obtained by an emergency registered nurse during the first contact with the patient in the ED triage box.

The respiratory rate was calculated by auscultation with a stethoscope for 30 s if the rhythm was regular or for 1 min if the rhythm was irregular or very fast. Oxygen saturation, systolic blood pressure, heart rate and temperature were measured using the Connex® Vital Signs Monitor (Welch Allyn, Inc).

The level of consciousness was measured using the Glasgow coma scale (GCS). The NEWS (Kemp et al., 2020) recommends the use of the alert, verbal, pain or unresponsive (AVPU score) scale and considering as abnormal any response other than alertness. In the ED triage box, an emergency registered nurse performed an evaluation of the GCS (3–15 points) with any score less than 15 points considered as abnormal.

Finally, by reviewing the patient's EMR, the SARS-CoV-2 infection was confirmed through a positive in the analytical diagnosis by polymerase chain reaction test; hospitalization rate, intensive care units inpatients, 2-day mortality and comorbidities necessary to calculate the ACCI were also extracted from the EMRs.

### 2.4.1 | Comorbidity cut-off points

The ACCI (Setter et al., 2020; Shuvy et al., 2020) used in this study was calculated by using 17 categories of comorbidities, myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular accident or transient ischemic attack, dementia, chronic obstructive pulmonary disease, connective tissue disease, peptic ulcer disease, liver disease mild, diabetes mellitus uncomplicated, hemiplegia, moderate to severe chronic kidney disease,

diabetes mellitus end-organ damage, solid tumour localized, leukaemia, lymphoma, liver disease moderate to severe, solid tumour metastatic and AIDS, together with the adjustment provided by age (for each decade after 50 years, add 1 point to total score).

Several studies have shown that a Charlson comorbidity score ≥4 points is associated with 30-day mortality (Ghanem et al., 2018; Ternavasio-de la Vega et al., 2018; Wei et al., 2019), or values ≥9 points are significantly associated with decreased short-term survival (Saji et al., 2017; Zhao et al., 2017). Based on these studies, an ACCI comorbidity classification was established in three groups: low level (0–4 points), medium level (5–8 points) and high level (≥9 points).

## 2.5 | Ethical considerations

The study was approved by the local institutional research review board of Rio Hortega Hospital (PI 138/20). The institutional research committee granted a waiver/exemption from the requirement of obtaining informed consent from the study participants but with the requirement of using deidentified data. The highest safety standards have always been followed, protecting the confidentiality of the participants, complying with national and international regulations for studies on human subjects included in the Declaration of Helsinki on Biomedical Research.

## 2.6 | Data analysis

The sample size needed to target a confidence interval of 95%, and assuming a proportion of outcome in the study population of 0.1, required at least 139 patients.

Categorical variables were represented by absolute values and percentages; continuous variables that did not follow a normal distribution were represented by medians and interquartile ranges (IQR) and means and standard deviations (SD) were used for those variables with a normal distribution. For the characterization of the total sample and with the objective of assessing the association between each independent variable and mortality, ANOVA, Kruskal–Wallis, Mann–Whitney $U$ test, $t$-test or chi-squared test was used, when it was necessary.

For the NEWS validation procedure, the sample was firstly randomly divided into a derivation (50%), a validation cohort (25%) and a revalidation cohort (25%), maintaining the proportion of the outcome variable in both validation and revalidation cohorts. The rationale of using validation and revalidation cohorts is to provide evidence of the reliability of the results. This is a common procedure to avoid overfitting in the predictive model and, more important, it allows to classify the study as diagnostic/prognostic. This three-cohort procedure was used for all the analysis, except for the combination of comorbidity and SARS-CoV-2 analysis due to the sample size reduction. For this last analysis, the previous methodology was repeated by considering the three ACCI groups.

The discriminatory capability of NEWS was assessed by the area under the receiver operating characteristic (ROC) curve (AUC), calculating in each case the p-value of the hypothesis contrast (H0: AUC = 0.5). The ROC curve analysis is the commonest test for the evaluation of the discriminatory power of a score by calculating the AUC of the plot of the true positive rates (sensitivity) versus the false positive rates (1–specificity). An AUC = 0.5 means that the discrimination capability is not over the chance. Instead, an AUC = 1 means that the score is able to correctly classify 100% of the patients. For descriptive purposes, the following criteria of AUC results was used: an AUC equal to 0.5–0.6 represents bad prognosis, 0.7–0.8 reasonable/moderate, and >0.8 good discrimination. The graphs of the ROC curves show the confidence interval (95% CI) obtained by re-sampling (or bootstrapping) 2000 iterations (shaded area). For ROC curve comparison, a Delong's test was used. Finally, the specificity, sensitivity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio of the scale obtained were calculated. These results can be found in Table S1.

All statistical analyses were performed using our own codes and base functions in R, version 4.0.3 (http://www.R-project.org).

## 2.7 | Validity and reliability/rigour

In order to perform a more consistent analysis, prior to the assessment of the NEWS validity, the whole cohort was randomly split into three cohorts (derivation, validation and revalidation), maintaining the proportion of the outcomes. The use of two cohorts is the proper way to determine whether a predictor, in this case the NEWS, is useful. The procedure was the following: the model, obtained from the derivation cohort was used on the validation cohort. The results of the model on the validation cohort, in terms of outcome, were compared with the actual outcomes of the validation cohort and this comparison provides the performance of the model. This was also used in another cohort (revalidation) to increase the consistency of the results.

To ensure data quality, a data linkage was performed between the standardized EMS history and the patient's EMR by an exact matching of at least five of the following extractors: date, time of arrival, day of the week, first and last name, age, sex and health card number. EMS medical records that were unable to be linked were excluded. In addition, the research team knew the standardized way to obtain the parameters for the calculation of the NEWS.

## 3 | RESULTS/FINDINGS

### 3.1 | Baseline characteristics

The total cohort included 1324 older adults recruited from 337 nursing homes and evacuated by ambulance to the ED (see Figure 1). The median age was 87 years (IQR: 82–91 years), with 57.9% females (767 cases, Figure S1). Table 1 presents the global and the 2-day mortality characteristics of the cohort, in which positive analytical
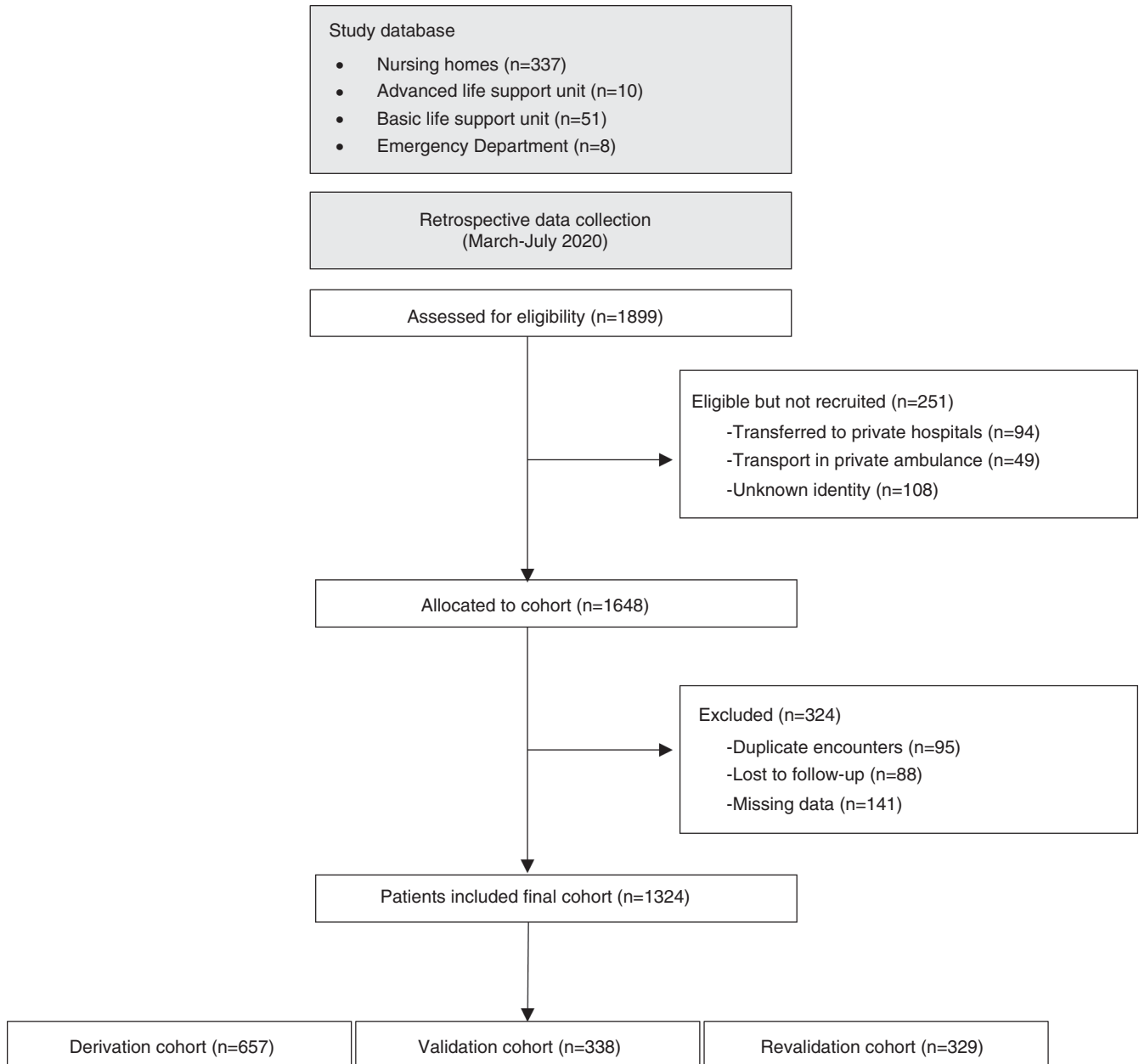
Study database

- Nursing homes (n=337)
- Advanced life support unit (n=10)
- Basic life support unit (n=51)
- Emergency Department (n=8)

Retrospective data collection
(March-July 2020)

Assessed for eligibility (n=1899)

Eligible but not recruited (n=251)
-Transferred to private hospitals (n=94)
-Transport in private ambulance (n=49)
-Unknown identity (n=108)

Allocated to cohort (n=1648)

Excluded (n=324)
-Duplicate encounters (n=95)
-Lost to follow-up (n=88)
-Missing data (n=141)

Patients included final cohort (n=1324)

| Derivation cohort (n=657) | Validation cohort (n=338) | Revalidation cohort (n=329) |

**FIGURE 1** Flowchart showing analysis population

tests of SARS-CoV-2 infection reached 51.2% (678 cases). A total of 1027 (77.7%) patients were hospitalized of which 11 (0.8%) went to the ICU, and with a 11.5% of 2-day mortality (152 cases).

Table 1 shows the comparison between survivors and non-survivors. In particular, survivors presented a median NEWS of 5 points (IQR: 3–8 points), compared to 10 points (IQR: 7–13 points) in non-survivors ($p < 0.001$). All analysed variables (except temperature, $p = 0.261$) showed statistical significance between survivors and non-survivors.

## 3.2 | Results for all patients

The predictive validity of NEWS to detect 2-day mortality presented an AUC in the validation cohort of 0.827 (95% CI: 0.767–0.888) and

0.771 (95% CI: 0.685–0.857) in the revalidation cohort (in both cases $p < 0.001$; Figure S2). The mortality distribution according to NEWS and the predicted probability of mortality are shown in Figure 2.

## 3.3 | Results for all patients considering the SARS-CoV-2 infection

When applied to confirmed SARS-CoV-2 patients, NEWS AUC reached a 0.737 (95% CI: 0.677–0.869) and 0.783 (95% CI: 0.676–0.890), for the validation and revalidation cohorts (in all cases $p < 0.001$) respectively. Instead, results for patients without SARS-CoV-2 outperformed the previous ones presenting an AUC of 0.866 (95% CI: 0.723–1) and 0.878 (95% CI: 0.802–0.954), for both the validation and revalidation cohorts (in all cases $p < 0.001$) respectively. However, the comparison

**TABLE 1** Characteristics of the study population according to 2-day mortality

| Characteristics[1] | Total | 2-day mortality | | p value[2] |
| --- | --- | --- | --- | --- |
| | | Survivors | Non-survivors | |
| No. (%) with data | 1324 (100) | 1172 (88.5) | 152 (11.5) | |
| Demographics outcomes | | | | |
| Age, years | 87 (82–91) | 87 (82–91) | 88 (83–92) | 0.127[a] |
| Sex, female | 767 (57.9) | 679 (57.9) | 88 (57.9) | 0.531[c] |
| Urban area | 566 (42.7) | 505 (43.1) | 61 (40.1) | 0.273[c] |
| Basal evaluation | | | | |
| BR, breaths/min | 16 (13–25) | 15 (13–25) | 25 (15–28) | <0.001[b] |
| SpO2, % | 93 (89–98) | 94 (90–97) | 90 (83–93) | <0.001[b] |
| Supplemental $O_2$ | 321 (24.2) | 254 (21.7) | 67 (44.1) | <0.001[c] |
| SBP, mmHg | 120 (104–141) | 121 (105–143) | 108 (89–134) | <0.001[b] |
| Heart rate, beats/min | 86 (73–99) | 85 (73–97) | 93 (72–111) | 0.016[b] |
| Temperature, °C | 36.6 (36.1–37.1) | 36.6 (36.1–37.2) | 36.8 (36–37.5) | 0.241[a] |
| GCS, points | 15 (13–15) | 15 (14–15) | 13 (10–15) | <0.001[b] |
| Comorbidities | | | | |
| AIDS | 2 (0.2) | 1 (0.1) | 1 (0.7) | 0.217[c] |
| Solid tumour metastatic | 23 (1.7) | 18 (1.5) | 5 (3.3) | 0.173[c] |
| Liver disease severe | 44 (3.3) | 39 (3.3) | 5 (3.3) | 0.607[c] |
| Lymphoma | 9 (0.7) | 6 (0.5) | 3 (2) | 0.074[c] |
| Leukaemia | 15 (1.1) | 10 (0.9) | 5 (3.3) | 0.022[c] |
| Solid tumour localized | 207 (15.6) | 189 (16.1) | 11 (11.8) | 0.192[c] |
| DM end organ damage | 84 (6.3) | 69 (5.9) | 15 (9.9) | 0.074[c] |
| Severe CKD | 312 (23.6) | 275 (23.5) | 37 (24.3) | 0.839[c] |
| Hemiplegia | 68 (5.1) | 54 (4.6) | 14 (9.2) | 0.029[c] |
| DM uncomplicated | 279 (21.1) | 243 (20.7) | 36 (23.7) | 0.399[c] |
| Liver disease mild | 35 (2.6) | 32 (2.7) | 3 (2) | 0.790[c] |
| Peptic ulcer disease | 88 (6.6) | 76 (6.5) | 12 (7.9) | 0.490[c] |
| Connective disease | 49 (3.7) | 44 (3.8) | 5 (3.3) | 0.499[c] |
| COPD | 164 (12.4) | 148 (12.6) | 16 (10.5) | 0.515[c] |
| Dementia | 648 (48.9) | 561 (47.9) | 87 (57.2) | 0.031[c] |
| Cerebrovascular disease | 252 (19) | 224 (19.1) | 28 (18.4) | 0.913[c] |
| Peripheral vascular disease | 152 (11.5) | 138 (11.8) | 14 (9.2) | 0.418[c] |
| Congestive heart failure | 299 (22.6) | 264 (22.5) | 35 (23) | 0.918[c] |
| Myocardial infarction | 125 (9.4) | 103 (8.8) | 22 (14.5) | 0.037[c] |
| ACCI (points) | 6 (5–8) | 6 (5–8) | 7 (5–8) | 0.058[a] |
| ACCI groups | | | | |
| 0–4 points | 209 (15.8) | 194 (16.6) | 15 (9.9) | |
| 5–8 points | 894 (67.5) | 785 (67) | 109 (71.7) | 0.276[c] |
| ≥9 points | 221 (16.7) | 193 (16.4) | 28 (18.4) | 0.614[c] |
| Outcomes | | | | |
| NEWS, points | 6 (3–9) | 5 (3–8) | 10 (7–13) | <0.001[a] |
| SARS-CoV-2 | 678 (51.2) | 575 (49.1) | 103 (67.8) | <0.001[c] |
| Hospitalization | 1027 (77.7) | 894 (76.3) | 133 (87.5) | 0.002[c] |
| ICU, No. (%) | 11 (0.8) | 10 (0.9) | 1 (0.7) | 0.634[c] |

Abbreviations: ACCI, age-adjusted Charlson comorbidity index; AIDS, acquired immunodeficiency syndrome; BR, breathing rate; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, Diabetes mellitus; GCS, Glasgow coma scale; ICU, intensive care unit; NEWS, National Early Warning Score; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SpO2, pulse oximetry saturation.

[1]Values expressed as total number (fraction) and medians [25 percentile–75 percentile], as appropriate.

[2]The Mann–Whitney U test[a], t-test[b] or chi-squared[c] test were used as appropriate.
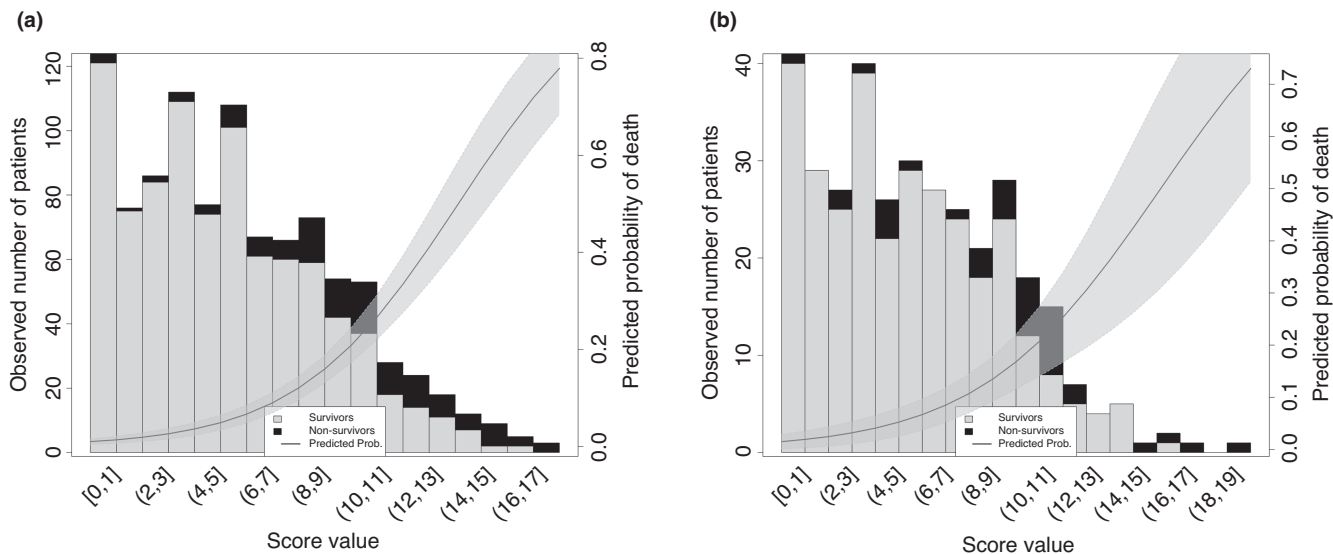
(a)

(b)



**FIGURE 2** NEWS versus real and predicted probability of death. (a) Validation cohort and (b) revalidation cohort. The grey area of the trend line corresponds to 95% confidence interval of the predicted probability of death (trend line). The bars correspond to the number of patients in the derivation cohort survivors (grey) or non-survivors (black)

between the AUC of confirmed patients and patients without SARS-CoV-2 did not reach statistically significance differences ($p = 0.29$ for validation and $p = 0.15$ for revalidation).

### 3.4 | Role of NEWS in three different ACCI levels

The demographics, clinical characteristics and statistical comparison of patients according to each ACCI group can be found in Table 2. The NEWS AUC for each group reached an AUC of 0.918 (95% CI: 0.834–1), 0.795 (95% CI: 0.715–0.875) and 0.619 (95% CI: 0.0.354–0.884) for the validation cohort and for the low-, medium- and high-level groups; and 0.885 (95% CI: 0.714–1), 0.778 (95% CI: 0.669–0.887) and 0.730 (95% CI: 0.546–0.915) for the revalidation cohort and for low-, medium- and high-level groups (Figure S3). The comparison between AUC of the different ACCI groups showed the following results: for low versus medium groups $p = 0.04$ for validation and $p = 0.3$ for revalidation, for the low versus high groups $p = 0.03$ for validation and $p = 0.23$ for revalidation, and for medium versus high groups $p = 0.21$ for validation and $p = 0.66$ for revalidation The mortality distribution according to comorbidity-adjusted NEWS by comorbidities and the predicted probability of mortality are shown in Figure 3.

### 3.5 | Results considering both the ACCI levels and the SARS-CoV-2 infection

The predictive capability of NEWS for the combination of comorbidity and SARS-CoV-2 was assessed by considering the subset of patients that resulted from each group of ACCI and the SARS-CoV-2 confirmation. This was performed despite the reduction in the number of patients, which prevents performing

a revalidation assessment; hence, only the results of a validation cohort resulted from a combination of validation and revalidation cohort are shown. Again, the results from patients without SARS-CoV-2 outperformed the results from those with confirmed SARS-CoV-2. The NEWS AUC for each group (low-, medium- and high-level groups respectively) reached an AUC of 0.876 (95% CI: 0.800–0.952), 0.800 (95% CI: 0.722–0.878) and 0.655 (95% CI: 0.468–0.842) for the confirmed SARS-CoV-2. For those without SARS-CoV-2 the AUC reached a 1 (95% CI: 1–1), 0.821 (95% CI: 0.716–0.926) and 0.903 (95% CI: 0.797–1) for low-, medium- and high-level groups respectively. The comparison between the different ACCI groups for patients with SARS-CoV-2 revealed the following results: for low versus medium groups $p = 0.17$, for the low vs high groups $p = 0.03$ and for medium versus high groups $p = 0.16$. The comparison between the different ACCI groups for patients without SARS-CoV-2 revealed the following results: for low versus medium groups $p < 0.001$), for the low versus high groups $p = 0.04$ and for medium versus high groups $p = 0.28$. Finally, the comparison between each ACCI group for patients with or without SARS-CoV-2 revealed the following results: for the low group $p = 0.001$, for the low versus high groups $p = 0.75$ and for the medium versus high groups $p = 0.02$.

Results on comparisons between AUCs are displayed in the summarizing Table S4 where all of the results can be found. Additionally, all the AUCs figures can be found in Figure S5.

## 4 | DISCUSSION

In this retrospective study of suspected SARS-CoV-2 older adults evacuated by high-priority ambulances from nursing homes to the

**TABLE 2** Demographics and clinical characteristics according to the categories of the age-adjusted Charlson comorbidity index

| Characteristics[1] | ACCI group | | | |
| | 0–4 points | 5–8 points | ≥9 points | p value[2] |
|---|---|---|---|---|
| No. (%) with data | 209 (15.8) | 894 (67.5) | 221 (16.7) | |
| Demographics outcomes | | | | |
| Age, years | 79 (72–89) | 88 (83–91) | 87 (84–91) | <0.001[b] |
| Sex, female | 87 (41.6) | 537 (60.1) | 103 (46.6) | <0.001[c] |
| Urban area | 87 (41.6) | 393 (44) | 86 (38.9) | 0.373[c] |
| Basal evaluation | | | | |
| BR, breaths/min | 14 (13–25) | 17 (13–25) | 18 (13–25) | 0.014[a] |
| SpO2, % | 93 (89–96) | 93 (89–96) | 93 (88–96) | 0.371[a] |
| Supplemental $O_2$ | 48 (23) | 207 (23.3) | 66 (29.9) | 0.102[c] |
| SBP, mmHg | 120 (105–140) | 121 (104–143) | 117 (102–136) | 0.300[a] |
| Heart rate, beats/min | 86 (75–98) | 86 (74–99) | 85 (71–99) | 0.773[a] |
| Temperature, °C | 36.7 (36.2–37.4) | 36.6 (36.1–37.3) | 36.6 (36.1–37.1) | 0.298[b] |
| GCS, points | 15 (14–15) | 15 (13–15) | 15 (13–15) | 0.003[a] |
| Comorbidities | | | | |
| AIDS | 0 | 0 | 2 (0.9) | 0.006[c] |
| Solid tumour metastatic | 0 | 0 | 23 (10.4) | <0.001[c] |
| Liver disease severe | 0 | 11 (1.2) | 33 (14.9) | <0.001[c] |
| Lymphoma | 0 | 3 (0.3) | 6 (2.7) | <0.001[c] |
| Leukaemia | 0 | 9 (1) | 6 (2.7) | 0.023[c] |
| Solid tumour localized | 1 (0.5) | 119 (13.3) | 87 (39.4) | <0.001[c] |
| DM end organ damage | 0 | 29 (3.2) | 55 (24.9) | <0.001[c] |
| Severe CKD | 1 (0.5) | 169 (18.8) | 143 (64.7) | <0.001[c] |
| Hemiplegia | 1 (0.5) | 38 (4.3) | 29 (13.1) | <0.001[c] |
| DM uncomplicated | 4 (1.9) | 208 (23.3) | 67 (30.3) | <0.001[c] |
| Liver disease mild | 1 (0.5) | 16 (1.8) | 18 (8.1) | <0.001[c] |
| Peptic ulcer disease | 2 (1) | 57 (6.4) | 29 (13.1) | <0.001[c] |
| Connective disease | 6 (2.9) | 26 (2.9) | 17 (7.7) | 0.003[c] |
| COPD | 8 (3.8) | 99 (11.1) | 57 (25.8) | <0.001[c] |
| Dementia | 35 (16.7) | 483 (54) | 130 (58.8) | <0.001[c] |
| Cerebrovascular disease | 8 (3.8) | 158 (17.7) | 86 (38.9) | <0.001[c] |
| Peripheral vascular disease | 2 (1) | 106 (11.9) | 44 (19.9) | <0.001[c] |
| Congestive heart failure | 4 (1.9) | 190 (21.3) | 105 (47.5) | <0.001[c] |
| Myocardial infarction | 1 (0.5) | 75 (8.4) | 49 (22.2) | <0.001[c] |
| Outcomes | | | | |
| NEWS, points | 4 (2–8) | 6 (3–9) | 6 (4–9) | 0.003[b] |
| SARS-CoV-2 | 128 (61.2) | 449 (50.2) | 101 (45.7) | 0.001[c] |
| Hospitalization | 151 (72.2) | 701 (78.4) | 175 (79.2) | 0.089[c] |
| ICU, No. (%) | 4 (1.9) | 6 (0.7) | 1 (0.5) | 0.098[c] |
| 2-day mortality | 15 (7.2) | 109 (12.2) | 28 (12.7) | 0.102[c] |

Abbreviations: ACCI, age-adjusted Charlson comorbidity index; AIDS, acquired immunodeficiency syndrome; BR, Breathing rate; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, Diabetes mellitus; GCS, Glasgow coma scale; ICU, intensive care unit; NEWS, National Early Warning Score; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SpO2, pulse oximetry saturation.

[1]Values expressed as total number (fraction) and medians [25 percentile–75 percentile], as appropriate.

[2]The ANOVA[a], Kruskal–Wallis[b] or chi-squared test[c] were used as appropriate.
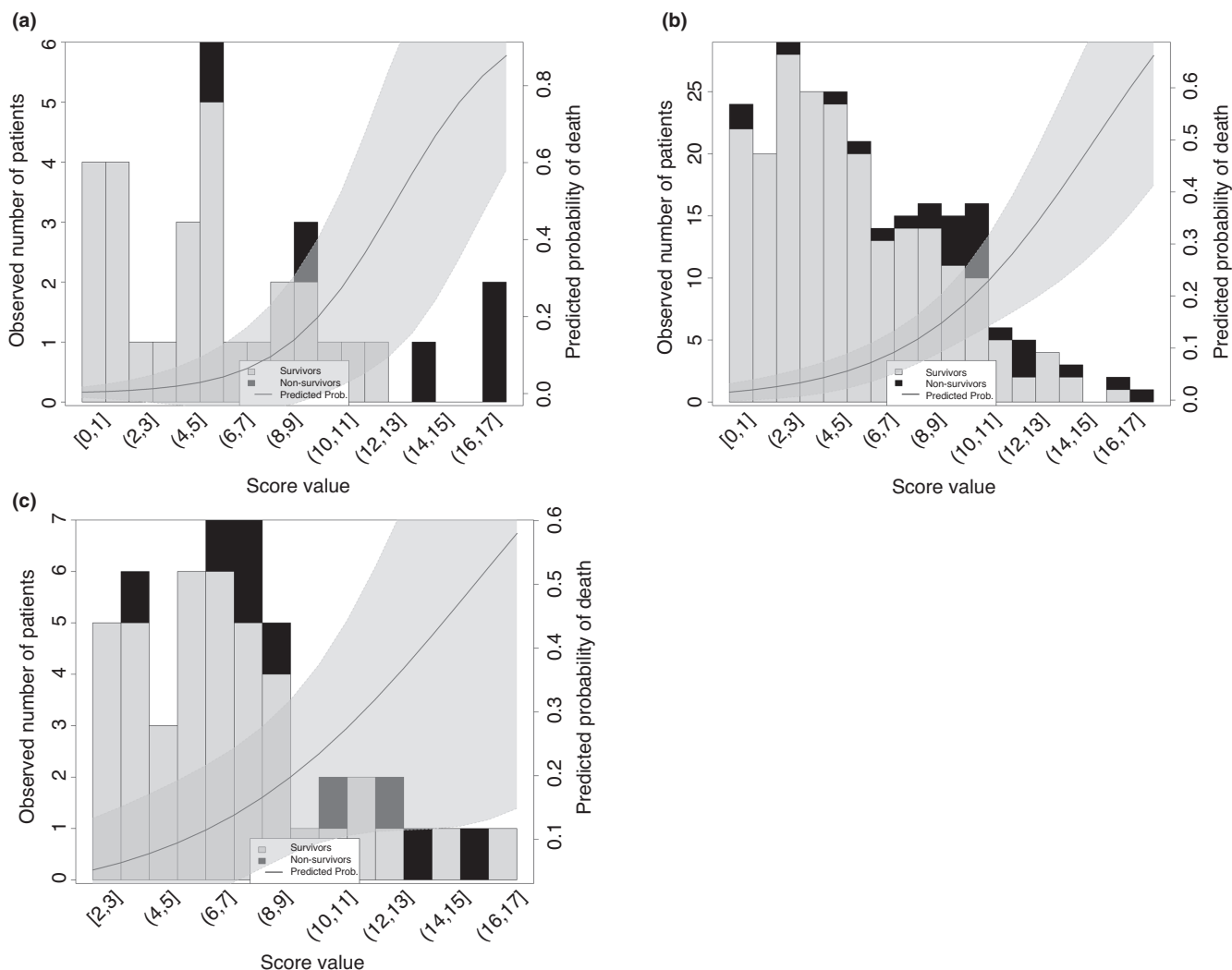
**FIGURE 3** Adjusted-NEWS by comorbidities versus real and predicted probability of death in revalidation cohort. (a) low level, (b) medium level and (c) high level. The grey area of the trend line corresponds to 95% confidence interval of the predicted probability of death (trend line). The bars correspond to the number of patients in the derivation cohort alive (grey) or dead (black)

ED, we have observed that the NEWS has a good predictive capability of identifying patients at high risk of clinical deterioration (2-day mortality). An essential characteristic of age is the increase in comorbidities, so, dividing the cohort into three groups according to the comorbidity level, our study has shown that the NEWS has a good predictive ability in older adults with low (ACCI = 0–4 points) or medium (ACCI = 5–8 points) level, decreasing its accuracy in the group of patients with a high comorbidity level (ACCI ≥ 9 points). Finally, the NEWS demonstrated higher capacity in non-SARS-CoV-2 patients compared to infected-SARS-CoV-2 patients, while maintaining acceptable levels of risk identification in the low and medium comorbidity groups.

The COVID-19 pandemic has overcrowded family centres, EMS, ED, inpatient units and ICUs. This fact has forced the healthcare systems the use of triage for selecting patients who will receive the highest level of care (Blomaard, Mooijaart, et al., 2020; Blomaard, Speksnijder, et al., 2020). Given these special circumstances, older adults, especially nursing home residents, have been one of the

groups most affected by COVID-19, with unacceptable mortality rates (Abrams et al., 2020; Belmin et al., 2020).

The early identification of patients at high risk of deterioration is a challenge for healthcare systems, but it is mandatory at the time to optimize the available resources (Covino et al., 2020; Hu et al., 2020; Knight et al., 2020).

NEWS has already been evaluated for its usefulness in patients with COVID-19, with the present study also in line with similar studies (Blomaard, Mooijaart, et al., 2020; Fan et al., 2020; Gidari et al., 2020; Sixt et al., 2021). Moreover, the role of comorbidities in the prognosis of patients with COVID-19 has also been studied (Jain & Yuan, 2020; Price et al., 2020; Wang et al., 2020; Zhou et al., 2020). However, there are very few studies that correlate the use of early warning scores with the level of comorbidities (Covino et al., 2021; Dynesen et al., 2019; Langsted et al., 2020; Varol et al., 2021). In particular, (Kostakis et al., 2021) conclude that the addition of new covariates is unnecessary when evaluating patients with COVID-19 using NEWS.

The usefulness of the comorbidity-adjusted NEWS is of considerable clinical interest in older adults with suspected COVID-19. Particularly, in those cases with low and medium comorbidity, where the accuracy of the score is higher as compared to the group of older adults with a high level of comorbidities. This information would be extremely useful for the optimum care of patients; for a case of low comorbidity and high NEWS score for instance, the probability of clinical deterioration is remarkably high. Thus, under the current pandemic, this tool for identifying high-risk patients is critical, because they will help the healthcare system to set a clear strategy to maximize its resources (Christensen et al., 2020; Guan et al., 2020). In older adults with many comorbidities (ACCI ≥ 9 points) the NEWS does not perform as well as in the other groups; this may be largely due to the chronic situation of these patients in whom the baseline situation is already critical with chronic alterations of certain physiological parameters, for example, heart failure, chronic obstructive pulmonary disease or dementia (Schulte et al., 2019; Wu et al., 2016). Additionally, it is interesting to note that in our cohort the median temperature was 36.6℃, so the presence of fever, which is a recurrent symptom in patients with COVID-19 (Adhikari et al., 2020; Wiersinga et al., 2020), is not evident. The reasons may be diverse: heterogeneous manifestations of the disease, limited clinical expression of the older adults, reduced capacity for adaptation and response to infections, administration of analgesics (in many cases also antipyretics) for concurrent processes (Gómez-Belda et al., 2021; Nikolich-Zugich et al., 2020), etc.; in short, it is a parameter that, although striking, once analysed does not seem to have much importance in short-term mortality.

Certainly, the hospital is not the most appropriate centre for older adults with SARS-CoV-2 (Perrotta et al., 2020). In nursing homes that are well-prepared, with adequate staff and resources and with proper training and clear intervention guidelines, many older adults could be ultimately treated without the need for unnecessary transfers. However, deciding both the destination and the kind of life support manoeuvres to be performed will depend on many factors. For this reason, it is essential to count with prognostic tools which can help nurses in their first step to perform structured evaluations and advise them when medical evaluation or transfer is required (Lithander et al., 2020).

Efforts to protect older adults by shielding nursing homes have been one of the most effective epidemiological measures to control the pandemic on these frail patients (American-Geriatrics-Society, 2020; Belmin et al., 2020). The dramatic mortality rates that have occurred so far should not be tolerable in modern societies. Once an older adult presents or is suspected of presenting a SARS-CoV-2 infection, it is not enough to isolate him/her with minimal care; it is necessary on the contrary, to provide him/her with the best solutions based on accurate assessments (Davidson & Szanton, 2020; Donnelly, 2020).

Nurses operating in nursing homes must make quick decisions at critical moments with very little data at hand. In many cases, the physician will not be present 24/7 in the nursing home, so having objective elements to identify the true condition of the patient and his or her short-term evolution can make the whole difference. The use of early warning scores represents a fundamental aid for objective decision making, determining the intensity of support manoeuvres to be performed or the need for continuous monitoring. Knowing the risk of short-term clinical deterioration has major implications: (i) need for transfer to a hospital, (ii) initiation of compassionate measures, (iii) contact with relatives to allow a dignified farewell. The comorbidity-adjusted NEWS provides real-time support for nursing home nurses. As the older population is growing and the need for nursing homes is increasing, this type of decision support is crucial. It is important to remark that these needs and conditions are certainly independent of the particular region or country where the nursing home is located.

## 4.1 | Limitations

Our study is not free of limitations, nonetheless. First, this is a retrospective study, so the available data were collected during the course of the disease and only later retrieved through the review of EMRs. Second, it was a convenience cohort with patients taken consecutively during the first wave of the pandemic. Any patient who met the inclusion criteria and did not present any reason for exclusion was included in the study, without further requirement. To minimize bias risks, we included older adults from different provinces, transferred in basic or advanced life support from nursing homes to hospitals of different levels, non-stop 24/7 during the entire study period, including both rural and urban areas. As an additional measure to minimize potential bias, validation and revalidation has been performed in different cohorts. Third, 2-day in-hospital mortality was chosen as the main outcome. Although it is true that it is a very particular time frame, we have tried to detect the risk of short-term deterioration in patients transferred by ambulance with high priority, since deaths occurring over a longer period of time may not be due to the demand of care that has led to the evacuation. Finally, this study has been carried out in a single region under a unique healthcare system. In order to generalize the results, it is essential to conduct international multicentre studies, with the involvement, over time, of a diversity of participants from different institutions.

## 4.2 | Strengths

The NEWS was selected in this study as the early warning score because of its high consistency throughout the literature and its implementation in multiple clinical contexts (Abbott et al., 2018; Carr et al., 2021; Pimentel et al., 2019), as is also the case with the ACCI (Setter et al., 2020; Shuvy et al., 2020; Imam et al., 2020), although we are well aware of the existence of several other scores.

On the other hand, the use of early warning scores encourages the accurate, concise and transparent communication of clinical reports and promoting patient safety and helping nurses to carry out

their work in a special way. Patient safety is a challenge for healthcare systems, a goal that must be decisively pursued by our institutions in order to develop a structured assessment with appropriate alert triggers, and thus improve the care of our patients.

## 5 | CONCLUSION

Adequately, the huge number of patients produced by the SARS-CoV-2 pandemic has led to an oversaturation of healthcare systems with older adults in nursing homes in the spotlight. Adequately identifying patients at high risk of deterioration must be mandatory to optimize available resources.

In this sense, the comorbidity-adjusted NEWS provides a good short-term prognostic criterion, which can help in the decision-making process in nursing houses by registered nurses, while guiding the best strategy for each older adult.

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