The variable relationship between the National Early Warning Score on admission to hospital, the primary discharge diagnosis and in-hospital mortality

Authors information

Mark Holland, School of Clinical and Biomedical Sciences, University of Bolton, Bolton, BL3 5AB, UK
ORCiD 0000-0001-8336-5336

John Kellett, Visiting Professor, University of Bolton, Bolton, BL3 5AB, UK
ORCiD 0000-0002-4741-9242

Stelios Boulitsakis Logothetis, Department of Public Health and Primary Care, University of Cambridge, Cambridge, CB2 0BB, UK
ORCiD 0009-0004-7622-9423

Matthew Watson, Department of Computer Science, Durham University, Durham, DH1 3LE, UK
ORCiD 0000-0001-6375-3905

Noura Al Moubayed, Department of Computer Science, Durham University, Durham, DH1 3LE, UK
ORCiD 0000-0001-8942-355X

Darren Green Department of Renal Medicine, Northern Care Alliance, Salford Royal Hospital, Salford, M6 8HD
ORCiD 0000-0002-9370-8176

Abstract

Background: Patients with an elevated admission National Early Warning Score (NEWS) are more likely to die while in hospital. However, it is not known if this increased mortality risk is the same for all diagnoses. The aim of this study was to determine and compare the increased risk of in-hospital mortality associated with an elevated NEWS and different primary discharge diagnoses in unselected emergency admissions to a UK university teaching hospital.

Methods: A non-interventional observational study of 122,321 consecutive, unselected, adult patients with complete data admitted as an emergency between 2014-2022.

Results: The overall in-hospital mortality was 4.3%. Eighty diagnostic groupings accounted for 85.8% of all admissions and 89.4% of all in-hospital deaths. Depending on diagnostic grouping, the risk of mortality associated with an admission NEWS ≥3 ranged from 2.3 to 100-fold. For example, the in-hospital mortality of COPD patients increased from 1.9% for those with admission NEWS <3 to 35.6% for those with NEWS ≥3, for chest pain mortality increased from 0.1% to 3.9%, and for patients with an opiate overdose from 0.2% to 7.7%. Conversely, for admission NEWS <3, aspiration pneumonia and intracranial haemorrhage had in-hospital mortalities of 13.7%, 12.1%, respectively.

Discussion: There is enormous variation in the mortality risk associated with an increased admission NEWS in different commonly encountered diagnoses. Therefore, the mortality risk of some 'low risk' conditions can be dramatically increased if their admission NEWS is elevated, whereas some 'high risk' conditions are still likely to die even if their admission NEWS is low.

Key Words
Early Warning Score
Mortality
Pathophysiology
Acute disease
Length of stay
Diagnosis

The variable relationship between the National Early Warning Score on admission to hospital, the primary discharge diagnosis and in-hospital mortality

Introduction

The National Early Warning Score (NEWS) is the most widely validated and used early warning score. The intended purpose of the National Early Warning Score (NEWS) is to, "*better identify patients at risk of clinical deterioration, to facilitate more timely and effective intervention and to save lives*" [1]. NEWS provides a common language for the assessment

of clinical severity in all patients, which can be used to trigger clinical interventions and assess the response to them [2]. Although it is an unreliable predictor of mortality beyond 24 hours [3], NEWS is advocated to help identify patients who are suitable for same day emergency care [4], and many clinicians recommend its use for risk stratification [5] and the prediction of in-hospital mortality [6].

We previously found that patients admitted to hospital with a NEWS <3 are eight times less likely to die than those with an admission NEWS ≥3 [7], although 45% of all hospital deaths occurred in patients with an admission NEWS <3. It is also not known if the increased mortality associated with NEWS ≥3 is the same for all diagnoses. Although NEWS has been used to predict the prognosis of pneumonia [8] and some other conditions [9-11], study designs vary, and most patient subgroups are not represented [12]. In an extensive review of the literature [3] we found no reports of the ability of NEWS to predict in-hospital mortality in all the diagnoses likely to be encountered in a hospital patient population.

The aim of this study was to identify the relationship between in-hospital mortality and admission NEWS of common primary discharge diagnoses made in emergency admissions to a university teaching hospital.

Methods

Setting and methodology

A single centre retrospective observational cohort study of all admissions to the emergency assessment unit at a university teaching hospital in the United Kingdom between 1st April 2014 and 31st March 2022. The hospital provides routine secondary care services, as well as tertiary care services in neurology, neurosurgery, stroke medicine, renal medicine, dermatology, and intestinal failure. The hospital does not provide maternity care. The study was conducted according to “The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies” [13].

Participants

Emergency (non-elective) admissions, including readmissions, of all patients aged ≥16 years old, with a documented NEWS on admission to the emergency assessment unit and primary ICD10 (version 2019 [14]) diagnosis recorded at death or discharge.

Outcome

The primary outcome measure was in-patient mortality and length of stay was a secondary outcome measure. Patient admissions were categorised into two NEWS categories, <3 and ≥3 [3]; therefore, all patients with a NEWS <3 were conscious and alert.

Data collection

Data was extracted from completed emergency patient admissions held in the electronic patient record. All patient data was collected in routine clinical practice and was provided in an anonymised and non-identifiable format. Data extracted included the patients' age, sex, length of hospital stay, in-hospital mortality, NEWS recorded on admission to the emergency assessment unit and the primary discharge ICD-10 diagnosis.

Identifying frequent conditions from ICD-10 discharge codes

We identified the most frequently encountered conditions by analysing the ICD-10 diagnostic codes assigned at discharge to 100 or more patients, and then combining them with codes of similar diagnoses. Using our clinical judgement, these commonly encountered ICD 10 codes were then grouped into frequently encountered conditions.

Statistical analysis

IBM SPSS Statistics Version 28.0.0.0 (190) was used for statistical analysis. Parametric data are reported by means with 95% confidence intervals (95% CI) and non-parametric data by medians with interquartile ranges (IQR). The statistical significance level was set at $p < 0.05$. Continuous numerical data was analysed using Student's t test for parametric data and the Mann-Whitney U test for non-parametric data. The odds ratios of categorical data were compared by the Chi square test; the Haldane correction was used when required to avoid division by zero [15].

Ethics approval

Permission was granted by the hospital trust's Research & Innovation (R&I 21HIP13) to access and analyse non-identifiable patient level data routinely collected in clinical practice.

Results

Study population defined by admission NEWS.

The final study population was the 122,321 (72.6%) out of 168,506 hospital admissions; 46,185 (27.4%) admissions did not have a NEWS recorded and were not included in the study, these admissions had a significantly lower in-hospital mortality rate (2.6% versus

4.3%, p<0.001), were younger (57.8 versus 65.1 years, p<0.001) and had a shorter length of hospital stay (0.2 versus 2.3 days, p<0.001).

Admissions in the study population of 122,321 who died in hospital were older than survivors, had a longer length of hospital stay, and males were more likely to die than females (odds ratio 1.2, 95% CI 1.1-1.3). The 18,493 (15.1%) patients with an admission NEWS ≥3, were more likely to die than those with an admission NEWS <3 (odd ratio 8.0, 95% CI 7.5-8.4).

The 2,381 patients with an admission NEWS <3 who died accounted for 45% of all in-hospital deaths, and were older and had a longer length of stay than those who died with a NEWS ≥3. In contrast, patients with an admission NEWS <3 who survived were younger and had a shorter hospital stay than survivors with an admission NEWS ≥3 (Table 1).

Study population according to discharge diagnosis.

The primary discharge diagnoses of patients were captured by 3,225 six-character ICD10 codes (37.9 patients per code). To identify the commonly encountered diagnoses we initially only examined the 187 ICD10 codes assigned to 100 or more patients; out of the remaining 3,038 less commonly encountered codes, 920 were very similar to many of the commonly encountered codes and were added to them. Using our clinical judgement, we organised commonly encountered codes into 80 diagnostic groupings of the most *frequent conditions;* these were in 104,905 admissions (Supplemental Table 1). The remaining 17,416 admissions had *infrequent conditions*, identified by 2,118 ICD10 codes, with an average of 8 patients per code (Fig 1).

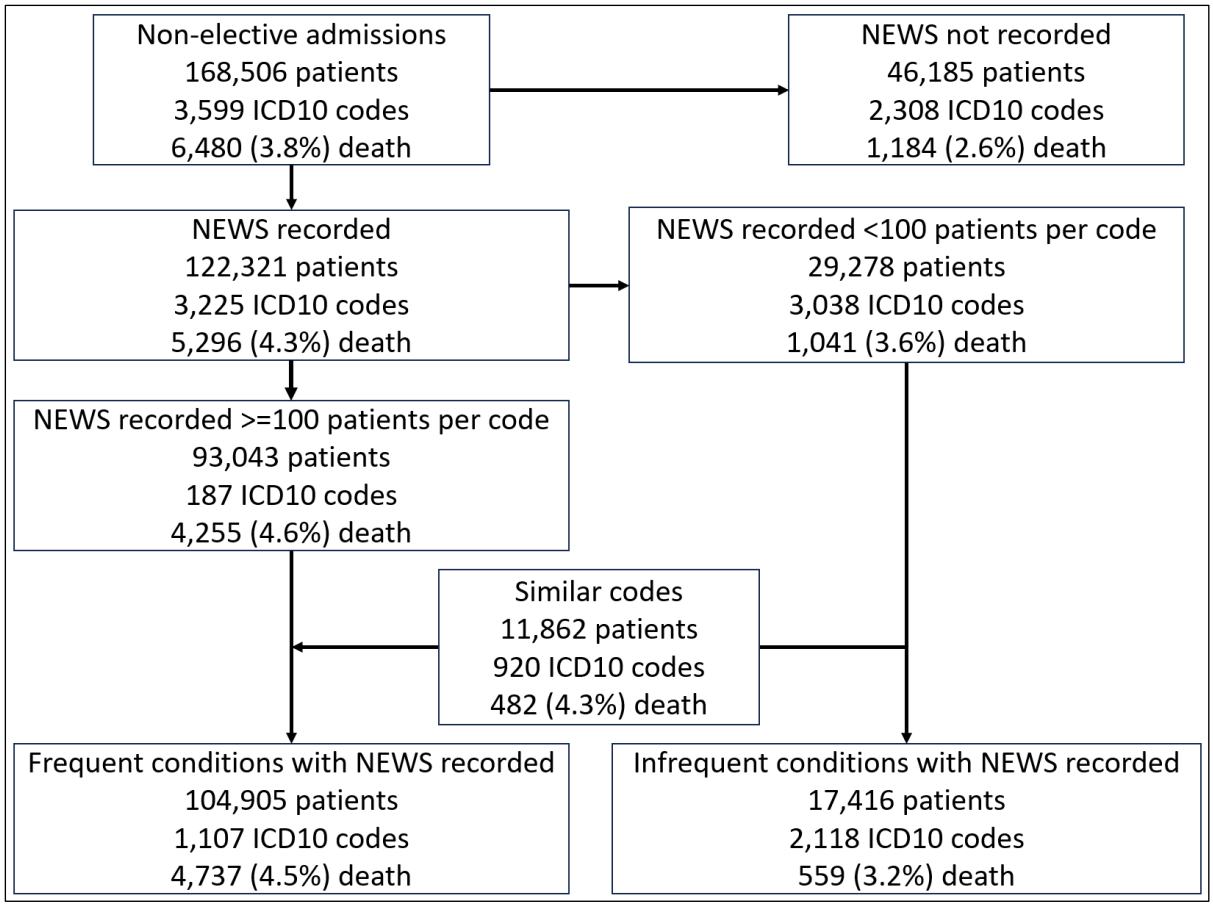

Fig 1: Flow chart of how the final study population of 122,321 was derived from all patients admitted to hospital as emergencies, and further subdivided into those with frequent and infrequent conditions.

Variation in the mortality risk associated with admission NEWS in different diagnoses.

There was considerable variation in the increased risk of mortality associated with an elevated admission NEWS. For 56 frequent conditions, there was a highly significant increase in mortality for patients admitted with a NEWS ≥3 compared with those with a NEWS <3, which ranges from an odds ratio of 2.4 for delirium to 105.0 for pericardial disease (Fig 2 and Supplemental Table 2). For example, the in-hospital mortality of COPD patients increased from 1.9% for those with an admission NEWS <3 to 35.6% for those with an admission NEWS ≥3, for those complaining of chest pain mortality increased from 0.1% to 3.9%, and for patients with an opiate overdose it increased from 0.2% to 7.7% (Supplemental Table 3). In contrast, in hospital mortality remained high for patients with a *high-risk* diagnosis even if they had an admission NEWS <3; for example, aspiration pneumonia, intracranial haemorrhage, and acute kidney injury patients with an admission NEWS <3 had in hospital mortalities of 13.7%, 12.1% and 6.2%, respectively (Table 2).

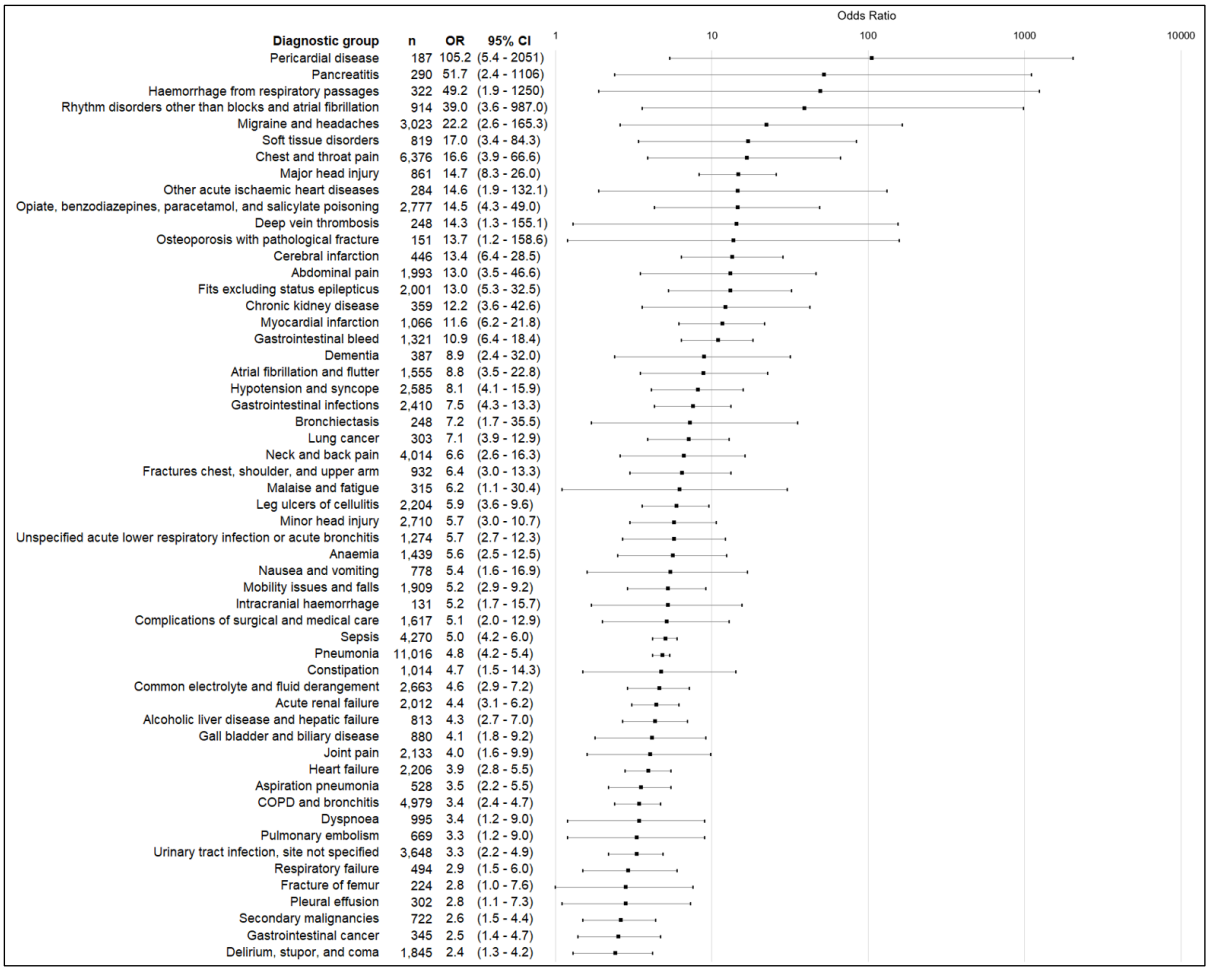

Fig 2: Odds ratio of in-hospital mortality of emergency patients with an admission NEWS ≥3 compared to an admission NEWS <3, according to discharge diagnostic grouping. The figure shows the 56 frequent conditions, which had a highly significant increase in mortality for patients admitted with a NEWS ≥3. The increase in mortality associated with and admission NEWS ≥3 in the remaining 24 conditions was not significant.

Diagnostic conditions according to frequency.

The 80 diagnostic groupings of frequently encountered conditions captured 85.8% of all patients and 89.4% of all in-hospital deaths. Five frequent conditions accounted for a quarter of all discharge diagnoses: pneumonia, chest and throat pain, chronic obstructive lung disease, sepsis, and neck and back pain. Of these, sepsis and pneumonia had the fifth and seventh highest mortality rates, whereas chest and throat, and neck and back pain had very low mortality rates.

Patients with infrequent conditions died from a variety of neoplastic, circulatory, and respiratory conditions (Supplemental Table 4), were more likely to be male, younger, and have a longer length of hospital stay, yet were less likely to have an admission NEWS ≥3

(odds ratio 0.59, 95% CI 0.56-0.62) and less likely to die in hospital than those with frequent conditions (Table 3).

Diagnostic conditions according to in-hospital mortality.
Seventeen diagnostic groupings had a statistically increased risk of mortality and were assigned to 26,264 patients (21.5% of all patients) who accounted for 62.0% of all in-hospital deaths (Table 2). Although overall, 31.8% of these patients had a NEWS ≥3, 35.5% of all deaths occurred in patients with a NEWS <3 on admission, while in-hospital mortality for patients with an admission NEWS <3 ranged from 2.9% to 17.1%.

Sixty-three diagnostic groupings were not at increased risk of in-hospital mortality: 26 groupings were without a statistically increased mortality and were assigned to 19,894 patients (16.3% of all patients), of whom 17,677 (88.9%) had an admission NEWS <3 (Supplemental Table 5). The remaining 37 diagnostic groupings had a statistically reduced risk of mortality and were assigned to 58,747 patients (48.0% of all patients), of whom 52,588 (90%) had an admission NEWS <3 (Supplemental Table 3).

Patients who died within 24 hours of admission
Regardless of NEWS on admission, pneumonia and sepsis accounted for 51.1% patients of deaths within 24 hours of admission. Within 24 hours, 41,916 (34.3%) patients had either been discharged or died; 2,944 (7.0%) of these patients had an admission NEWS ≥3, of whom 314 (10.7%) died. In contrast, only 44 (0.1%) of the 38,972 patients with an admission NEWS <3 died within 24 hours (odds ratio 105.6, 95% CI 76.0-147.1). Patients who were discharged alive within 24 hours were markedly younger than those who died within 24 hours (57.5 years, 95% CI 57.3-57.7 versus 77.6 years, 95% CI 76.3-79.0, p <0.001).

Discussion

Main findings
This study found that there was considerable variation in the increased risk of mortality associated with an admission NEWS ≥3, which can range from just over a 2-fold increase for some diagnostic groupings up to a 100-fold increase for others. Therefore, the mortality risk of some *low-risk* conditions, such as chest pain, headache, overdose etc., can be dramatically increased when NEWS is elevated, whereas some *high-risk* conditions are still likely to die even if their admission NEWS is low.

Interpretation

The 80 diagnostic groupings we identified were representative of the most frequent conditions admitted to our hospital and accounted for 85.8% of all emergency admissions and 89.4% of all in-hospital deaths. Five of the 80 groupings account for a quarter of all emergency admissions and 17 were associated with a significantly increased risk of in-hospital mortality; these 17 groupings accounted for 21.5% of all emergency conditions and 62.0% of all in-hospital deaths.

While generating these groupings, we tried to ensure that they were likely to be easily recognised within a few hours of hospital arrival and would probably reflect the *working diagnosis on admission*. As *diagnosis on admission* was not available to us, we used the primary ICD-10 codes assigned at discharge to capture the likely reasons for hospital admission. However, this may not always have been the case. For example, patients with a primary diagnosis of respiratory failure were almost certainly not admitted with this diagnosis, as one third of them had an admission NEWS <3 (see Table 2).

Only 45 ICD10 codes were assigned to more than 500 patients, whereas 943 codes were assigned to more than 10 patients. Therefore, we made a pragmatic decision to select only those ICD10 codes assigned to more than 100 patients to start the identification of common conditions, because this yielded a manageable number of ICD10 codes to further analyse.

Clinical implications

The findings of this paper are important, as there is a growing misconception that the risk of mortality is mostly driven by vital sign values, and that the traditional role of doctors to make a diagnosis is less important. Our Figure 2 clearly indicates that this is not the case. Although overall an admission NEWS ≥3 had an eight-fold increased risk of death, 45% of all in-hospital deaths occurred in patients with an admission NEWS <3. Most patients who die in hospital are elderly, frail, and are admitted as emergencies [16]. The findings of this study show that in clinical practice, about 90% of emergency admissions suffer from a limited number of common conditions that most doctors should be able to diagnose and treat, whereas 10% will have an uncommon disease that may require more skill, expertise and help to manage [17]. Sixty per cent of in-hospital deaths were associated with infections, circulatory, respiratory diseases, or cancer. As in Osler's day, pneumonia remains "*the captain of the men of death*" [18]. About 20% of common conditions have a high risk of mortality and will probably require hospital admission regardless of their NEWS at presentation. Of the 50% of patients with a low risk of mortality, many might be safely considered for outpatient or ambulatory emergency care. However, for some of these *low-risk* common conditions, such as chest pain, headache, overdose etc., the risk of mortality

can be dramatically increased when NEWS is elevated. More importantly, we do not know what other clinical information and investigations may have prompted admission decisions or how treatments may have affected outcomes.

The Ambulatory Care Score [19] and the Glasgow Admission Prediction Score [20] have been considered as methods for determining the need for hospital admission or ambulatory emergency care. Neither of these scores considers diagnosis or presenting complaint. In the UK, NHS England have proposed a NEWS threshold of <4 for patients who can be considered for streaming to same-day emergency care from an emergency department [4]; however, this study has identified patient groups who are physiologically stable on admission with a NEWS <3 but subsequently die. This study also shows that most deaths in hospital are from a relatively small number of conditions, all of which should be easy to recognise once the possibility that they may be present is seriously considered. These diagnoses must always be considered when determining the safest management of acutely ill patients.

Limitations

This study did not explore other factors associated with mortality, such as comorbidity and functional status [21] and it is possible that our hospital is not representative of other hospitals. We had no way of verifying the accuracy of data entry or ICD-10 coding, and the generation of diagnostic groupings from ICD10 codes was based on the authors' clinical judgements. The study analysed clinical data collected between 2014 and 2022 and, therefore, included some collected before and some during the COVID-19 pandemic. We analysed the NEWS recorded at the time of admission and we cannot say if this calculation was always correct. More than a quarter of all emergency admissions did not have NEWS recorded, and these patients were younger, had a shorter length of hospital stay, and were less likely to die in hospital.

Conclusion

The increased risk of mortality associated with an admission NEWS ≥3 ranged from a 2.3-fold increase for some diagnostic groupings to more than a 100-fold increase for others. Because of this enormous variation, the mortality risk of some *low-risk* conditions can be dramatically increased if their admission NEWS is elevated, whereas patients with some *high-risk* conditions are still likely to die even if their admission NEWS is low. Therefore, patients' diagnoses should be considered in conjunction with physiological vital signs, to ensure the safest management of acutely ill patients.

References

[1] Royal College of Physicians. *National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*. Updated report of a working party. London: RCP, 2017. (Accessed 27 November 2023, at https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news-2)

[2] Williams B. The National Early Warning Score: from concept to NHS implementation. Clin Med (Lond) 2022;22:499-505. doi:10.7861/clinmed.2022-news-concept

[3] Holland M, Kellett J. A systematic review of the discrimination and absolute mortality predicted by the National Early Warning Scores according to different cut-off values and prediction windows. Eur J Intern Med 2022;98:15-26. doi:10.1016/j.ejim.2021.12.024

[4] NHS Improvement, Ambulatory Emergency Care Network. Ambulatory emergency care guide: same day emergency care - clinical definition, patient selection and metrics. London, NHS Improvement, 2018. (Accessed 22 November 2023, at https://www.england.nhs.uk/wpcontent/uploads/2021/05/aec-same-day-emergency-care-clinical-definition-patient-selectionmetrics.pdf)

[5] Pimentel MAF, Redfern OC, Gerry S, et al. A comparison of the ability of the National Early Warning Score and the National Early Warning Score 2 to identify patients at risk of in-hospital mortality: A multi-centre database study. Resuscitation 2019;134:147-156. doi:10.1016/j.resuscitation.2018.09.026

[6] Liu VX, Lu Y, Carey KA, et al. Comparison of Early Warning Scoring Systems for Hospitalized Patients With and Without Infection at Risk for In-Hospital Mortality and Transfer to the Intensive Care Unit. JAMA Netw Open 2020;3:e205191. doi:10.1001/jamanetworkopen.2020.5191

[7] 15. Holland M, Dannatt A, Kellett J, Green D. Emergency admissions' diagnoses and risk of in-hospital death according to the primary ICD-10 chapter assigned at discharge and the National Early Warning Score on admission. Acute Med 2023;22:113-9.

[8] Sbiti-Rohr D, Kutz A, Christ-Crain M, et al. The National Early Warning Score (NEWS) for outcome prediction in emergency department patients with community-acquired pneumonia: results from a 6-year prospective cohort study. BMJ Open 2016;6:e011021. doi:10.1136/bmjopen-2015-011021

[9] Zhou HJ, Lan TF, Guo SB. Outcome prediction value of National Early Warning Score in septic patients with community-acquired pneumonia in emergency department: A single center retrospective cohort study. World J Emerg Med 2020;11:206-215. doi:10.5847/wjem.j.1920-8642.2020.04.002

[10] Kovacs C, Jarvis SW, Prytherch DR, et al. Comparison of the National Early Warning Score in non-elective medical and surgical patients. Br J Surg 2016;103:1385-1393. doi:10.1002/bjs.10267

[11] Kostakis I, Smith GB, Prytherch D, et al. The performance of the National Early Warning Score and National Early Warning Score 2 in hospitalised patients infected by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Resuscitation 2021;159:150-57. doi:10.1016/j.resuscitation.2020.10.039

[12] Alhmoud B, Bonnici T, Patel R, Melley D, Williams B, Banerjee A. Performance of universal early warning scores in different patient subgroups and clinical settings: a systematic review. BMJ Open 2021;11:e045849. doi:10.1136/bmjopen-2020-045849

[13] von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 2007;370:1453-57. doi:10.1016/S0140-6736(07)61602-X

[14] World Health Organization. (2004). ICD-10: International statistical classification of diseases and related health problems. Geneva, World Health Organization, 2004. (Accessed 27 November 2023, at https://icd.who.int/browse10/2019/en)

[15] Haldane, J.B.S. The mean and variance of chi2, when used as a test of homogeneity, when expectations are small. Biometrika 1940;29:133–34. https://doi.org/10.2307/2332614

[16] Stewart K, Choudry MI, Buckingham R. Learning from hospital mortality. Clin Med (Lond) 2016;16:530-34. doi:10.7861/clinmedicine.16-6-530

[17] Griggs RC, Batshaw M, Dunkle M, et al. Clinical research for rare disease: opportunities, challenges, and solutions. Mol Genet Metab 2009;96:20-6. doi:10.1016/j.ymgme.2008.10.003

[18] Reynolds AR. Pneumonia: the new ‘Captain of the men of death’. Its increasing prevalence and the necessity of methods for its restriction. JAMA 1903;XL:583–86. doi:10.1001/jama.1903.92490090031001k

[19] Ala L, Mack J, Shaw R, et al. Selecting ambulatory emergency care (AEC) patients from the medical emergency in-take: the derivation and validation of the Amb score. Clin Med (Lond) 2012;12:420-26. doi:10.7861/clinmedicine.12-5-420

[20] Cameron A, Rodgers K, Ireland A, Jamdar R, McKay GA. A simple tool to predict admission at the time of triage. Emerg Med J 2015;32:174-79. doi:10.1136/emermed-2013-203200

[21] Pompei P, Charlson ME, Douglas RG Jr. Clinical assessments as predictors of one year survival after hospitalization: implications for prognostic stratification. J Clin Epidemiol 1988;41:275-284. doi:10.1016/0895-4356(88)90132-1

Legends to Figures

Both figures are in black and white

Figure 1: Flow chart of how the final study population of 122,321 was derived from all patients admitted to hospital as emergencies, and further subdivided into those with frequent and infrequent conditions.

Figure 2: Odds ratio of in-hospital mortality of emergency patients with an admission NEWS ≥3 compared to an admission NEWS <3, according to discharge diagnostic grouping. The figure shows the 56 frequent conditions, which had a highly significant increase in mortality for patients admitted with a NEWS ≥3. The increase in mortality associated with and admission NEWS ≥3 in the remaining 24 conditions was not significant.

Legends to Tables

Table 1 Demographics of all emergency admission with NEWS recorded on admission, further stratified by NEWS value and in-hospital mortality.
Legend: Patients who died in hospital were older than survivors (78.3 years, 95% CI 78.0-78.6, versus 64.5 years, 95% CI 64.3-64.6, p <0.001), had a longer length of hospital stay (8.7 days, IQR 3.6 - 18.9m versus 2.1 days, IQR 0.6-6.8, p <0.001), and men were more likely to die than women (odds ratio 1.2, 95% CI 1.1-1.3).

Table 2 Frequently encountered conditions with a statistically increased risk of in-hospital mortality compared to other emergency conditions on whom NEWS was recorded.

Table 3 Comparison of frequently and infrequently encountered conditions, further stratified by NEWS value and in-hospital mortality.

Supplemental Table 1 80 diagnostic groupings of frequently encountered conditions.

Supplemental Table 2 Odds ratios with 95% confidence intervals (95%CI) for in-hospital mortality of emergency patients with an admission NEWS ≥3 compared to an admission NEWS <3, according to discharge diagnostic grouping.
Legend: The table shows the 56 frequent conditions, which had a highly significant increase in mortality for patients admitted with a NEWS ≥3. The increase in mortality associated with and admission NEWS ≥3 in the remaining 24 conditions was not significant.

Supplemental Table 3 Frequently encountered conditions at the same risk statistically of in-hospital mortality as the average patients admitted to hospital as an emergency on whom NEWS was recorded.

Supplemental Table 4 Infrequently encountered conditions according to ICD-10 chapters and their risk of mortality.

Supplemental Table 5 Frequently encountered conditions with a statistically reduced risk of in-hospital mortality compared to other emergency conditions on whom NEWS was recorded.