Pre-hospital National Early Warning Score (NEWS) is associated with in-hospital mortality and critical care unit admission: A cohort study

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ABSTRACT

Background: National Early Warning Score (NEWS) is increasingly used in UK hospitals. However, there is only limited evidence to support the use of pre-hospital early warning scores. We hypothesised that pre-hospital NEWS was associated with death or critical care escalation within the first 48 h of hospital stay.

Methods: Planned secondary analysis of a prospective cohort study at a single UK teaching hospital. Consecutive medical ward admissions over a 20-day period were included in the study. Data were collected from ambulance report forms, medical notes and electronic patient records. Pre-hospital NEWS was calculated retrospectively. The primary outcome was a composite of death or critical care unit escalation within 48 h of hospital admission. The secondary outcome was length of hospital stay.

Results: 189 patients were included in the analysis. The median pre-hospital NEWS was 3 (IQR 1–5). 13 patients (6.9%) died or were escalated to the critical care unit within 48 h of hospital admission. Pre-hospital NEWS was associated with death or critical care unit escalation (OR, 1.25; 95% CI, 1.04–1.51; p = 0.02), but NEWS on admission to hospital was more strongly associated with this outcome (OR, 1.52; 95% CI, 1.18–1.97, p < 0.01). Neither was associated with hospital length of stay.

Conclusion: Pre-hospital NEWS was associated with death or critical care unit escalation within 48 h of hospital admission. NEWS could be used by ambulance crews to assist in the early triage of patients requiring hospital treatment or rapid transport. Further cohort studies or trials in large samples are required before implemention.

1. Introduction

Early warning scores or rapid response systems are commonplace in UK hospitals [1]. They assign weighting to routine clinical measurements and are used to detect patients in need of clinical review or resuscitation [2]. The National Early Warning Score (NEWS), developed by the Royal College of Physicians, is designed to standardise and replace the multiple existing early warning previously used in UK hospitals (Table 1) [3]. NEWS is associated with clinical outcome, including hospital mortality and intensive care unit admission [4–8]. However, early warning scores are not widely used in the pre-hospital setting, reflecting the limited current evidence available to support their use.

Only two studies have evaluated pre-hospital early warning scores. A retrospective review of patients admitted to a single emergency department by ambulance found that modified early warning score (MEWS) – a similar scoring system that pre-dates NEWS - was more sensitive than clinician judgement for identifying critical illness in the community [9]. A prospective cohort study of patients with medical and trauma presentations admitted to a single hospital by ambulance found that NEWS was associated with intensive care unit admission and mortality [10]. However, it is unclear whether these results are generalisable to other populations with different demographics and case mixes. In addition, it is unclear whether a pre-hospital early warning score could be used by hospital staff for inpatient risk stratification.

Therefore the importance of ambulance early warning scores to both ambulance crews and hospital physicians remains uncertain.

We hypothesise that NEWS derived from pre-hospital observations...
A score of over 7 triggers a review by a critical care outreach team or medical response team [3, 4, 11].

2. Method

2.1. Study design

This was a planned secondary analysis of data from an observational cohort study of adult patients admitted to a single hospital with acute medical presentations [4, 11]. The methods and results of the main study have been published previously [4, 11]. All new adult medical admissions to the Acute Assessment Unit (AAU) at the Royal London Hospital between 25th March and 13th April 2013 that were brought to hospital by ambulance were included in this analysis. Patients admitted directly to the critical care unit from the emergency department were not included. The National Research Ethics Service prospectively reviewed and approved this study (12/LO/1985). The study was retrospectively checked for accuracy. The outcome measures were dependent on the accuracy of the data collected.

2.2. Data collection

The exposures of interest were NEWS calculated from physiological observations obtained by ambulance staff before hospital admission, and NEWS derived from similar observations on admission to hospital. Researchers prospectively collected physiological measurements that were recorded by nurses or healthcare assistants at the point of admission to the Acute Assessment Unit (AAU) at the Royal London Hospital. The study was registered retrospectively with Research Registry (UIN: re-searchregistry3194). Data were collected using an electronic database. The database was independently checked for accuracy. The outcome measures were determined by checking patient notes, electronic patient records and discharge summaries. We calculated NEWS retrospectively using Microsoft Excel (Microsoft Inc., Redmond WA) [4, 11].

2.3. Outcome measures

The primary outcome measure was a composite of critical care unit escalation and death within 48 h of hospital admission. We further hypothesise that NEWS derived from pre-hospital observations is more strongly associated with the outcome measure than NEWS on admission to hospital.

2.4. Statistical analysis

Data were analysed using SPSS version 21 (IBM, Armonk, NY). Data were stratified according to the presence or absence of ambulance data. Missing data were handled by list-wise deletion. In order to test for association between NEWS and the primary outcome measure, multivariable logistic regression models were constructed and adjusted for age and gender - a strategy consistent with previous similar research [5, 6]. NEWS was firstly considered as a continuous variable. Odds ratios derived from pre-hospital observations (pre-hospital NEWS) and for admission observations (admission NEWS) were calculated and compared. Secondly, NEWS was considered as a categorical variable, with the sample divided according to the recommended risk groups (NEWS 1–4, 5–6, > 7) and the analysis repeated [15]. Thirdly, the correlation between pre-hospital NEWS and admission NEWS was assessed using the Pearson product-moment correlation coefficient. Finally, to test for association between NEWS and the secondary outcome measure (length of hospital stay), a linear regression model was constructed, where length of stay was considered a continuous variable. The r² values for pre-hospital NEWS with admission NEWS were compared.

3. Results

453 adult medical patients were admitted during the study period, of which 258 were brought to hospital by ambulance. After excluding cases with missing data, 189 cases were included in the primary analysis and 180 were included in the secondary analysis (Fig. 1). The mean age of the entire cohort was 61 (sd. 22) years, compared to 67 (sd. 21) years for patients admitted by ambulance. There was no difference in the gender distribution for patients admitted by ambulance, compared to entire cohort. 13 patients (6.9%) admitted by ambulance died or were escalated to the critical care unit within 48 h. The median length of stay for patients admitted by ambulance was 4 (IQR 2–8) days. Baseline characteristics are provided in Table 2.

Multivariable logistic regression analysis was used to test for the association between NEWS and the primary outcome measure. When considered as a continuous variable, pre-hospital NEWS and admission NEWS were both associated with the primary outcome measure (OR, 1.25; 95% CI, 1.04–1.51; p = 0.02 and OR, 1.52; 95% CI, 1.18–1.97, p < 0.01 respectively) (Table 3). When considered as a categorical variable, pre-hospital NEWS and admission NEWS were both associated with the primary outcome measure (Table 4). We identified a moderate correlation between pre-hospital NEWS and admission NEWS (r = 0.44, p < 0.01). Pre-hospital NEWS differed

### Table 1

| National Early Warning Score (NEWS) | 3     | 2.5–36.0 | 36.1–38.0 | 38.1–39.0 | > 39.0 |
|-----------------------------------|-------|----------|-----------|-----------|--------|
| Temperature (°C)                  | < 35.0| 35.1–36.0| 36.1–38.0 | 38.1–39.0 | > 39.0 |
| Heart rate (beats/min)            | < 41  | 41–50    | 51–90     | 91–110    | > 110  |
| Systolic BP (mmHg)                | < 91  | 91–100   | 101–110   | 111–120   | > 120  |
| Respiratory Rate (breaths/min)    | < 9   | 9–11     | 12–20     | 21–24     | > 25   |
| Oxygen Saturation (%)             | < 92  | 92–93    | 94–95     | > 96      |
| Supplemental oxygen               | Yes   | No       |           |           |
| CNS response (AVPU)               | A     | V, P, U  |           |           |

Each category is graded 0–3. Scores for each category are added together to give a total. Composite scores of greater than 5 (or 3 in any one parameter) trigger an urgent medical review. A score of over 7 triggers a review by a critical care outreach team or medical response team [3, 4, 11].
from admission NEWS in 33 cases (17.4%), of which 7 cases (21.2%) had a greater admission NEWS and 26 cases (78.8%) had a greater pre-hospital NEWS. Neither pre-hospital nor admission NEWS were associated with hospital length of stay ($r^2 = 5.1\%, p = 0.48$ and $r^2 = 5.2\%, p = 0.92$ respectively).

### 4. Discussion

The main finding of this analysis is that NEWS derived from pre-hospital observations is associated with critical care unit escalation or death within 48 h of hospital admission. But, NEWS derived from observations taken on admission to the medical ward were more strongly associated with critical care unit escalation or death within 48 h of hospital admission, compared to NEWS derived from pre-hospital observations. This study identified a moderate correlation between ambulance NEWS and admission NEWS – in 83% of cases NEWS at both time points was the same. Where the scores were different, ambulance NEWS was greater in the majority of cases suggesting an improvement in clinical condition between pre-hospital assessment and medical ward admission. However, the variability in measurement techniques, equipment or clinical practice must be considered when interpreting these results. Patients with a pre-hospital NEWS of 7 or more had a four-fold increase in the odds of death or critical care unit admission compared to patients with a pre-hospital NEWS of 4 or less. Pre-hospital NEWS was not associated with hospital length of stay; this is consistent with our previous findings [4].

Our results are similar to other published work in this area. A recent single-centre observational study identified association between NEWS calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10]. Other authors found that another early warning score (MEWS), when calculated using ambulance data and both intensive care unit admission and mortality within 48 h of hospital admission [10].

From the point of view of the hospital physician, our results suggest that pre-hospital NEWS is not a better marker of clinical status compared to NEWS calculated on admission to
hospital. Thus, whilst our results demonstrate the efficacy of pre-hospital NEWS, we are cautious in drawing conclusions regarding its effectiveness in the real clinical environment. We acknowledge that this is a single-centre study, so our results may not be generalisable to other clinical settings.

A strength of our analysis is that our sample represents a broad spectrum of medical specialties (Table 2), but unlike other research in this field, it excluded patients suffering traumatic injury [10]. Inpatient data, including admission NEWS, were collected prospectively. However, for logistical reasons we were only able to collect the ambulance data in retrospect. At the time the study was conducted NEWS was not routinely used at our institution, which necessitated retrospective calculation of NEWS. This approach avoids observer error associated with early warning score calculation, which has been previously reported with a frequency of 18–27% [4,17,19,20].

This analysis has a number of limitations. Our sample size was 258, but we were only able to include 189 cases in the primary analysis due to a higher than expected rate of missing data from the ambulance patient report forms. While our sample is a similar size to other studies of early warning scores, the missing data could represent a source of selection bias [9,10,17,21]. In order to minimise this potential source of bias, future studies should implement strategies to minimise missing data from ambulance report forms. We used a composite outcome measure of critical care admission or death within two days of hospital admission, which has been used in similar studies [5,6,14]. Our definition of critical care was based on the Intensive Care Society description, including level two and three care [22]. This reflects the organisation at our institution and may be different to other hospitals. We excluded patients who were admitted to the critical care unit directly from the emergency department, since this was a study of adult medical patients who, due to the limits of our ethics approval, were medical patients and did not include patients admitted to the critical care unit from the emergency department. This choice was made to maintain the primary outcome, which is similar to other studies of this type [9,23]. Our statistical methods are appropriate to the sample size. The sample includes a small number of patients receiving palliative care. We ran a sensitivity analysis that excluded these cases and the results were very similar.

5. Conclusion

Pre-hospital NEWS is associated with death or critical care unit escalation within 48 h of hospital admission. However, admission NEWS is more strongly associated with outcome, which may represent patients who fail to improve despite treatment by the ambulance crew. Pre-hospital care may represent an important and useful extension of NEWS. However, evidence from large multi-centre studies is needed before implementing a pre-hospital version of NEWS.

Ethical approval

Research ethics approval was provided by the National Research Ethics Service (12/LO/1985).

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Author contribution

Study design: TA, NV, DI, JE. Data collection: TA, HT, DI, NV. Statistical analysis: NC. Writing first draft of manuscript: TA. Critical review and approval of manuscript: All.

Conflicts of interest

No conflicts to declare.

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