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ORIGINAL RESEARCH

# Modified National Early Warning Scores (MNEWS) for Predicting the Outcomes of Suspected Sepsis Patients; A Prospective Cohort Study

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**Abstract:** **Introduction:** The National Early Warning Score (NEWS) is commonly used to identify patients at high mortality risk. However, it has notable limitations. In this study, to enhance the accuracy, we revised it and evaluated the performance of modified NEWS (MNEWS) in predicting the outcomes of suspected sepsis patients. **Methods:** This single-center, prospective cohort study was conducted on patients with suspected sepsis to evaluate the accuracy of MNEWS in predicting mortality, survival to discharge, vasopressor requirements, and the need for mechanical ventilation. The MNEWS comprises the NEWS variables plus age, chronic major organ dysfunction, malignancy, functional status, and specific infected organ involvement. Sensitivity, specificity, likelihood ratio (LR), and area under the receiver operating characteristic curve (AUROC) were used to evaluate the performance of the MNEWS in predicting the studied outcomes. **Results:** Of the 1,393 patients included in this study, 209 died. Mean MNEWS was significantly higher in non-survivors than survivors (19.8 vs. 14.9, p<0.001). The AUROC of MNEWS in predicting 30-day mortality was 0.82 (95% CI: 0.79–0.85). MNEWS ≥ 18 had the highest accuracy for 30-day mortality prediction with 76.1% sensitivity, 75% specificity, positive LR of 3.13, and AUROC of 0.76 (95% CI: 0.73–0.79). The AUROC of MNEWS ≥18 for predicting survival until discharge, need for vasopressors, and need for mechanical ventilation were 0.75 (95% CI: 0.72–0.78), 0.72 (95% CI: 0.69–0.75), and 0.76 (95% CI: 0.73–0.79), respectively. Additionally, MNEWS ≥18 demonstrated superior predictive performance, compared with NEWS ≥7 and qSOFA ≥2 for various clinical outcomes. **Conclusion:** The MNEWS was similar to the NEWS in overall predictive accuracy for 30-day mortality but exhibited a higher predictive accuracy than did the qSOFA score. Notably, MNEWS ≥18 was a significant indicator of 30-day mortality risk, as well as the likelihood of requiring vasopressors, survival to discharge, and 7-day mortality.

**Keywords:** Modified national early warning score; Sepsis; Mortality; Clinical decision rules; Emergency service, hospital

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## 1. Introduction

Sepsis is a serious medical condition characterized by life-threatening organ dysfunction caused by dysregulated immune responses to infections (1). Sepsis-related mortality accounts for approximately 19.7% of all deaths (2). The diagnosis and management of sepsis in the emergency department (ED) remain formidable challenges. Several early warning scores (EWSs) have been developed and implemented to identify high-risk patients with sepsis in the ED who require early sepsis management (3, 4).

Numerous sepsis screening tools are used and evaluated in the ED (5-7). However, each method has inherent limitations. The quick sequential organ failure assessment (qSOFA) score has shown poor sensitivity in sepsis screening (6) , with an inconsistent accuracy in predicting mortality (8). The well-known systemic inflammatory response syndrome (SIRS) criteria lack specificity in predicting 30-day mortality (9). The predisposition-insult response and organ failure (PIRO) scoring system was introduced for staging severe sepsis and mortality prediction (10). It has been used to predict sepsis by considering comorbidities, septic sources, and physiological status. The PIRO score has also been used to determine the prognosis of sepsis in the ED and intensive care unit (ICU) (11).

The national early warning score (NEWS) is an established tool in EDs for the early detection of patient deterioration and mortality prediction, including cases of sepsis; however, it has demonstrated limited sensitivity and specificity in predicting mortality in patients with suspected sepsis (7). Despite its utility, recent studies have highlighted gaps in the NEWS, particularly its lack of consideration for age and co-

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morbidities, which are independent predictors of mortality (12). Therefore, we applied a modified NEWS (MNEWS), incorporating additional clinical parameters such as age, chronic major organ dysfunction, malignancy, functional status, and specific infected organ involvement. The aim of this study was to evaluate the effectiveness of the MNEWS in predicting 30-day mortality among patients with suspected sepsis in the ED.

## 2. Methods

### 2.1. Study design and setting

This prospective cohort study was conducted at the ED of Thammasat University Hospital (TUH), a tertiary-care facility, on patients with suspected sepsis to evaluate the accuracy of MNEWS in predicting mortality, survival to discharge, vasopressor requirements, and need for mechanical ventilation. The MNEWS comprises the NEWS variables plus age, chronic major organ dysfunction, malignancy, functional status, and specific infected organ involvement. Sensitivity, specificity, likelihood ratio (LR), and area under the receiver operating characteristic curve (AUROC) were used to evaluate the performance of the MNEWS in predicting the studied outcomes.

The authors confirmed that all methods were carried out in accordance with the relevant guidelines and regulations. The study was approved by the ethics committee of the Faculty of Medicine, Thammasat University (Ref. No.: MTU-EC-EM-0-242/63). Written informed consent was obtained from all participants of the study and/or their legal guardian, where applicable.

### 2.2. Participants

Adult patients aged 18 years and older who presented to the ED and were suspected to have sepsis according to the TUH sepsis protocol were included. The TUH sepsis protocol is based on a combination of clinical judgment, recognition of signs and symptoms of infection, organ dysfunction assessment, and application of early warning scores. These scores include the qSOFA score, NEWS, and SIRS criteria. Exclusion criteria for this study were as follows: treatment at another hospital prior to ED visit in TUH, referral from another healthcare facility, and presence of a do-not-resuscitate (DNR) order.

### 2.3. Exposure

MNEWS encompasses the NEWS variables plus age, chronic major organ dysfunction, malignancy, functional status, and specific infected organ involvement, incorporating 11 categories, each assigned 0–3 points (Table 1). The score was assessed upon initial presentation to the ED, with subsequent considerations given to the administration of oxygen therapy by experienced medical personnel. Consequently, the variable pertaining to the "supplementation of oxygen" was excluded from the scoring system. We modified the assessment of mental status by using the Glasgow Coma Scale (GCS) to provide more detailed information about neurological function, rather than the Alert, Verbal, Pain, and Unresponsive (AVPU) scale used in the original NEWS. The GCS is more granular and correlates well with outcomes in patients both with and without trauma (13, 14), despite being more time-consuming. This change was made to enhance the accuracy of the score in predicting patient outcomes.

Advanced age is widely recognized as a strong predictor of sepsis outcomes (15-17). The elderly are more prone to sepsis-related complications and mortality due to immunosenescence, inflammaging, sarcopenia, and frailty (18). To reflect the impact of age on sepsis risk, we categorized age into four groups, based on guidance from experts in emergency medicine and critical care.

Chronic major organ dysfunction, adapted from the Acute Physiology and Chronic Health Evaluation–II (APACHE II) score (19), includes liver failure, cardiovascular failure, renal failure, respiratory failure, and immunocompromised status. These dysfunctions diminish a patient's response to sepsis, increasing the risk of rapid decompensation and mortality. This reflects the patient's baseline health, and those with pre-existing organ dysfunction are more likely to develop worse outcomes (16, 20). Patients with any of these conditions were assigned three points. Functional status was assessed using a simplified version of the modified Rankin Scale (mRS) (21) and categorized into four groups: no disability, slight disability, moderate disability, and severe disability. This categorization was based on expert consensus to ensure a practical and clinically relevant assessment of functional status in patients with sepsis. Our previous study supports the finding that patients in the ED with more severe GCS scores, advanced age, chronic major organ dysfunction, or poor functional status are more likely to experience early in-hospital cardiac arrest (22).

Malignancy, particularly metastatic or treatment-associated cancer, is included in the MNEWS due to its association with sepsis mortality (20).

Cancer impairs immune response and often leads to organ dysfunction from either the disease itself or its treatments, complicating both the diagnosis and management of sepsis. The Charlson comorbidity index (CCI) malignancy category (23) was applied to the MNEWS, categorizing patients into four groups: no malignancy, malignancy without metastases, malignancy with metastases, and malignancy undergoing chemotherapy. Each category was assigned a score between 0 and 4, reflecting its severity and impact on outcomes, and it was adapted to fit the MNEWS model.

Specific infected organ involvement, especially in organs like the lungs and abdomen, is associated with increased sepsis-related mortality and often leads to organ-specific complications (e.g., respiratory failure) that further increase mortality (24, 25). In the ED, the infection site is crucial for selecting appropriate antibiotics. Detecting the infection site allows physicians to initiate timely source control, e.g. drainage

for abdominal infections, which is essential for effective sepsis management. Including this factor in the MNEWS supports accurate risk assessment, guidance for interventions, and aligns seamlessly with ED workflows, as infection site identification is already a key component of sepsis care.

The "Infection/Injury" component of the PIRO score accounts for the site of infection or specific organ involvement, evaluating how these factors influence sepsis outcomes (10). The "I" component from the PIRO score was simplified in the MNEWS, assigning 3 points to patients with specific organ involvement, preserving its clinical relevance and practical application.

### 2.4. Outcomes

The primary objective of this study was to evaluate the accuracy of the MNEWS in predicting 30-day mortality among patients presenting with suspected sepsis in the ED. Secondary outcomes included evaluating the utility of MNEWS in predicting 7-day mortality, survival to discharge, vasopressor requirements, and the need for mechanical ventilation.

### 2.5. Statistical analysis

The sample size was determined based on a pilot study, in which patients with suspected sepsis in the ED had a 30-day mortality rate of 18%. The sample size calculations were based on a two-sided test with a significance level (alpha) of 0.05 and a desired power of 0.8. Considering a margin of error of 10%, this study used a sample size of 1,388 participants.

Descriptive statistics are presented as mean with standard deviation (SD), median with interquartile range (IQR), or percentage. Unpaired t-tests and exact probability tests were used for continuous and categorical variables, respectively. The performance of MNEWS, NEWS, and qSOFA in predicting 30-day mortality among patients with suspected sepsis was evaluated using sensitivity, specificity, likelihood ratios (LRs), and area under the receiver operating characteristic curve (AUROC). The cutoff value for the MNEWS was determined using AUROC. Statistical significance was defined as a p-value less than 0.05. Data analysis was performed using STATA program version 14 (StataCorp, College Station, TX, USA).

## 3. Results

### 3.1. Baseline characteristics of studied cases

Of the 1,580 patients initially enrolled, 187 patients were excluded including those who were referred from other hospitals (124), received treatment prior to ED visit (56), and had a DNR order (7). Therefore, 1,393 patients were included in the final analysis (Figure 1).

Table 2 compares the baseline characteristics of studied cases between survived and non-survived patients. Survivors were significantly younger than non-survivors (70.5 vs. 76.1 years, p<0.001). Higher scores on the sepsis screening tools (qSOFA score ≥2 and NEWS >7) were associated with increased mortality rates. Notably, mean MNEWS was significantly higher in non-survivors than survivors (19.8 vs. 14.9, p<0.001). In the non-survivor group, a clear gradient was observed regarding functional status. Patients with severe disability had the highest mortality rate (57.9%), followed by those with moderate (34.4%), slight (4.8%), and no (2.9%) disability. Pulmonary infection was the most common suspected source of sepsis in both groups. However, the prevalence was higher in non-survivors (69.4%) than in survivors (49.1%). This was followed by genitourinary tract and abdominal infections, with a slightly higher prevalence among the survivors for the latter.

### 3.2. Predictive performance of MNEWS

In patients with suspected sepsis, MNEWS demonstrated superior predictive performance for 30-day mortality, compared with the NEWS and qSOFA score, with AUROC values of 0.82 (95% CI: 0.79–0.85), 0.80 (95% CI: 0.77–0.84), and 0.72 (95% CI: 0.68–0.75), respectively (Figure 2A). To establish the optimal cutoff value for mortality prediction using the MNEWS, the Youden index was evaluated, resulting in an optimal value of 18 points. For MNEWS ≥18, the sensitivity was 76.1%, and specificity was 75.7% (Table 3). The optimal sensitivity, specificity, and positive likelihood ratio values, respectively, for 30-day mortality prediction were as follows: 76.1%, 75.7%, and 3.13 for MNEWS ≥18; 87.6%, 48.3%, and 1.69 for NEWS ≥7; and 55.0%, 82.8%, and 3.19 for qSOFA score ≥2 (Table 4). When comparing the predictive performance of these cutoff points, the AUROC values for 30-day mortality were 0.76 (95% CI: 0.73–0.79), 0.68 (95% CI: 0.65–0.71), and 0.69 (95% CI: 0.65–0.72), respectively (Figure 2B). Pairwise comparisons of the AUROC values for 30-day mortality were as follows: MNEWS versus qSOFA, p<0.001; MNEWS ≥18 versus NEWS, p <0.001; and NEWS ≥7 versus qSOFA ≥2; p = 0.60. For 7-day mortality, MNEWS ≥18 exhibited superior predictive performance compared with NEWS ≥7 and qSOFA ≥2, with AUROC values of 0.78 (95% CI: 0.74–0.81), 0.69 (95% CI: 0.66–0.72), and 0.67 (95% CI: 0.62–0.72), respectively.

Additionally, MNEWS ≥18 demonstrated superior predictive performance, compared with NEWS ≥7 and qSOFA ≥2 for various clinical outcomes, including survival until discharge (0.75, 95% CI: 0.72–0.78 for MNEWS ≥18; 0.68, 95% CI: 0.66–0.72 for NEWS ≥7; 0.67, 95% CI: 0.62–0.72 for qSOFA ≥2), need for vasopressors (0.72, 95% CI: 0.69–0.75 for MNEWS ≥18; 0.66, 95% CI: 0.63-0.68 for NEWS ≥7; 0.65, 95% CI: 0.62–0.68 for qSOFA ≥2), and need for mechanical ventilation (0.76, 95% CI: 0.73–0.79 for MNEWS ≥18; 0.72, 95% CI: 0.70–0.74 for NEWS ≥7; 0.68, 95% CI: 0.65–0.71 for qSOFA ≥2) (Table 4).

### 3.3. Internal validation of predictive performance of the MNEWS, NEWS and qSOFA score

Following 10,000 bootstrap replications within the dataset, the AUROC values indicating the predictive performance of

MNEWS ≥18, NEWS ≥7 and qSOFA ≥2 for 30-day mortality were 0.76 (95% CI: 0.75–0.77), 0.68 (95% CI: 0.67–0.69), and 0.681 (95% CI: 0.67–0.70), respectively.

## 4. Discussion

This study was conducted to evaluate the MNEWS for predicting 30-day mortality in patients with suspected sepsis. Notably, mean MNEWS was significantly higher in patients who died within 30 days compared with survivors. Through Youden Index analysis, an optimal MNEWS cutoff value of 18 was established. Importantly, MNEWS demonstrated superior predictive capabilities over both NEWS and qSOFA, evidenced by its higher AUROC value compared to NEWS and qSOFA. These findings highlight the MNEWS as a potentially superior sepsis screening tool in EDs.

Rapid identification of high-risk patients with sepsis is essential for timely treatment initiation. While the qSOFA is favored for its specificity, it falls short in sensitivity. Clar et al. demonstrated the inadequate discriminative performance of qSOFA score ≥2 in predicting in-hospital mortality among patients with community-acquired sepsis (AUROC 0.60 [95%CI: 0.48–0.72], sensitivity [62%], and specificity [70%]) (5).

Research conducted by Seymour et al. indicated that the qSOFA showed divergent accuracy in predicting mortality. Its efficacy was notably superior in non-ICU settings (AUROC 0.81, 95% CI: 0.80–0.82) (3). Conversely, in ICU settings, the predictive performance diminished significantly, with AUROC values reported to be as low as 0.60 (95% CI: 0.60–0.63). Raith et al. similarly reported that the predictive capability of qSOFA for in-hospital mortality in patients with sepsis admitted to the ICU was poor (AUROC 0.61, 95% CI: 0.60–0.61) (8). Meta-analyses reflect this trend, indicating qSOFA's low sensitivity yet reasonable specificity for predicting in-hospital mortality (26). Consistent with these findings, we observed a limited predictive capability for qSOFA (AUROC 0.69), with low sensitivity (55%). This highlight concerns regarding the applicability of the qSOFA score in predicting sepsis-related mortality in the ED. Current guidelines, acknowledging these limitations, advise against exclusive reliance on the qSOFA for diagnosing sepsis or septic shock and advocate more comprehensive assessment approaches (27).

The NEWS is a well-known early warning score used to detect deteriorating status and predict mortality in the ED. Our findings showed that the NEWS exhibited higher sensitivity than did the qSOFA; however, both scoring systems demonstrated comparable performance in predicting 30-day mortality. Oduncu et al. indicated that the NEWS had a slightly higher discriminatory ability than did the qSOFA (AUROC 0.77 vs. 0.76). However, the difference between the NEWS and qSOFA was not statistically significant (p=0.43) (28).

The study conducted by Redfern et al., a comparison between NEWS and qSOFA in non-ICU patients with suspected infection, indicated that NEWS outperformed qSOFA in predicting in-hospital mortality (AUROC 0.81 vs. 0.68) (29). In contrast, a report from Durr et al. showed that the NEWS had superior discriminatory ability compared to the qSOFA for sepsis-related mortality (AUROC 0.70 vs. 0.63) (30). A study conducted across 28 hospitals in California and Illinois by Liu et al. demonstrated the superior performance of NEWS with AUROC values of 0.87 and 0.86 in California and Illinois, respectively. This was followed by the qSOFA (AUROC 0.78 for both cities) and the SIRS criteria (AUROC 0.76 for both cities). These results indicate that the NEWS exhibits the highest predictive performance for in-hospital mortality (31).

The CCI is a weighted index that incorporates seventeen specific comorbidities along with age, aiming to estimate mortality risk. The CCI is associated with hospital mortality in patients with sepsis. Elevated CCI score is associated with an increased risk of mortality (1–2 points: odds ratio (OR) 1.95 [95% CI: 1.10–3.46, p=0.022], 3–4 points: OR 4.02 [95% CI: 2.09–7.76, P<0.001] and ≥5 points OR 11.8 [95% CI: 6.49–21.44, p<0.001]). Age (≥ 65 years) and presence of organ failure are strongly associated with in-hospital mortality (32). The PIRO score encompasses clinical risk factors, including age, chronic obstructive pulmonary disease (COPD), liver disease, nursing home residency, and malignancy, within the "P" component of the scoring system. Vafaei et al. revealed the performance of the PIRO score for 1-month mortality prediction in patients with sepsis, with an AUROC value of 0.83 (95% CI: 0.78–0.89) (33). Our scoring system incorporates age, chronic major organ dysfunction, malignancy, functional status, and specific infected organ involvement as clinical risk factors, and we anticipate that this comprehensive approach will increase the accuracy of the score.

Advanced age and the presence of multiple comorbidities are pivotal risk factors contributing to high mortality in sepsis (15-17), often due to factors such as immunosenescence, inflammaging, sarcopenia, frailty, and malnutrition (18). Age >55 years, malignancies, chronic kidney disease, and cirrhosis have been found to be associated with elevated risk of bloodstream infection as well as sepsis (34). Comorbidities, including end-stage renal disease, chronic liver disease, COPD, congestive heart failure, and malignancy, are significantly associated with community-acquired sepsis (35). Both the APACHE II and SOFA scores include chronic organ dysfunction parameters due to their association with higher patient mortality. Chronic major organ dysfunction (e.g., heart, lungs, kidneys) also diminishes a patient's response to sepsis, thereby increasing the risk of rapid deterioration and death (16, 20).

In the present study, no significant difference in mortality was observed between patients with and without autoimmune conditions. However, detailed data were not obtained on autoimmune disease severity, specific types of immunosuppressive therapies administered, or duration of these treatments. Some patients in the autoimmune group may not have received strong immunosuppressive therapy, which could have influenced the outcomes. This could explain why no difference in mortality was observed in the univariable

analysis. Detailed data on autoimmune disease severity of autoimmune disease and strength and duration of immunosuppression are required for better stratification of these patients in future analyses.

The NEWS is highly accurate in predicting in-hospital mortality in patients with sepsis (9). The MNEWS was developed by integrating the NEWS, age, chronic major organ dysfunction, malignancy, functional status, and specific infected organ involvement, with the aim of enhancing accuracy in adverse sepsis outcome prediction. In the present study, the MNEWS was similar to the NEWS in predictive accuracy for 30-day mortality but exhibited a higher predictive accuracy than did the qSOFA score. For example, the MNEWS may predict a higher risk of sepsis-related mortality if the patient is of advanced age, has more underlying diseases, or has a moderate disability.

MNEWS ≥18 was superior to NEWS ≥7 and qSOFA score ≥2 in 30-day mortality prediction in the ED, with AUROC values of 0.76, 0.68, and 0.69, respectively, as well as short-term mortality prediction, survival to discharge, and the need for vasopressors.

Delayed sepsis recognition and resuscitation are associated with increased risk of in-hospital mortality (36). In clinical practice, employing a combination of clinical assessments, EWSs, and relevant laboratory values is recommended to ascertain the presence or absence of sepsis.

Patients with suspected sepsis presenting with high EWSs (NEWS, qSOFA, and MEWS) in the ED have been reported to experience unfavorable outcomes (e.g., need for emergency intubation, need for vasopressors, in-hospital death, or ICU admission) (37, 38). EWSs alert physicians to identify high-risk patients and facilitate early and prompt sepsis resuscitation (27). Clinicians who treat patients with suspected sepsis and elevated MNEWS should be more aware of the potential increased risk of mortality, similar to that observed when using other EWSs. The MNEWS helps guide clinical decision-making by highlighting patients who may require more intensive monitoring and timely intervention. It retains core features of the traditional NEWS while incorporating additional parameters from established models such as APACHE. This approach provides a reliable, practical tool tailored to the complexities of sepsis identification and management. The inclusion of comorbidities allows the MNEWS to be used across a wide range of patient populations. By combining vital signs, comorbidities, and organ involvement, the MNEWS also provides a thorough assessment of sepsis severity, supporting enhanced risk stratification in complex cases. Frequent assessment of patients with suspected sepsis enhances the likelihood of identifying at-risk individuals, thereby providing the opportunity to initiate early treatment.

Modification of the NEWS to create the MNEWS introduces additional complexity, particularly owing to the inclusion of more clinical parameters. Nonetheless, the MNEWS incorporates several key clinical risk factors, such as chronic major organ dysfunction and other comorbidities, which are not part of the original NEWS or qSOFA score. Our results demonstrate that the MNEWS outperformed both the NEWS and qSOFA in mortality prediction, supporting the utility of additional parameters in refining risk stratification. While increased complexity may raise concerns about practicality in the ED, the MNEWS can be integrated into clinical practice using computerized decision support systems. These systems can automate the calculation, reducing the burden on healthcare providers, while ensuring real-time availability of MNEWS risk assessment.

To our knowledge, our study is the first to involve the use of the NEWS in conjunction with clinical risk factors to assess mortality rates among patients with suspected sepsis in the ED. In addition, the prospective design of this study increases the reliability of the data.

## 5. Limitations

This study has several limitations. First, it is a single-center study, and the results may not be generalizable to other settings. External validation in multicenter settings is essential to confirm the generalizability of these findings. Second, patients with suspected sepsis were not included in the study if the physicians did not use the TUH sepsis protocol. Future research should be focused on MNEWS validation in various healthcare settings, including hospitals with different patient demographics, resources, and levels of care. This provides a more comprehensive understanding of the applicability and effectiveness of the MNEWS.

## 6. Conclusions

The MNEWS was similar to the NEWS in overall predictive accuracy for 30-day mortality but exhibited a higher predictive accuracy than did the qSOFA. Furthermore, MNEWS ≥18 was a significant indicator of 30-day mortality risk, as well as the likelihood of requiring vasopressors, survival to discharge, and 7-day mortality.

Elevated values of the MNEWS or other EWSs should alert physicians to initiate early sepsis treatment to reduce mortality. In the future, the development of a predictive score that incorporates comorbidities or non-vital sign-related risk factors is required to enhance the precision of predicting outcomes and identifying individuals at high risk of adverse outcomes.

## 7. Declarations

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### 7.3. Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### 7.4. Author's contribution

ND and KD were responsible for conceptualization and methodology. NP and BU were responsible for data curation and investigation. KD and WS were responsible for formal analysis. KD, NP, BU, WS and PP were responsible for supervision, validation, and review and editing. NP, KD, WS, BU, and PP were responsible for original draft preparation. All authors contributed to data interpretation and discussion and approved the published version of the manuscript.

### 7.5. Competing interests

The authors declare that they have no competing interests.

### 7.6. Using artificial intelligence chatbots

This manuscript was developed with the assistance of Chat GPT. These tools were utilized for grammar correction, readability optimization, and paraphrasing to enhance the clarity and precision of the text.

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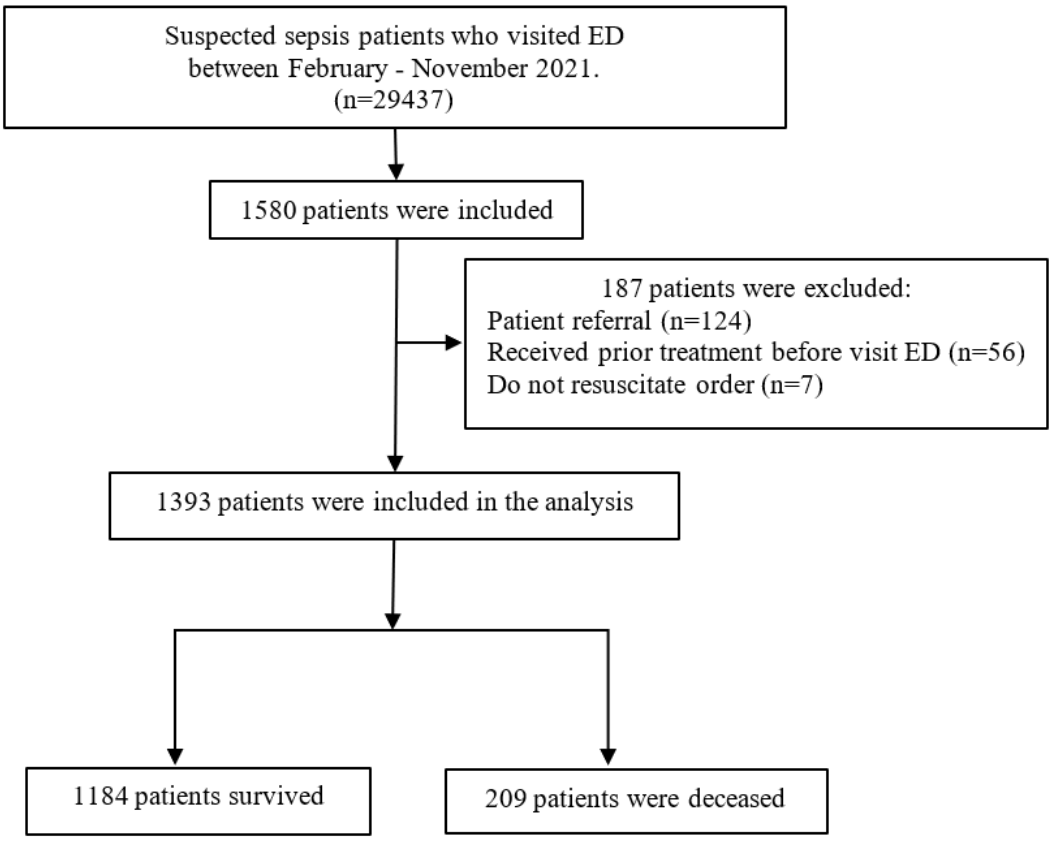


**Figure 1:** The study flowchart of patient inclusion. ED: emergency department.

**Table 1:** Modified National Early Warning Score (MNEWS)

| Parameter | Score | | | |
|---|---|---|---|---|
| | 3 | 2 | 1 | 0 |
| **Original NEWS parameters** | | | | |
| Respiration rate (per minute) | ≤ 8 or ≥ 25 | 21–24 | 9–11 | 12–20 |
| Oxygen saturation (%) | ≤ 91 | 92–93 | 94–95 | ≥ 96 |
| Systolic blood pressure (mmHg) | ≤ 90 or ≥ 220 | 91–100 | 101–110 | 111–219 |
| Pulse (per minute) | ≤ 40 or ≥ 131 | 111–130 | 41–50 or 91–110 | 51–90 |
| Glasgow coma score | Severe (3-8) | Moderate (9-12) | Mild (13-14) | Normal (15) |
| Temperature (°C) | ≤ 35.0 | ≥39.1 | 35.1–36.0 or 38.1–39.0 | 36.1–38.0 |
| **Added parameters** | | | | |
| Age (year) | > 80 | 6580 | 5064 | < 50 |
| Chronic major organ dysfunction[1] | Yes | | | No |
| Malignancy | Chemotherapy | Metastatic | Non-metastatic | No |
| Functional status (disability) [2] | Severe | Moderate | Slight | Normal |
| Specific infected organ involvement | Yes | | | No |

1. Chronic Major Organ dysfunction was defined as:
Liver: Biopsy-proven cirrhosis with portal hypertension; episodes of past upper gastrointestinal bleeding attributed to portal hypertension; hepatic failure, encephalopathy, or coma.
Cardiovascular: New York Heart Association (NYHA) class IV heart failure.
Respiratory: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40 mmHg); or respirator dependency.
Renal: Receiving chronic dialysis.
Immunocompromised: The patient has received therapy that suppresses resistance to infection (e.g., immunosuppression, chemotherapy, radiation, long-term or high-dose steroids, or advanced leukemia, lymphoma, or AIDS).
2. Functional Status was defined as:
Slight Disability: unable to carry out all previous activities, but able to look after own affairs without assistance.
Moderate Disability: unable to walk and attend to bodily needs without assistance.
Severe Disability: Bedridden, incontinent requiring constant nursing care and attention.

**Table 2:** Comparing the baseline characteristics of studied patients between survived and non-survived cases

| Characteristic | 30-day survival | | P-value |
|---|---|---|---|
| | Yes (n=1184) | No (n=209) | |
| **Age (Years)** | | | |
| Mean ± SD | 70.5 ± 15.1 | 76.1 ±12.3 | <0.001 |
| **ESI Triage** | | | |
| Critical | 54 (4.6) | 68 (32.5) | <0.001 |
| Emergency | 1126 (95.1) | 141(67.5) | |
| Urgency | 4 (0.3) | 0 (0.0) | |
| **Scoring system** | | | |
| qSOFA ≥2 | 204 (17.23) | 115 (55.02) | <0.001 |
| NEWS >7 | 612 (51.68) | 183 (87.56) | <0.001 |
| MNEWS | 14.9 ± 3.8 | 19.8 ±3.7 | <0.001 |
| **Co-morbidities** | | | |
| Chronic lung disease | 107 (9.0) | 38 (18.2) | <0.001 |
| Coronary artery disease | 159 (13.4) | 44 (21.1) | 0.01 |
| Chronic kidney disease | 268 (22.6) | 82 (39.4) | <0.001 |
| Liver disease | 105 (8.9) | 9 (4.3) | 0.03 |
| Cerebrovascular disease | 430 (36.3) | 94 (45.0) | 0.02 |
| Diabetes | 571 (48.2) | 94 (45.0) | 0.41 |
| Hypertension | 743 (62.8) | 137 (65.6) | 0.48 |
| Autoimmune | 40 (3.4) | 7 (3.4) | 1.00 |
| Malignancy | 115 (9.7) | 60 (28.7) | <0.001 |
| Malignancy with metastasis | 81 (6.8) | 57 (27.3) | <0.001 |
| Malignancy on chemotherapy | 59 (5.0) | 30 (14.4) | <0.001 |
| Total | 880 (74.3) | 195 (93.3) | <0.001 |
| **Functional status** | | | |
| Normal | 79 (6.7) | 6 (2.9) | <0.001 |
| Slight disability | 223 (18.8) | 10 (4.8) | |
| Moderate disability | 631 (53.3) | 72 (34.4) | |
| Severe disability | 251 (21.2) | 121 (57.9) | |
| **Suspected source of infection** | | | |
| Pulmonary infection | 569 (48.1) | 145 (69.4) | <0.001 |
| Genitourinary tract infection | 326 (27.5) | 60 (28.7) | 0.74 |
| Abdominal infection | 201 (17.0) | 26 (12.4) | 0.11 |
| Skin and soft tissue infection | 47 (4.0) | 4 (1.9) | 0.17 |
| Central nervous system infection | 80 (6.8) | 1 (0.5) | <0.001 |
| Vascular related catheter infection | 15 (1.3) | 4 (1.9) | 0.51 |
| Unknown | 42 (3.6) | 4 (1.9) | 0.29 |
| Total | 1142 (96.5) | 202 (96.7) | 1.00 |
| **Vital signs** | | | |
| Mean arterial pressure | 92.25 ± 18.57 | 85.82 ± 21.37 | <0.001 |
| Respiratory rate | 27.58 ± 2.84 | 28.86 ± 4.48 | <0.001 |
| Heart rate | 93.10 ± 20.57 | 103.01 ± 24.08 | <0.001 |
| **Vasopressor use** | | | |
| Yes | 141 (11.9) | 165 (78.9) | <0.001 |
| **Required mechanical ventilation** | | | |
| Yes | 86/1184 (7.26) | 161/209 (77.03) | <0.001 |

Data are presented as mean ± standard deviation (SD) or frequency (%). ESI: Emergency Severity Index; MNEWS: Modified National Early Warning Score; NEWS: National Early Warning Score; qSOFA: quick Sepsis-related Organ Failure Assessment.

**Table 3:** The optimal point using Youden index of Modified National Early Warning Score (MNEWS) for predicting 30-day mortality

| Cut point | Sensitivity (%) | Specificity (%) | PLR | NLR |
|---|---|---|---|---|
| ≥ 12 | 98.56 | 18.16 | 1.20 | 0.08 |
| ≥ 13 | 97.61 | 23.82 | 1.28 | 0.10 |
| ≥ 14 | 94.26 | 33.36 | 1.41 | 0.17 |
| ≥ 15 | 89.95 | 43.16 | 1.58 | 0.23 |
| ≥ 16 | 85.65 | 53.97 | 1.86 | 0.27 |
| ≥ 17 | 81.34 | 65.37 | 2.35 | 0.29 |
| ≥ 18 | 76.08 | 75.68 | 3.13 | 0.32 |
| ≥ 19 | 66.99 | 82.69 | 3.87 | 0.40 |
| ≥ 20 | 56.94 | 87.92 | 4.71 | 0.49 |
| ≥ 21 | 46.41 | 93.67 | 7.33 | 0.57 |
| ≥ 22 | 26.79 | 96.71 | 8.13 | 0.76 |
| ≥ 23 | 22.01 | 98.65 | 16.29 | 0.79 |
| ≥ 24 | 15.31 | 99.41 | 25.90 | 0.85 |
| ≥ 25 | 8.61 | 99.83 | 50.98 | 0.92 |

PLR: Positive likelihood ratio; NLR: Negative likelihood ratio.

**Table 4:** Screening performance characteristics of MNEWS, NEWS, and qSOFA for mortality and clinical outcomes

| Outcome | Sensitivity | Specificity | PLR | AUROC |
|---|---|---|---|---|
| **30-day mortality** | | | | |
| MNEWS ≥18 | 76.1(69.7-81.7) | 75.7(73.1-78.1) | 3.13(2.76-3.55) | 0.76 (0.730.79) |
| NEWS ≥7 | 87.6(82.3-91.7) | 48.3(45.4-51.2) | 1.69(1.57-1.83) | 0.68 (0.65-0.71) |
| qSOFA ≥2 | 55.0(48-61.9) | 82.8(80.5-84.9) | 3.19(2.68-3.80) | 0.69 (0.650.72) |
| **7-day mortality** | | | | |
| MNEWS ≥18 | 83.0(74.5-89.6) | 72.1(69.6-74.5) | 2.98(2.63-3.37) | 0.78 (0.740.81) |
| NEWS ≥7 | 91.5(84.5-96) | 45.89(43-48.5) | 1.69(1.56-1.82) | 0.69 (0.660.72) |
| qSOFA ≥2 | 54.7(44.8-64.4) | 79.7(77.4-81.9) | 2.70(2.20-3.31) | 0.67 (0.620.72) |
| **Survival until discharge** | | | | |
| MNEWS ≥18 | 72.7(66.7-78.2) | 76.5(73.9-78.9) | 3.09(2.71-3.52) | 0.75(0.720.78) |
| NEWS ≥7 | 87.6(82.8-91.5) | 49.3(46.4-52.3) | 1.73(1.61-1.86) | 0.68 (0.660.71) |
| qSOFA ≥2 | 50.4(43.9-56.9) | 82.9(80.6-85) | 2.95(2.46-3.52) | 0.67 (0.630.70) |
| **Vasopressor need** | | | | |
| MNEWS ≥18 | 65.7(60.1-71) | 77.4(74.8-79.8) | 2.90(2.53-3.33) | 0.72 (0.690.75) |
| NEWS ≥7 | 81.7(76.9-85.9) | 49.9(46.8-52.9) | 1.63(1.5-1.76) | 0.66 (0.630.68) |
| qSOFA ≥2 | 46.1(40.4-51.8) | 83.6(81.3-85.8) | 2.81(2.35-3.37) | 0.65 (0.620.68) |
| **Need for mechanical ventilation** | | | | |
| MNEWS ≥18 | 74.5(68.6-79.8) | 77.1(74.5-79.5) | 3.25(2.85-3.69) | 0.76 (0.730.79) |
| NEWS ≥7 | 93.5(89.7-96.3) | 50.8(47.8-53.7) | 1.90(1.78-2.03) | 0.72 (0.700.74) |
| qSOFA ≥2 | 52.2(45.8-58.6) | 83.4(81.1-85.5) | 3.15(2.64-3.76) | 0.68 (0.650.71) |

All measures are presented with 95% confidence interval (CI). PLR: Positive likelihood ratio; AuROC: Area under the receiver operating characteristic curve; MNEWS: Modified National Early Warning Score; NEWS: National Early Warning Score; qSOFA: quick Sepsis-related Organ Failure Assessment.

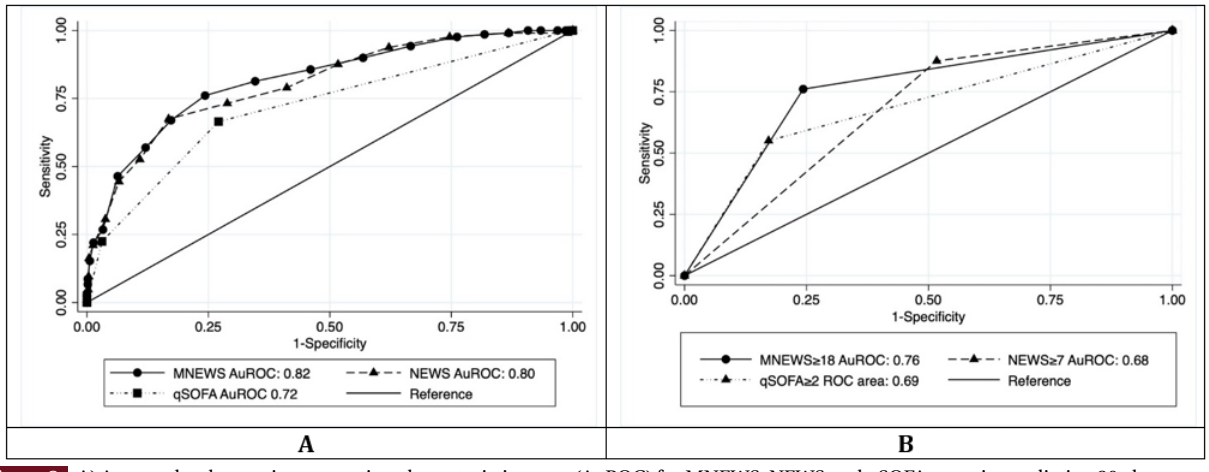


**Figure 2:** A) Area under the receiver operating characteristic curve (AuROC) for MNEWS, NEWS and qSOFA score in predicting 30-day mortality. B) Area under the receiver operating characteristic curves for MNEWS ≥ 18, NEWS ≥ 7 scores and qSOFA ≥ 2 in predicting 30-day mortality. MNEWS: Modified National Early Warning Score; NEWS: National Early Warning Score; qSOFA: quick Sepsis-related Organ Failure Assessment.