Simple Mortality Predictive Models for Improving Critical Care in Resource-Limited Settings: An Insight on the Modified Early Warning Score and Rapid Emergency Medical Score

Abstract
Mortality rate among critically ill patients admitted to the Intensive Care Unit is high, particularly in low-income countries (LIC). Many scores have been developed to predict these fatal outcomes. In LIC, the applicability of scoring systems is precluded by the unavailability of resources to compile all the parameters of these scores. Herein, we highlight the advantages of two models: the Modified Early Warning Score (MEWS) and the Rapid Emergency Medical Score (REMS). The REMS and the MEWS have the advantage of being accurate, simple, inexpensive, and practical for LIC.

Keywords: Critical care, low-income countries, mortality, predictive scores

Introduction
In contrast to high-income countries, the burden of the Intensive Care Unit (ICU) mortality is more significant in low-income countries (LIC) due to lack of essential drugs, limited health infrastructures, and understaffed and underfunded health-care systems.[10] Predictive mortality scores permit the identification of patients requiring special attention on admission.[2,3] The most commonly used scores are the Acute Physiology and Chronic Health Evaluation (APACHE), the Prince of Wales Emergency Department Score,[4] the Simplified Acute Physiology Score, the Modified Early Warning Score (MEWS), the Rapid Emergency Medicine Score (REMS), the Sequential Organ Failure Assessment,[11] the Mortality Probability Model (MPM),[4,5] and the Logistic Organ Dysfunction Score (LODS).[6] Several studies assessing the various performances of these models in predicting of ICU mortality have showcased the LODS, APACHE, and MPM models to have the highest predictive potentials.[3,4,6,7] However, in LIC, the use of these scores is complex and requires supplementary financial and technical resources (such as serum bilirubin, prothrombin time, partial pressure of arterial oxygen, fraction of inspired oxygen, and arterial pH), hence, limiting their use for a large scale of critically ill patients.[1,6,8] Resource-challenged settings need simple, feasible, and cost-effective clinical scores which can ensure the rapid identification of patients requiring critical care.[9] To this effect, clinical scores assessing routine vital signs have been proposed as feasible options to identify critical illness, monitor treatment in critically ill patients, triage those in need of intensive interventions, and to predict in-ICU mortality in these resource-constrained environments.[9]

The MEWS was designed for the early detection of basic physiological dysfunctions in respiratory rate, heart rate, systolic blood pressure, urine output, temperature, and the neurological state, which are often observed before cardiac arrest[10] [Table 1]. The MEWS has been shown to have a good correlation with mortality as patients with a score of zero, four, and five have an in-ICU mortality of 5.2%, 16%, and 26%, respectively.[10,11] In a more recent study carried out in 2016 in Uganda to evaluate the prognostic performance of the MEWS system, a MEWS ≥5 was found to be an independent predictor of in-hospital mortality (odds ratio: 5.82; 95% confidence interval: 2.420–13.987; P < 0.0001) among critically ill patients.[12]

Furthermore, the REMS is relatively simple and highly applicable to resource-poor settings, because its input variables which...
are readily available in most intensive care settings. It is based on five physiological parameters, namely: the mean arterial pressure, respiratory rate, blood pressure, peripheral oxygen saturation, and the Glasgow Coma Scale. Except for the age (0–6 points), each parameter is graded from 0 to 4 and the maximum score is 26 [Table 2]. With area under the receiver operating characteristic curve (AUC) values of 0.74 in developed countries and 0.71 in developing countries, evidence abounds on the external validity of the REMS in the prediction of death. The probability of 30-day mortality increases by 30% for each additional REMS unit. REMS has been shown to be more accurate than MEWS AUC: 0.642 versus 0.568 for MEWS and to have the same predictive accuracy as the APACHE II.

MEWS and REMS are valid scoring systems for in-hospital mortality prediction; they have the advantage of being solely clinical, with fewer parameters than others scoring systems. The scarcity of sophisticated laboratories to carry out the necessary investigations (e.g. \(\text{FiO}_2\), \(\text{PaO}_2\), serum bicarbonate, blood pH, serum creatinine, serum bilirubin, and serum electrolytes), coupled with the high cost of these investigations, makes the MEWS and REMS of invaluable economic and prognostic interests in LIC. Moreover, from a point of view of applicability, only few health personnel are familiar with the use of sophisticated scores such as APACHE and LODS.

### Table 1: The Modified Early Warning Score

| Parameters         | Finding          | Points |
|--------------------|------------------|--------|
| Age (years)        | <45              | 0      |
|                    | 45-54            | 2      |
|                    | 55-64            | 3      |
|                    | 65-74            | 5      |
|                    | >74              | 6      |
| MAP (mmHg)         | >159             | 4      |
|                    | 130-159          | 3      |
|                    | 110-129          | 2      |
|                    | 70-109           | 0      |
|                    | 50-69            | 2      |
|                    | ≤49              | 4      |
| Heart rate (bpm)   | >179             | 4      |
|                    | 140-179          | 3      |
|                    | 110-139          | 2      |
|                    | 70-109           | 0      |
|                    | 55-69            | 2      |
|                    | 40-54            | 3      |
|                    | ≤39              | 4      |
| Respiratory rate (bpm) | >49              | 4      |
|                    | 35-49            | 3      |
|                    | 25-34            | 1      |
|                    | 12-24            | 0      |
|                    | 10-11            | 1      |
|                    | 6-9              | 2      |
|                    | ≤5               | 4      |
| POS (%)            | 75               | 4      |
|                    | 75-85            | 3      |
|                    | 86-89            | 1      |
|                    | >89              | 0      |
| GCS                | 3-4              | 4      |
|                    | 5-7              | 3      |
|                    | 8-10             | 2      |
|                    | 11-13            | 1      |
|                    | 14-15            | 0      |

\(\text{sbp}\): Systolic blood pressure; HR: Heart rate; RR: Respiratory rate; MEWS: Modified Early Warning Score; AVPU: Alert, Verbal response, Pain response, Unconscious. Adapted from prediction of critical illness in general surgery using the MEWS by Stenhouse et al.

### Table 2: The Rapid Emergency Medical Score

| Parameters         | Finding          | Points |
|--------------------|------------------|--------|
| SBP (mmHg)         | <70              | 71-80  |
|                    | 81-100           | 101-199|
|                    | ≥200             | 2      |
| HR (bpm)           | <40              | 40-50  |
|                    | 51-100           | 101-110|
|                    | 111-129          | 1      |
| RR (bpm\(^{\dagger}\)) | <9              | 9-14   |
|                    | 15-20            | 21-29  |
| Temperature (°C)   | <35.0            | 35.1-36.0|
|                    | 36.1-38.0        | 38.1-38.5|
|                    | ≥38.6            | 2      |
| Conscious level (AVPU) | Alert          | Reacting to voice |
|                    | 120-800 ml       | >800 ml |

\(\text{SBP}\): Systolic blood pressure; HR: Heart rate; RR: Respiratory rate; MEWS: Modified Early Warning Score; AVPU: Alert, Verbal response, Pain response, Unconscious. Adapted from prediction of critical illness in general surgery using the MEWS by Stenhouse et al.

Conclusion

The accuracy of mortality predictive models for critically ill patients has been ameliorated in recent years in high-income countries at the expense of their financial cost in low-income settings. Although widely used in high-income countries, their applicability in LIC is limited by a lack of qualified health personnel, sophisticated laboratories to carry out the necessary laboratory investigations, and the issue of cost-effectiveness. The REMS and MEWS have the advantage of being accurate, simple, inexpensive, and practical. With the increasing burden from complications of critical illness in resource-challenged settings, particularly in Sub-Saharan Africa, the generalizability of the REMS and MEWS cannot be overemphasized.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.
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