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Original article

Two simple replacements for the Triage Early Warning Score to facilitate the South African Triage Scale in low resource settings

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ABSTRACT

Background: The South African Triage Scale (SATS) requires the calculation of the Triage Early Warning Score (TEWS), which takes time and is prone to error.
Aim: to derive and validate triage scores from a clinical database collected in a low-resource hospital in sub-Saharan Africa over four years and compare them with the ability of TEWS to triage patients.
Methods: A retrospective observational study carried out in Kitovu Hospital, Masaka, Uganda as part of an ongoing quality improvement project. Data collected on 4482 patients was divided into two equal cohorts: one for the derivation of scores by logistic regression and the other for their validation.
Results: Two scores identified the largest number of patients with the lowest in-hospital mortality. A score based on oxygen saturation, mental status and mobility had a c statistic for discrimination of 0.83 (95% CI 0.079–0.87) in the derivation, and 0.81 (95% CI 0.77–0.86) in the validation cohort. Another score based on respiratory rate, mental status and mobility had a c statistic of 0.82 (95% CI 0.078–0.87) in the derivation, and 0.81 (95% CI 0.77–0.86) in the validation cohort. The oxygen saturation-based score of zero points identified 51% of patients in the derivation cohort who had in-hospital mortality rate of 0.5%, and 49% of patients in the validation cohort who had in-hospital mortality of 1.0%. A respiratory rate-based score of zero points identified 45% in the derivation cohort who had in-hospital mortality rate of 0.5%, and 44% of patients in the validation cohort who had in-hospital mortality of 0.8%. Both scores had comparable performance to TEWS.
Conclusion: Two easy to calculate scores have comparable performance to TEWS and, therefore, could replace it to facilitate the adoption of SATS in low-resource settings.

African relevance

- Two simple, and rapid, scores can identify patients most in need of the fastest and best care available.
- Both scores have comparable performance to the Triage Early Warning Score (TEWS)
- Replacing TEWS with either score could facilitate the South African Triage Scale (SATS) in low-resource settings.

Introduction

An efficient triage tool must not only identify those patients that require urgent care, but also as many patients as possible who do not require it and who can be managed later or electively. The identification of these low-risk patients is particularly important in emergency departments in low- and middle-income countries, which may lack experienced emergency healthcare providers and cannot afford to waste other scarce resources [1,2]. The South African Triage Scale (SATS) has been widely implemented and evaluated in South Africa, in several low- or middle-income countries, and in a wide range of settings [3]. Although it was designed for nursing assistants [4], lower cadres of nursing staff in a Ugandan hospital found it difficult to use [5]. It requires the calculation of the Triage Early Warning Score (TEWS), an aggregated weighted score based on a full set of vital signs. Vital sign measurements are often inaccurate [6] and the calculation of scores from them also prone to error [7]. Their measurement takes time: in a

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cohort of 18,305 patients 4.1 ± 1.3 min per patient were required to measure a complete set [8]. Moreover, the appropriate equipment to measure vital signs must be available, and staff trained on how to use it.

SATS uses clinical discriminators (i.e. mechanism of injury, clinical presentation, pain, and senior health-care personnel's opinion), TEWS and additional investigations to risk stratify patients and initiate their management. Patients with cardiac arrest, obstructed airways, convulsions etc. are triaged as RED emergencies for immediate management. TEWS is used to help evaluate the remaining patients. Those with high energy transfer mechanism of injury, breathlessness, stroke, loss of consciousness, burns, bleeding etc. are triaged as very urgent AMBER patients to be seen within 10 min. Based on their discriminators and TEWS the remaining cases are triaged as either urgent YELLOW patients to be seen within 60 min and routine GREEN patients to be seen within 4 h [9].

In this study, we derived and validated simple triage scores from a clinical database collected in a low-resource hospital in sub-Saharan Africa over several years and compared them with the ability of TEWS to identify the largest number of patients with the lowest in-hospital mortality.

Methods

Study design

A retrospective observational study carried out as part of an on-going quality improvement project.

Setting

The 46-bed medical ward and admission unit of St. Joseph's Kitovu Health Care Complex, is part of a 248 bedded low-resource healthcare facility located near Masaka, Uganda, 140 km from the capital city of Kampala. Together with the 330 bed Masaka Regional Referral Government Hospital, it serves Masaka Municipality (population of 79,200) and Masaka District with a rural population of 804,300.

Participants

All consecutive medical patients admitted during the study period and re-assessed at least once after admission. A detailed description of the common symptoms, signs and diagnoses of patients admitted to this unit has been reported [10].

Data collection

From July 15th 2016 to December 24th 2019, the clinical status and vital signs of every patients admitted to the hospital's medical unit were entered on admission into a clinical data management and decision support system (Rapid Electronic Assessment Data System (READS) Tapa Healthcare DAC). Data entry into the READS system was automatically time and date stamped: there was no missing data as it was impossible to complete a READS assessment without entering all the data required, or to enter values that was outside a plausible range, or to close the assessment without entering the patient's condition at hospital discharge (i.e. dead or alive).

All patients were initially assessed in the emergency department, a one room annex to the medical ward, where a decision to discharge or admit to either the medical or surgical ward was made. All patients arrived at the hospital for emergency assessment, and none arrived by appointment or electively. No patients admitted to the medical ward were excluded from the study: patients who had suffered from recent trauma were admitted to the surgical ward and, therefore, were not included. After admission to hospital all patients were assigned a study number: those with an odd number were placed in the derivation cohort and those with an even number in the validation cohort. Therefore, both cohorts were assessed and managed by the same clinical staff, at the same time with the same resources.

The READS bedside assessment requires that the patient's contemporaneous mental status, functional status and complaints be entered each time the vital signs are measured [11]. Any patient who was not alert, attentive, calm, and coherent was considered to have an altered mental status. Impaired mobility on presentation was defined as lack of a stable independent gait when first assessed and, therefore, included all patients who had an unstable gait, needed help to walk or needed a wheelchair, or were bedbound. No attempt was made to determine if changes in mental status and mobility were recent or chronic or identify their possible causes. Patients with a stable independent gait scored zero TEWS points, those who needed help to walk or required a wheelchair scored one TEWS point, and those who were bedridden scored two TEWS points [4]. Vital signs were considered normal if they were within the ranges regarded as score zero in the National Early Warning Score (NEWS) points. NEWS [12] is a well-validated and widely used predictor of imminent mortality and assigns a score zero to any vital sign value that has the lowest association with death within 24 h (i.e. respiratory rate 12–20 bpm, oxygen saturation ≥ 96%, temperature 36.1–38 °C, systolic blood pressure 111–219 mm Hg, and heart rate 51–90 bpm).

Data analysis

Regardless of presentation ≥7 TEWS points identifies "Emergency" triage level, 5–6 points "Very Urgent", 3–4 points "Urgent", and 0–2 points the need for "Routine" care [4]. The three components of TEWS (i.e. mental status, mobility, and vital signs) were individually tested to determine in what proportion of patients they were abnormal and the association of these abnormalities with in-hospital mortality. The unadjusted odds ratios of mortality for each component was then adjusted for the others by logistic regression to determine if all three remained significantly associated with mortality. These three components were then tested to determine the combination that identified the largest number of patients with the lowest in-hospital mortality. Initially vital signs were defined in these models as either normal or abnormal, and then by a process of trial and error the threshold value of each vital sign that converted it into the optimal predictor of mortality was determined.

Statistical methods

All calculations were performed using Epi-Info version 6.0 (Center for Disease Control and Prevention, USA). The p value for statistical significance was 0.05 and was tested using Student's *t*-test and Chi square analysis that applied Yates continuity correction. Logistic regression analysis was performed using Logistic software [13]. The c statistic was used to assess the discrimination of predictive models according to the method of Hanley and McNeil [14].

Ethical approval

Ethical approval of the study was obtained from the Scientific Ethics Committee Kitovu Hospital, which conformed to the principles outlined in the Declaration of Helsinki [15]. Since no interventions were additional to the usual standard of care the need for written consent was waived. The study is reported in accordance with the STROBE statement [16].

Results

During the study period 4482 patients were admitted to hospital for an average length of stay of 4.2 SD 3.2 days (IQR 2–5 days), and 277 (6.2%) of them died while in hospital. The mean patient age was 48.5 SD 22.9 years (IQR 28–69 years) and 2024 (45.2%) were male. Patients who died in hospital were older than survivors (56.8 SD 22.7 versus 48.0 SD 22.8 years, $p < 0.0001$). Both the derivation and validation cohorts contained 2241 patients, and there was no significant differences in age (48.4 SD 23.3 versus 48.6 SD 22.7 years), male gender (45.5% versus 44.8%), length of hospital stay (4.1 SD 3.1 versus 4.3 SD 3.3 days), or in-hospital mortality (5.8% versus 6.6%).

Derivation of score models

The three components of TEWS (i.e. mental status, mobility, and vital signs) were individually tested in the derivation cohort to determine in how many of the total 2241 patients they were normal and abnormal. The highest odd ratios for in-hospital mortality were for abnormal alertness and impaired gait. All these values were statistically significant. When adjusted for mental status and mobility by logistic regression all vital sign abnormalities remained significantly associated with in-hospital mortality (Table 1).

Simple predictive models of in-hospital mortality were constructed that assigned one point to altered mental status, one point to impaired mobility and one point to any vital sign abnormality, so that a total score of zero identified the patients in which all components of the model were normal (Table 2). The model which included impaired alertness, impaired mobility and an abnormal temperature had the highest proportion of patients with a score of zero (47.1% of the total). In contrast, patients with normal systolic blood pressure, normal alertness and normal mobility had the lowest proportion of the total patients (32.7%) and the highest in-hospital mortality (1.0%). The model of oxygen saturation, alertness and mobility had the highest ratio between the proportion of total patients with a score or zero and the in-hospital mortality of zero point patients: 5 (0.5%) of 999 (44.6% of all patients) died (i.e. percent zero point patients to zero point patient mortality ratio of 89.2). The models with the highest c statistic for discrimination were those using oxygen saturation, temperature, and respiratory rate (Table 2).

Models that awarded one point for alertness, one point for mobility and one point for every vital sign value were tested to find the threshold value for each vital sign for which a score of zero captured the most patients with the lowest mortality (i.e. the highest percent zero patients to zero patient mortality ratio). Of the six model, the one that used an oxygen saturation <94% and the one that used a respiratory rate >23 bpm had the highest percent zero patients to zero patient mortality ratio, and comparable discrimination (Table 3).

Validation of models

All six models had comparable discrimination in the derivation and validation cohorts, apart from the model using temperature <36 °C. In both the derivation and validation cohorts the oxygen saturation <94% model, respiratory rate >23 bpm model and TEWS consistently had the highest c statistics (Table 4). For the oxygen saturation score, the respiratory rate score and TEWS there was no statistical difference between the derivation and validation cohorts in the proportion of patients with each point of the score and the in-hospital mortality rates associated with each point (Fig. 1). Both scores and TEWS had a sensitivity of 0.95 or more and a negative predictive value > 0.99, and an increase in each of the three scores was associated with similar (but not always statistically the same) proportions of patients and similar in-hospital mortality rates. In-hospital mortality increased linearly in both cohorts as the points for all three scores increased.

The proportion of patients with zero points for the oxygen saturation model, respiratory rate model and TEWS <3 points were 51%, 45%, 49% for the derivation cohort and 49%, 44%, and 48% for the validation cohort, respectively. The in-hospital mortality rate for patients with zero points for the oxygen saturation model, respiratory rate model and TEWS <3 points were 0.5%, 0.5%, 0.6% for the derivation cohort and 1.0%, 0.8%, and 1.0% for the validation cohort, respectively.

Discussion

Main findings

This study identified two easy to calculate scores with a comparable performance to TEWS at identifying the largest number of patients with the lowest in-hospital mortality. One requires the measurement of oxygen saturation and the other respiratory rate, and both require the assessment of mental status and mobility. The information needed for both scores can be quickly and easily obtained at the bedside at no additional cost.

Strengths and weaknesses

We studied an unselected cohort of consecutive medical patients admitted to a low resource hospital in sub-Saharan African using a system that eliminated the possibility of missing data. The derivation and validation cohorts were identical and concurrent and, therefore, could not have been influenced by seasonal variations of diseases such as malaria, or temporal variations in treatments according to drug, antibiotic, and other resource availability.

The main weaknesses are that this was a retrospective single centre study confined to medical patients admitted to hospital and follow-up after hospital discharge was not possible, so the number of patients who may have died after discharge is unknown. Furthermore, we did not consider the causes of changes in mental status or mobility, or whether they were acute or chronic. Although no major trauma patients were included, 10% had chest pain, 9% were short of breath, 9% has loss of consciousness, 8% had diabetes, 6% a stroke, 3% were bleeding, and 3% were poisonings or overdoses [10]. Many of these patients would, therefore, have been considered as very urgent AMBER patients by SATS.

Interpretation

Inclusion of our scores into SATS as a replacement for TEWS will need further evaluation and validation. It remains to be seen if low cadre staff in low resource and other settings will find them easier and quicker to use than TEWS, and less prone to error. Validation of a triage system is inherently problematic and based on limited scientific evidence [17–19]. Most validation studies have used either the utilisation of

Table 1
Derivation cohort's unadjusted odds ratios for in-hospital mortality of abnormalities in mental status, mobility, and vital signs, and odds ratios for vital signs adjusted for mental status and mobility.

Abnormal variable	Number of normal patients (%)		Normal patient deaths (%)		Unadjusted odds ratio (95% CI)		Odds ratio adjusted for mobility and mental status (95% CI)	
Impaired mental status	2067	(92.2%)	85	(4.1%)	7.89	(5.14–12.11)	–	
Impaired mobility	1345	(60.0%)	17	(1.3%)	11.16	(6.46–19.52)	–	
Oxygen saturation <96%	1522	(67.9%)	45	(3.0%)	4.34	(2.93–6.44)	3.08	(2.08–4.55)
Respiratory rate <12 or >20 bpm	1159	(51.7%)	30	(2.6%)	3.79	(2.44–5.91)	3.04	(1.98–4.68)
Heart rate <51 or >90 bpm	1310	(58.5%)	47	(3.6%)	2.60	(1.76–3.83)	2.09	(1.42–3.07)
Temperature <36.1 or >38.0 °C	1763	(78.7%)	71	(4.0%)	3.29	(2.24–4.82)	3.28	(2.23–4.83)
Systolic blood pressure <111 or >219 mm Hg	1243	(55.5%)	53	(4.3%)	1.85	(1.27–2.71)	2.04	(1.39–2.98)

Table 2
Derivation cohort models that awarded one point to altered mental status, one for impaired mobility and one point for any vital sign outside the normal range according to the ratio of patients (%) with zero points to the mortality rate (%) of patients with zero points; bpm = beats or breaths per minute.

Models assigned one point for altered mental status, one for impaired mobility and one for an abnormal vital sign	Number of patients with zero points (%)		Number of zero points patient deaths (%)		Zero points to zero points mortality ratio	C statistic (95% CI)		
Model with mental status, mobility and								
Temperature <36 or >38 °C	1056	(47.1%)	6	(0.6%)	78.5	81.8%	(77.3%	86.3%)
Oxygen saturation <96%	999	(44.6%)	5	(0.5%)	89.2	82.1%	(77.6%	86.6%)
Heart rate <50 or >90 bpm	832	(37.1%)	5	(0.6%)	61.8	80.2%	(75.5%	84.8%)
Respiratory rate <12 or >20 bpm	752	(33.6%)	4	(0.5%)	67.2	81.0%	(76.5%	85.6%)
Systolic blood pressure <110 or >219mm Hg	733	(32.7%)	7	(1.0%)	32.7	78.5%	(73.7%	83.2%)

Table 3
Derivation cohort models that awarded one point to altered mental status, one for impaired mobility and one point for a vital sign value that captured the most patients with the lowest mortality (i.e. the highest percent zero score patients to zero score patient mortality ratio). The models ranked according to the zero score patients to zero score patient mortality ratio. Apart from TEWS each model had a maximum of 3 points: one point was awarded for impaired alertness, one for impaired mobility, and one for a vital sign abnormality. bpm = beats or breaths per minute.

Models assigned one point for altered mental status, one for impaired mobility and one for an abnormal vital sign	Number of patients with zero points (%)		Number of zero points patient deaths (%)		Zero points to zero points mortality ratio	C statistic	(95% CI)	
Model with mental status, mobility and								
Oxygen saturation <94%	1153	(51.45%)	6	(0.52%)	99	83.0%	(78.5%	87.4%)
Respiratory rate >23 bpm	1017	(45.38%)	5	(0.49%)	93	82.1%	(77.6%	86.5%)
Heart rate >88 bpm	777	(34.67%)	3	(0.39%)	89	80.0%	(75.4%	84.7%)
Temperature <36 °C	1182	(52.74%)	7	(0.59%)	89	82.3%	(77.8%	86.7%)
TEWS ≥ 3[a]	1108	(49.44%)	7	(0.63%)	78	82.7%	(78.3%	87.2%)
Systolic blood pressure <100 mm Hg	1040	(46.41%)	7	(0.67%)	69	80.1%	(75.5%	84.8%)
Temperature >37.8 °C	1291	(57.61%)	15	(1.16%)	50	79.1%	(74.4%	83.8%)

[a] A TEWS of 0–2 points was equivalent to zero points.

Table 4
Discrimination of models that awarded one point to altered mental status, one for impaired mobility and one point for the vital sign value shown. The models that used an oxygen saturation <94% or a respiratory rate >23 breaths per minute had the highest c statistics in both the derivation and validation cohorts. Although a temperature < 36 °C had a high c statistic in the derivation cohort, it was much lower in the validation cohort. bpm = breath or beats per minute.

Models assigned one point for altered mental status, one for impaired mobility and one for an abnormal vital sign	Derivation cohort			Validation cohort		
	C statistic	(95% CI)		C statistic	(95% CI)	
Model with mental status, mobility and						
Oxygen saturation <94%	83.0%	(78.5%	87.4%)	81.3%	(77.0%	85.6%)
Respiratory rate >23 bpm	82.1%	(77.6%	86.5%)	81.4%	(77.1%	85.6%)
Heart rate >88 bpm	80.0%	(75.4%	84.7%)	79.5%	(75.1%	83.9%)
Temperature <36 °C	82.3%	(77.8%	86.7%)	77.6%	(73.1%	82.1%)
Systolic blood pressure <100 mm Hg	80.1%	(75.5%	84.8%)	78.4%	(73.9%	82.9%)
Temperature >37.8 °C	79.1%	(74.4%	83.8%)	78.5%	(74.0%	82.9%)
TEWS	82.7%	(78.3%	87.2%)	83.3%	(79.2%	87.4%)

resources or a patient outcome, such as mortality, as a proxy metric [17]. However, the clinical usefulness of a triage classification cannot be solely assessed by these things. An efficient triage process should deliver the best care with the minimum waste. This is especially true in clinical settings with limited resources so that clinicians with the most expertise are quickly directed to those patients who need it most.

Clinical applicability

This study highlights the prognostic value of mental status [20,21], mobility [22,23] and vital signs [24,25]. In a prospective multicentre study acutely ill patients from Switzerland, Denmark and Uganda with normal vital signs and mobility had the same low in-hospital mortality [26]. Moreover, almost none of the patients attending Danish and Swiss emergency departments who were able to walk independently and had normal vital signs died within a year [27]. A study that compared several early warning scores in our hospital found that the best performing early warning scores all assessed alertness, mobility, and vital signs [28].

Calmness, alertness, and ability to engage in a coherent conversation can be quickly assessed, as can the ability to walk with a stable independent gait. However, we do not know if they can be reliably determined with a high interobserver agreement [29]. Although the assessment of mental status is used by many early warning scores, its reliability has been questioned [30]. Similarly, the intra- and interobserver variability of mobility assessment requires further study [31].

Although many healthcare settings now regularly use early warning scores based on a full set of vital signs for risk assessment and to trigger the escalation of care [32], vital signs measurements are not a universal feature of all triage systems, and frequently not required for triaging the most emergent and urgent patients. Iversen et al., for example, have reported that simply "eyeballing" the patient triages more efficiently than the formal procedures of the Danish triage system that uses a complex algorithm based on the primary complaint and a full set of vital signs [33]. The Emergency Severity Index only mandates vital sign measurement for patients likely to require multiple resources to deliver their care [34], and vital sign measurement and the calculation of TEWS is only the final part of the SATS triage process. Both scores identified by

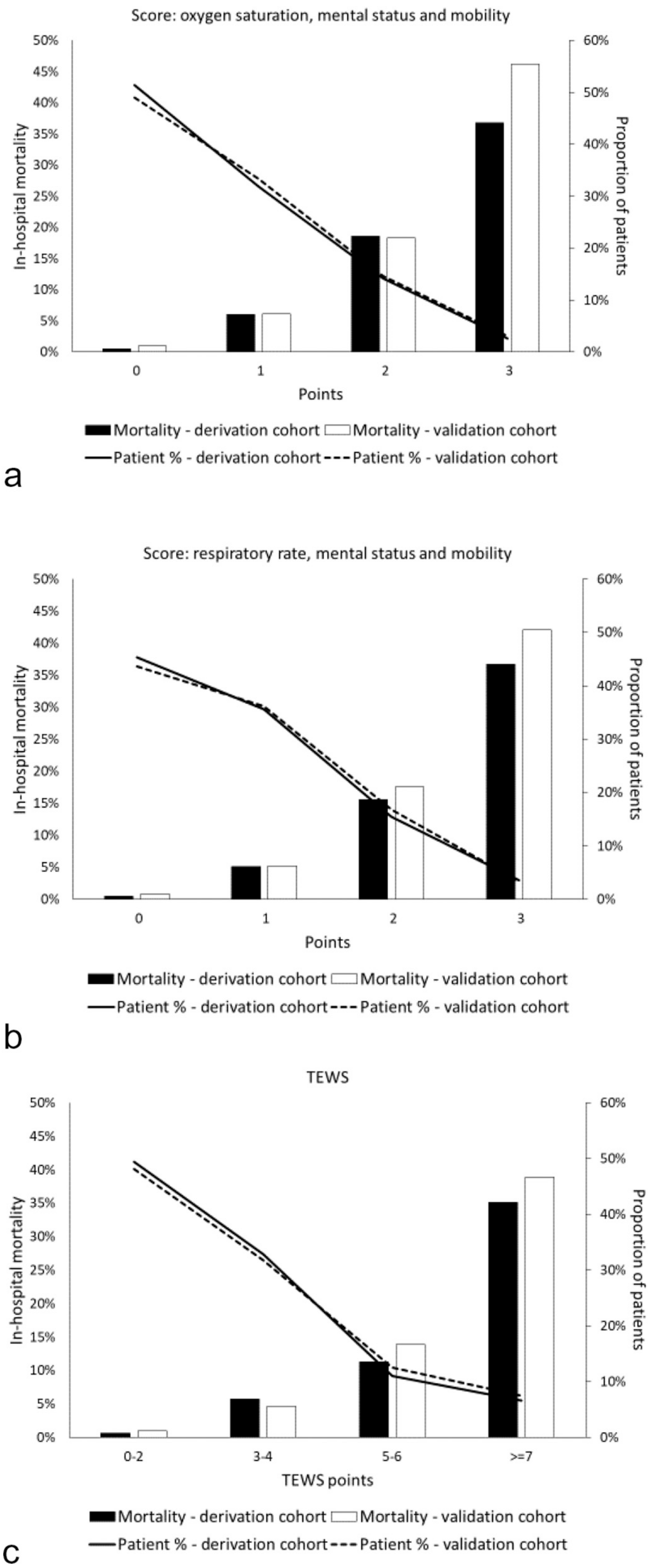

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Fig. 1. a: The proportion of total patients and the in-patient mortality associated with the derivation and validations cohorts for the Mental status, Mobility and Oxygen saturation < 94% score. There was no statistical difference between the derivation and validation cohorts in the proportion of patients with each point of the score and the in-hospital mortality rates associated with each point. In-hospital mortality increased linearly in both cohorts as the score points increased.
b: The proportion of total patients and the in-patient mortality associated with the derivation and validations cohorts for the Mental status, Mobility and Respiratory rate >23 breaths per minute score. There was no statistical difference between the derivation and validation cohorts in the proportion of patients with each point of the score and the in-hospital mortality rates associated with each point. In-hospital mortality increased linearly in both cohorts as the score points increased.
c: The proportion of total patients and the in-patient mortality associated with the derivation and validations cohorts for the Triage Early Warning Score (TEWS). There was no statistical difference between the derivation and validation cohorts in the proportion of patients with each range of points score and the in-hospital mortality rates associated with each range of points. In-hospital mortality increased linearly in both cohorts as the TEWS points increased.

this study do not require a complete set of vital signs and can be simply expressed as: is the patient walking and talking with either an oxygen saturation ≥ 94% or a respiratory rate ≤ 23 breaths per minute? The purpose of these scores is to rapidly identify patients who need urgent care: once identified a complete set of vital signs will become an essential part of their management. Unfortunately, in many low resource settings complete sets of vital signs are often not performed [35,36] and/or cannot be measured because the equipment required was not available [35,37].

The use of oxygen saturation as part of the triage process has frequently been recommended [38–40]. A systematic literature review of triage systems found oxygen saturation to be one of the three variables, along with age and level of consciousness, that best predicted mortality during hospitalization [18]. However, as far as we know, this is the first report to directly compare its performance with all the other vital signs in a low-resource setting. In the past it has been suggested that oximetry is unaffordable, but this is no longer true. Cheap (~US$20), accurate and robust pulse oximeters are now easily available. Oximeters also provide an estimate for heart rate, but these readings may not be accurate, especially in patients with tachycardia [41]. In contrast, respiratory rates can be accurately measured by a free mobile phone app that can now be widely accessed throughout sub-Saharan Africa [42].

In a low resource setting the principal purpose of triage is to prioritize patient evaluation and not to make disposition or management decisions. Neither of our scores can give as much insight into the patient's underlying condition and treatment required as a full set of vital signs. For example, hypotension and tachycardia suggest hypovolemia; tachypnea, temperature and hypoxia imply pneumonia; and hypoxia and bradypnea over sedation. Nevertheless, low oxygen saturation, increased respiratory rate and impaired alertness should trigger immediate interventions such as supplemental oxygen, checking the blood sugar level, lying the patient on their left side and not letting them eat or drink [43].

Conclusion

This study identified two easy to calculate scores based on mental status, mobility and either oxygen saturation or respiratory rate. Both have a comparable performance to TEWS and, therefore, could replace it to facilitate the adoption of SATS in low-resource settings.

Dissemination of results

Results from this study have been shared with staff members at the data collection site. This study is part of an ongoing quality improvement project by the Kitovu Hospital Study Group, which is now addressing the hospital's triage process by staff education and ongoing audit cycles.

Authors' contribution

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: L W-K and JK contributed 20% each; and PN, IN, JN and TN contributed 15% each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

CRediT authorship contribution statement

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Declaration of competing interest

All costs were borne by the authors. John Kellett is a major shareholder, director, and chief medical officer of Tapa Healthcare DAC. The other authors have no potential conflicts of interest.

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