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Is the Kampala Trauma Score an Effective Predictor of Mortality in Low-Resource Settings? A Comparison of Multiple Trauma Severity Scores

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Abstract
Background In the developed world, multiple injury severity scores have been used for trauma patient evaluation and study. However, few studies have supported the effectiveness of different trauma scoring methods in the developing world. The Kampala Trauma Score (KTS) was developed for use in resource-limited settings and has been shown to be a robust predictor of death. This study evaluates the ability of KTS to predict the mortality of trauma patients compared to other trauma scoring systems.
Methods Data were collected on injured patients presenting to Central Hospital of Yaoundé, Cameroon from April 15 to October 15, 2009. The KTS, Injury Severity Score, Revised Trauma Score, Glasgow Coma Scale, and Trauma Injury Severity Score were calculated for each patient. Scores were evaluated as predictors of mortality using logistic regression models. Areas under receiver operating characteristic (ROC) curves were compared.
Results Altogether, 2855 patients were evaluated with a mortality rate of 6 per 1000. Each score analyzed was a statistically significant predictor of mortality. The area under the ROC for KTS as a predictor of mortality was 0.7748 (95 % CI 0.6285–0.9212). There were no statistically significant pairwise differences between ROC areas of KTS and other scores. Similar results were found when the analysis was limited to severe injuries.
Conclusions This comparison of KTS to other trauma scores supports the adoption of KTS for injury surveillance and triage in resource-limited settings. We show that the KTS is as effective as other scoring systems for predicting patient mortality.

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Introduction

Injury accounts for an estimated 5.8 million deaths worldwide every year, with more than 90 % occurring in low- and middle-income countries [1–4]. Multiple scoring systems for injury severity have been developed and validated for use in tracking and scoring patients presenting with traumatic injuries. Decades worth of data in trauma registries led to the development of several systems, including the Revised Trauma Score (RTS), Injury Severity Score (ISS), and the TRISS methodology [5–7]. The ISS relies on the six-point Abbreviated Injury Scale (AIS) in six body regions. The RTS is based on the respiratory rate, systolic blood pressure, and Glasgow Coma Score (GCS). TRISS is based on a combination of the ISS, RTS, and patient age.

Although there are evidence-based proponents of both consensus-based scoring systems and database-derived probabilistic models, most studies have consistently shown little if any difference in their predictive power of mortality [8–10]. Furthermore, these scores have not been validated for use in the developing world, where the burden of injury is the highest. Several studies have demonstrated that they, in fact, underpredict mortality in resource-limited settings [11–16]. This discrepancy in predictive value between developed and developing settings likely results from the fact that scores are developed in and for resource-rich settings. In particular, coefficient-based scoring systems such as RTS and TRISS have been derived from outcomes in large trauma registries. Unfortunately, such databases are in their infancy in the developing world, and so similar analysis for the development of scoring systems is not yet possible.

In response to these findings, the Kampala Trauma Score (KTS) was developed and tested in 2000 by Kobusingye and Lett [17] to create an injury severity score for resource-limited settings that requires minimal data collection and recording. KTS—which relies on a patient's number of serious injuries, age, systolic blood pressure, respiratory rate, and neurologic status—was shown to be highly predictive of the need for admission or death. The total KTS ranges from 5 to 16, with lower scores indicating more severe injury. The scoring rubric for the KTS is shown in Table 1. KTS was shown to be a robust predictor of death in a study that retrospectively applied KTS to a cohort of 150 trauma patients, achieving statistical performance comparable to that of RTS, ISS, and TRISS [18]. KTS has further been shown prospectively to be a reliable severity filter for injured patients but was not compared to other injury scores to assess comparative utility [19]. Consequently, although KTS has been shown to have potential to replace other scoring systems in resource-limited settings, the literature supporting the utility of this tool over others is currently limited to retrospective analysis and small cohorts. It is important to assess the utility and comparative performance of KTS as a triage tool in a large patient cohort, particularly as some studies and hospital trauma registries have already adopted its use [20–22].

This study aimed to compare five trauma severity scores as predictors of mortality in a large patient cohort from the emergency department of a teaching and referral hospital in Cameroon. According to the World Health Organization, injuries in Cameroon, a country in west Central Africa, cost the loss of 16,000 lives annually [23]. Additionally, patterns of age, sex, and mechanism of injury are similar to reports from other countries from the same geographic region [24], suggesting that results from a study conducted there might be applicable to a larger population in sub-Saharan Africa. We performed head-to-head analysis of KTS to scoring systems previously validated in the developed world. The results led us to make an argument for the adoption of KTS for injury surveillance and triage in resource-limited settings.

Table 1 Components of the Kampala Trauma Score

Component	Score
Age (years)	
5–55	2
<5 or >55	1
Systolic blood pressure (mmHg)	
>89	4
50–89	3
1–49	2
Undetectable	1
Respiratory rate (/min)	
10–29	3
>30	2
<9	1
Neurologic status	
Alert	4
Responds to verbal stimuli	3
Responds to painful stimuli	2
Unresponsive	1
Serious injuries	
None	3
1	2
≥2	1
Total score	5–16

Methods

This study analyzed prospective data collected in the Emergency Department (ED) of the Central Hospital of Yaoundé, a 500-bed teaching and referral hospital that handles the largest trauma volume in the capital city of Cameroon [24]. The hospital serves an estimated 1.5 million inhabitants and accepts patients 24 h a day. Injured patients are received in the ED and are either cared for and discharged home, admitted to the general ward or the intensive care unit (ICU), or transferred to the operating room or another facility. The ED has eight medical beds and six surgical beds, but patients are often housed on the floor. Triage is conducted by the front-desk nurse, and treatment is given by resident and staff physicians.

Physicians staffing the emergency room are not specifically trained in this field as emergency medicine is not yet available as a residency track in Cameroon. Although the hospital operates a small ambulance service, the majority of patients arrive at the hospital via private or commercial vehicles, such as buses, taxis, or other public transportation [24].

Patients of all ages admitted for traumatic injuries, as defined by the World Health Organization's Injury Surveillance Guidelines [25], to our ED between April 15 and October 15, 2009 were asked to participate in a pilot trauma registry. There were no exclusion criteria. Collected data from consented patients consisted of demographic information and details of the injury context, clinical presentation, care, and outcome. Demographic information included age, sex, residence, education, occupation, and a number of socioeconomic indicators. The injury context was defined by the geographic location and activity at the time of injury and the mechanism of injury. The clinical presentation included the body region and nature of the most severe injury as well as components required for calculating injury severity scores—e.g., blood pressure, respiratory rate, neurologic status, AIS—for each of six anatomical regions. The AIS was estimated using previously described methods that rely on clinical assessment and the diagnosis assigned by the attending physician [18, 26]. These estimated AIS scores were used to calculate the ISS. Physicians and clinical research staff together performed most of the injury scoring after the diagnosis was determined. Six full-time and three part-time research associates had undergone extensive training prior to the study start date in didactics and practical experience recording clinical information in a trauma setting. At least one of these research associates was available in-house 24 h a day, 7 days a week. This full-time research staff was necessary for complete data capture for our study, given the potential inconsistencies and incompleteness of clinical record-keeping in this resource-limited setting.

Data were captured via a surveillance form, entered into Excel, and imported into Stata version 11.0 statistical software for analysis. Injuries classified as gunshots, animal bites, or stabs/cuts were classified as penetrating. All other injuries were considered blunt trauma. For each patient, The KTS, ISS, RTS, and GCS were calculated and recorded. TRISS was retrospectively calculated based on data collected and following the probability equation:

$$Ps = 1/\left(1 + e^{-b}\right)$$

where b is the $b_0 + b_1$ (RTS) + b_2 (ISS) + b_3 (age index) [5]. The age index is defined as 0 if the age is <55 years and 1 if the age is ≥55 years—the weighted coefficients for new outcome norms [7]. Injury scores were evaluated as predictors of mortality using logistic regression models and analysis of areas under the receiver operating characteristic (ROC) curve (AUC). Scores were also assessed with Akaike information criteria as well as Pearson's χ^2 goodness-of-fit test. The AUCs were then calculated based on nonparametric assumptions. ROC curves assess the overall discriminatory performance of a score, whose results are expressed as a continuous variable, assuming that sensitivity and specificity are equally important [27]. The AUCs along with 95 % confidence intervals (CI) were compared between KTS and the other four scores in pairwise fashion. The statistical tool used in the Stata software program utilizes the nonparametric jackknife method of DeLong et al. [28]. A value $p < 0.05$ was considered statistically significant.

The study was conducted in collaboration with the Cameroon Ministry of Health. The study was approved by the National Ethics Review Committee in Cameroon and the institutional review board of Johns Hopkins School of Public Health in the United States.

Results

A total of 2,855 trauma patients were enrolled in the study, representing 91 % capture of patients presenting with traumatic injuries to the ED during the study time period. Overall, 73 % of patients were male; and 60 % presented after a road traffic injury. The median age was 28 years with an interquartile range (IQR) of 22 to 38 years. ISS classification was mild (<9) for 60 % of patients, moderate (ISS 9–15) for 29 %, severe (ISS 16–24) for 8 %, and profound (ISS >24) for 3 % (Table 2). The mortality rate was 6 per 1,000. Stratified by ISS score, the mortality rate was 5 per 1000 for ISS scores <9 ($n = 1{,}686$), 4 per 1,000 for ISS scores from 9 to 15 ($n = 797$), 15 per 1,000 for ISS scores 16 to 24 ($n = 210$), and 68 per 1,000 for ISS scores ≥25 ($n = 75$). The median age of the patient cohort was 28 years (IQR 22–38). Men comprised 73.2 % of the cohort, and road traffic injuries accounted for 59.8 % of injuries. Other causes of injuries included falls, stab wounds, blunt trauma, animal bites, burns, gunshot wounds, and poisoning.

The data for KTS, ISS, RTS, GCS, and TRISS were complete for 2,472 patients, who were included in the further analysis. These patients did not differ significantly from the full patient cohort when sex, mechanism of injury, injury severity (quantified by ISS), and mortality were compared. Logistic regression models showed each trauma score to be a statistically significant predictor of mortality (Table 3). Analysis using Akaike Information Criteria to evaluate goodness-of-fit showed they are generally predictive for mortality. KTS, ISS, and GCS all showed adequate fit based on Pearson's χ^2 goodness-of-fit test. Models using the RTS and TRISS did not demonstrate similar levels of fit using the Pearson test. The fit of the TRISS model was adequate when the Hosmer–Lemeshow test was used to assess goodness-of-fit (χ^2 6.17; $p = 0.62$). Models for the other scoring systems did not permit the segregation of data into 10 separate bins without ties as is required for validity of the test.

Logistic regression models were used to construct ROC curves for sensitivity and specificity. The greatest AUC was calculated for the ROC curve of KTS, with an AUC of 0.7748 (95 % CI 0.6285–0.9212) (Fig. 1). When compared to the RTS, ISS, TRISS, and GCS in a pairwise fashion (Fig. 2), KTS not only had a greater AUC but had greater sensitivity for a given specificity at all points except one point in the comparison with TRISS. No pair-wise difference between the area under the ROC curve of KTS compared to the other scores was statistically significant ($p > 0.05$ for all) (Table 4).

ROC analysis was also performed on the subset of 244 patients with severe injuries, defined as having an ISS ≥16. As with the more inclusive analysis above, when compared to RTS, ISS, TRISS, and GCS in a pairwise fashion, KTS not only had a greater AUC but had greater sensitivity for a given specificity at all points (Fig. 3). The greatest AUC was calculated for the ROC curve of KTS, with an AUC of 0.9820 (95 % CI 0.9585–1.000). Again, no pairwise differences between ROC areas of KTS and other scores were statistically significant (Table 5).

Table 2 Demographic characteristics of the patient cohort

Characteristic	Data ($n = 2{,}855$)
Age (years)	
Median, range	28 (1–89)
Interquartile range	22–38
Sex	
Male	2071 (73.2 %)
Female	760 (26.8 %)
Missing values	24
Mechanism of injury	
Road traffic injury	1686 (59.8 %)
Fall	211 (7.5 %)
Stab/cut	158 (5.6 %)
Blunt trauma	102 (3.6 %)
Animal bite	97 (3.4 %)
Burn	77 (2.7 %)
Gunshot	22 (0.8 %)
Poisoning	4 (0.1 %)
Other	461 (16.3 %)
Missing values	37
ISS category	
Mild (<9)	1,686 (60.9 %)
Moderate (9–15)	797 (28.8 %)
Severe (16–24)	210 (7.6 %)
Profound (≥25)	75 (2.7 %)
Missing values	87

Results are given as the number and percent unless otherwise noted

ISS Injury Severity Score

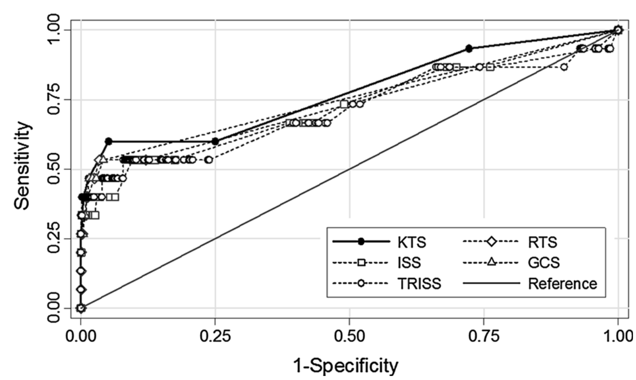

Fig. 1 Comparison of injury scores by mortality receiver operating characteristic (ROC) curves. *KTS* Kampala Trauma Score, *ISS* Injury Severity Score, *TRISS* Trauma Score Injury Severity Score, *RTS* Revised Trauma Score, *GCS* Glasgow Coma Scale

Table 3 Logistic regression analysis of injury scores

Predictive regression model ($n = 2{,}472$)	Odds ratio[a] (95 % CI)	p (Wald test)	Akaike Information Criteria	Pearson's χ^2 test
KTS	0.34 (0.25–0.46)	<0.001	135	8.17 ($p = 0.31$)
RTS	0.35 (0.26–0.49)	<0.001	147	54 ($p < 0.001$)
ISS	1.10 (1.07–1.14)	<0.001	148	25.45 ($p = 0.92$)
TRISS	0.0026 (0.000015–0.0043)	<0.001	133	359 ($p < 0.001$)
GCS	0.61 (0.53–0.68)	<0.001	143	12 (0.36)

CI confidence interval, *KTS* Kampala Trauma Score, *RTS*: Revised Trauma Score, *TRISS* Trauma Score Injury severity Score, *GCS* Glasgow Coma Score

[a] Odds of death per unit change in score

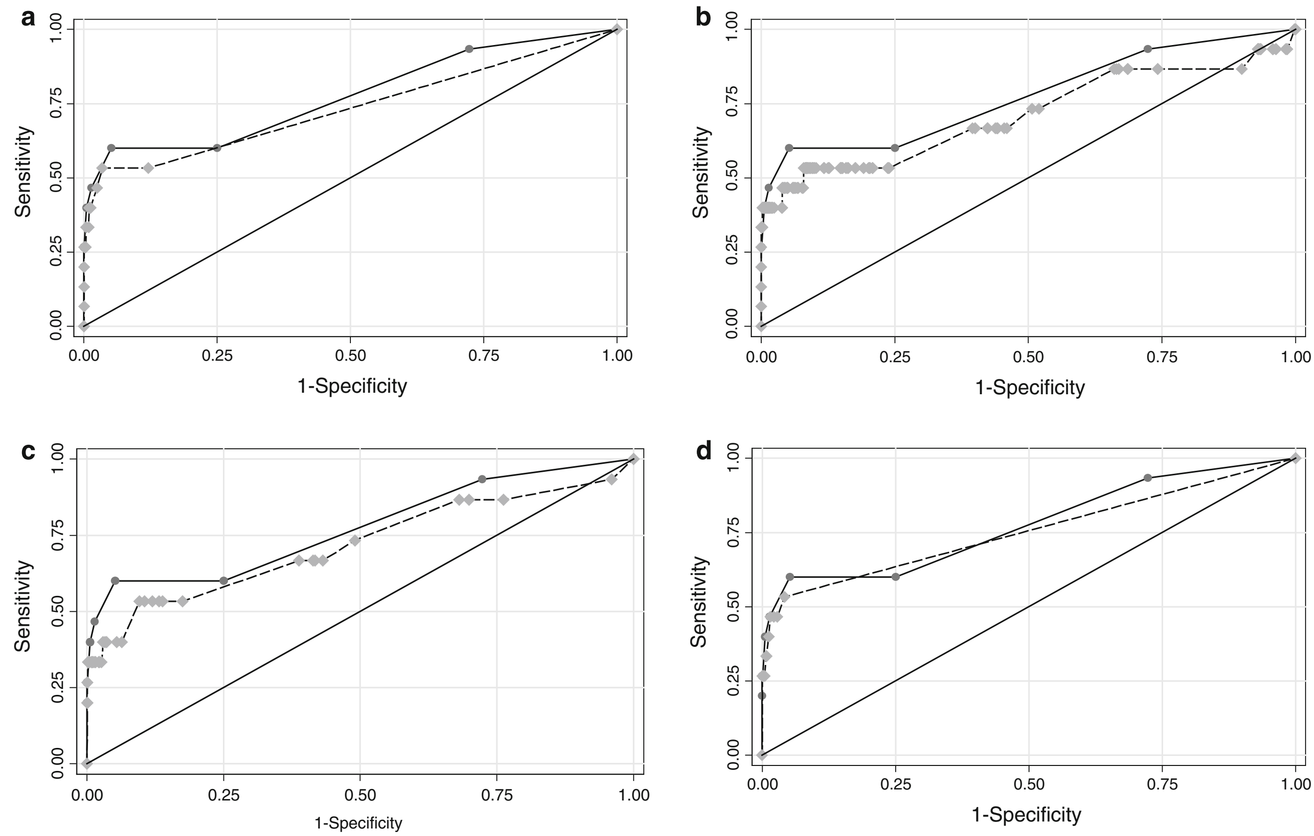

Fig. 2 Pairwise comparison of injury scores by mortality ROC curves. *Dark circles*, *solid line:* KTS ROC; *gray diamonds*, *dashed line:* ROC for RTS (**a**), ISS (**b**), TRISS (**c**), GCS (**d**)

Table 4 Analysis of areas under ROC curves

Test (n = 2,472)	AUC	95 % CI	p
Reference	0.7748	0.6285–0.9212	–
RTS	0.7341	0.5896–0.8786	0.3340
ISS	0.7183	0.5491–0.8885	0.1541
TRISS	0.7117	0.5346–0.8888	0.0816
GCS	0.7525	0.6184–0.8866	0.5863

ROC receiver operating characteristic, *AUC* area under the curve

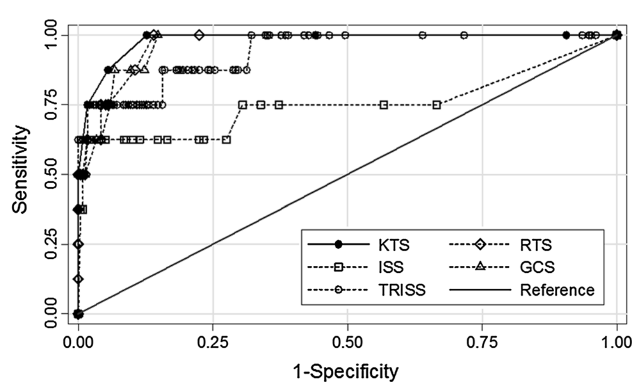

Fig. 3 Injury scores compared using mortality ROC curves, severe injuries (n = 244)

Table 5 Severe injuries: analysis of areas under ROC curves (ISS ≥16)

Score (n = 244)	AUC	95 % CI	p
KTS	0.9820	0.9585–1.000	(reference)
RTS	0.9674	0.9330–1.000	0.1070
ISS	0.7521	0.4925–1.000	0.0608
TRISS	0.9386	0.8566–1.000	0.1589
GCS	0.9658	0.9301–1.000	0.1202

Discussion

The results of this study indicate that KTS is a statistically significant predictor of mortality in a cohort of 2,855 trauma patients in Yaoundé, Cameroon. These results are consistent with previous findings of Kobusingye and Lett [17] and MacLeod et al. [18] in another setting. Furthermore, KTS is as effective a predictor of mortality as ISS, RTS, TRISS, and GCS. More-focused analysis was performed with a subset of severely injured patients given previous work suggesting that cohorts with a large number of mildly injured dilute the power of a prognostic instrument, therefore making comparisons of instruments less accurate [27, 29]. Under this more precise definition of injury (ISS $\geq$16), the performance of KTS persists and even improves.

Prior work by Kobusingye and Lett [17] and MacLeod et al. [18] laid the foundation for establishing the role of KTS in injury severity scoring. The former study demonstrated that KTS was predictive for admission or death, and the latter showed that KTS performed as well as other scoring systems in a patient cohort of 150 severely injured patients. This study reinforces their findings in a larger patient cohort of 2,855 patients, as the logistic regression model for mortality showed KTS to be a predictor of mortality, with adequate fit based on evaluation of goodness-of-fit using Akaike Information Criteria and Pearson's χ^2 test.

Furthermore, using the definition of severe injury employed by MacLeod et al. [18], the Yaoundé study population yielded a sample of 244 patients to which to apply this methodology for subgroup analysis. Again, this study's findings confirm the performance of KTS as a scoring system for this subset of patients in a larger sample and a different study context, suggesting greater generalizability of KTS than the initial studies may have indicated.

As in most low- and middle-income countries in sub-Saharan Africa, Cameroon lacks an established prehospital care service, and patients frequently arrive at the hospital on foot or via private vehicles. It has been previously noted that hospital-based studies in resource-limited settings often underestimate the magnitude of fatal injuries [30]. It is therefore likely that our patient cohort represents only a percentage of the injured patients in the area, with a possible selection bias toward less severely injured patients, as those who died on scene or shortly thereafter often do not present to the hospital. However, as our demographics are markedly similar to other large trauma studies in the developing world with respect to age, sex, mechanism of injury, and injury severity, we assume that this patient cohort is representative of the patients who present to the hospital setting and may be therefore applicable to other hospital settings in sub-Saharan Africa or the developing world.

Although the KTS has repeatedly been shown to be a predictor of mortality, one limitation of our work is that interrater reliability and accuracy of KTS has not yet been established. This important question and the evaluation of KTS utility in different settings were beyond the scope of our study and merit future work. Additionally, the TRISS coefficients, which form the basis of one of the scores used for comparison, are based on high-income country data that are more than a decade old. Thus, the applicability of these coefficients in a modern but resource-limited setting is unclear. Although this scoring system has not been updated in some time and, as with the other scores compared in this study, was designed in developed countries, we wanted to compare KTS to existing scoring systems that have a proven record and whose validity has been extensively studied.

Other avenues of interest for future inquiry include developing coefficient-based scoring systems for the developing world that draw on the power of large trauma registries as has been done in the developed world. Given the current limitations of clinical record-keeping in many settings, this remains challenging. A final limitation of our work is that scoring of ISS was done in an estimated method as previously described [18, 26]. Given the limited imaging resources and the scope of the study, which was limited to ED disposition, full imaging studies and operative findings are not reflected in the diagnoses on which the ISS was estimated. The reliance on a final diagnosis is a limitation of the ISS in this setting and underscores its retrospective nature. Again, this limitation would be diminished by a trauma registry-based study that could follow patients throughout their hospital stay and follow-up.

As Kobusingye and Lett detailed in their original presentation of KTS, the importance of a simple score for trauma surveillance in sub-Saharan Africa cannot be understated. Most hospitals are understaffed, and even basic record-keeping is given a low priority, ICD codes are not in use, and routinely collected data often exclude information on the severity of injuries [17, 31]. The importance of measuring injury severity is critical if data are to be used to determine priorities and the allocation of scarce resources.

Trauma scoring systems are routinely used in high-income countries to drive quality improvement and research agendas [5, 6]. As injuries are increasingly recognized as a leading source of morbidity and mortality in developing countries, context-specific research is necessary to identify opportunities for prevention and improved treatment [32]. An appropriate injury severity scoring system is an essential component to scientific study of trauma [18]. Additionally, as trauma systems mature in low-resource settings, inexpensive and readily available scoring systems will be integral to establishing performance improvement programs to guide improvements in patient care. KTS is a simple score that can be incorporated by emergency room staff into routine protocols, an essential step for hospital-based surveillance to succeed [33].

Conclusions

This analysis of KTS comparing it to several trauma scores from the developed world supports the potential adoption of KTS for injury surveillance and triage in resource-limited settings. As injury severity scores are a necessary tool for evaluating patient care and establishing institutional quality improvement and research practices, it is important to develop and validate scoring systems for use in the developing world. We show that the KTS is as effective as other scoring systems in predicting patient mortality. It is simple to administer and record and therefore is a potentially valuable tool available for resource-limited settings.

Conflict of interest The authors have no potential or real conflicts of interest to report.

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