African Journal of Emergency Medicine 13 (2023) 287–292

Contents lists available at ScienceDirect

African Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/afjem

Original article

The value of shock index, modified shock index and age shock index to predict mortality and hospitalisation in a district level emergency centre

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ARTICLE INFO

Keywords:
Emergency medicine
Triage
Shock index
Patient outcomes
Mortality

ABSTRACT

Introduction: Triage is the most important step in patients' journey through an Emergency Centre (EC) and directly impacts time to critical actions. Triage tools, like the South African Triage Scale, are however not designed to predict patient outcomes. The shock index (SI), modified shock index (MSI) and age shock index (ASI) are clinical markers derived from vital signs and correlate with tissue perfusion in critically ill patients. This study aimed to assess the value of SI, MSI and ASI to predict mortality and the need for hospitalisation in all adult patients presenting to a district level emergency centre in South Africa.

Methods: This diagnostic study was performed as a retrospective observational study, using data from an existing electronic registry at a district level hospital emergency centre over a period of 24 months. All adult patients who presented to Mitchells Plain Hospital were eligible for inclusion. Sensitivity, specificity and likelihood ratios were calculated for each variable as a predictor of mortality and hospitalisation with pre-determined thresholds.

Results: During the study period of 24 months, a total of 61 329 patients ≥ 18 years old presented to the EC with 60 599 included in the final sample. A red SATS triage category (+LR = 7.2) and SI ≥1.3 (+LR = 4.9) were the only two predictors with any significant clinical value. The same two markers performed well for both patients with and without trauma and specifically for patients who died while under the care of the emergency centre.

Discussion: The study demonstrated that patients with a SI≥1.3 at triage have a significantly higher likelihood to die or require hospitalisation, whether the presenting complaint is trauma related or not, especially to predict mortality while under the care of the EC. Incorporating this marker as a triage alert could expedite the identification of patients requiring time critical interventions and improve patient throughput in the emergency centre.

African relevance

- The global burden of disease and injuries affects low- and middle-income countries disproportionately, where a pronounced mismatch between capacity and demand exist.
- The South African Triage Scale has been widely adopted within and beyond Africa to help prioritise patients based on their level of acuity to ensure that the severely ill or injured receives timely care.
- The sensitivity of triage tools to detect time-critical illnesses are often suboptimal and the evidence to validate tools in low-and middle-income countries are often limited.
- This study found that selected clinical markers at triage could improve the predictive value of the South African Triage Scale and may improve access to time-critical interventions for those in low- and middle-income countries.

Background

Triage is the first and single most important step in patients' journey through an Emergency Centre (EC) [1,2]. The information derived from the triage process directly impacts the time to critical actions and promotes distributive justice so that the greater good happens to the greater number of people [3]. Evidence based triage systems that are locally validated improve patient outcomes and ultimately saves lives [4,5]. While the most validated triage systems for ECs globally include the Canadian Triage Assessment Scale, Australian Triage Score, Manchester Triage System, and Emergency Severity Index (ESI) [6], the South African Triage Scale (SATS) is widely used in various low- and middle-income countries (LMICs) [4,5,7]. Despite their differences, the all-encompassing goal is to identify patients in need of emergency treatment and to prioritise the sickest patients first [6].

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https://doi.org/10.1016/j.afjem.2023.09.007
Received 14 December 2022; Received in revised form 11 August 2023; Accepted 17 September 2023

Vital signs influence triage decisions [8], predict hospital admission and in-hospital mortality [9,10]. Studies have attempted to use clinical discriminators exclusively in a bid to simplify and expedite the triage process, with varying results [11–13]. This is especially relevant in LMICs where a lack of appropriately trained staff is a significant barrier [14]. The combination of vital signs and discriminators produce a more robust and effective triage tool [12]. The shock index (SI), modified shock index (MSI) and age shock index (ASI) are clinical markers that correlate with tissue perfusion in critically ill patients [15,16]. SI (the ratio of heart rate to systolic blood pressure) has been shown to be a better predictor of critical outcomes than conventional vital signs [17]. Despite its increasing popularity, very few studies have assessed its value in predicting hospitalisation and mortality in the general cohort of patients presenting to ECs. The ASI incorporates the age of a patient, taking into consideration the differences in physiology at both extremes of age [18], and the MSI uses mean blood pressure instead of systolic blood pressure [16]. Zarzaur et al. (2008)[19], found that older patients with an ASI ≥50 had a mortality rate of 10% compared to those with ASI ≥60 with a 15% mortality rate. An MSI value of ≥1.3 is associated with an increased probability of admission to an intensive care unit (ICU) and death as shown in the initial study by Liu et al. (2012) [16]. Studies by Shangguan et al. (2015), also demonstrated an MSI threshold ≥0.9 to be a predictor of mortality and MACE within seven days in STEMI patients with a myocardial infarct [20].

Predictors of outcomes during the triage process may complement existing triage systems by providing additional information that could improve efficiency with resource allocation to patients at risk [21]. This would specifically be useful in ECs that are overwhelmed with capacity-demand mismatches and subsequent long waiting times. During surges, predictors may assist with sorting or sub-triaging within a particular triage category and may identify who to prioritise [22]. This study assessed the value of SI, MSI and ASI to predict hospitalisation and mortality in all adult patients presenting to a district level emergency centre in South Africa.

Methods

Study design

This is a retrospective observational study, that analysed secondary data from an existing database over a 24-month period.

Study setting

This study occurred at Mitchells Plain Hospital, a large district hospital located in Cape Town, South Africa. It is located 32 km from the central business district and caters to a diverse population of about 600 000 people. It serves the nearby communities of Mitchells Plain, a low- to middle-income population and Philippi a large informal settlement with mainly low-income families. The EC attends to an average of 4 500 high acuity patients (~60% of adults triaged Orange and Red) per month. The disease profile reflects the quadruple burden of disease in South Africa: maternal, newborn and child health; HIV/AIDS and TB; non-communicable diseases; and trauma and injuries. Patients are triaged when they arrive in the EC with the SATS and their vital signs and demographic details entered into an official provincial electronic registry, Hospital and Emergency Centre Tracking and Information System (HECTIS). The overall admission rate is 38% (including transfers out), and there is no intensive care or high care facility at Mitchells Plain Hospital.

Study population and sampling

All adult patients (≥ 18 years of age) who presented to Mitchells Plain Hospital EC between 1st of January 2018 and the 31st of December 2019 (24-months) were eligible for inclusion. A study period of 24 months was chosen to limit the effects of month-to-month and seasonal variance. Extracted data included only cases without incomplete or missing triage information. Patients who are dead on arrival, left before completion of care (absconded/refusal of hospital treatment) were excluded.

Data collection and management

Eligible participants were identified from the electronic database, HECTIS, an official provincial application to track patients' throughput in the EC. Demographical details, disposition data and triage data for each participant meeting the inclusion criteria were extracted onto a spreadsheet and shock index (SI), modified shock index (MSI) and age shock index (ASI) were calculated (Table 1).

HECTIS is an electronic registry that captures information regarding patient demographics, location within the EC, ICD-10 diagnostic codes, and process times routinely. HECTIS also integrates the SATS and is used by nurses, clinicians and administrative personnel in real time. Triage data is entered by nurses who are trained in using HECTIS and the application of the SATS tool. Triage accuracy is monitored as part of a continuous quality improvement project and frequent audits are performed. Clinical data is entered by clinicians and include ICD-10 coding and disposition data. Hospitalisation were defined as an EC disposition that included: (i) patients who were transferred out to a tertiary hospital (including those requiring admission to high care unit (HCU) or ICU) and (ii) patients who required admission to general wards. To ensure confidentiality, only de-identified data were exported.

Electronic processes within HECTIS guarantees that essential triage data is complete for all patients. The input of vital signs and discriminators as required by SATS is a compulsory step for all patients. Data were cleaned and managed by the principal investigator, initially with the help of a spreadsheet and then exported to the Statistical Package for the Social Sciences (SPSS) Version 28 for analysis.

Deidentified data were extracted from the HECTIS registry to ensure patient confidentiality. Files were stored centrally at the University of Cape Town (UCT) Division of Emergency Medicine offices and were password protected. Study data and information were also backed up on a cloud server weekly, with access only by the study personnel.

Data analysis

Data were presented using descriptive and inferential statistics. Continuous variables were all non-normally distributed and presented as medians and interquartile ranges, while categorical variables were presented as proportions and distributions. Non-random associations between groups (categorical variables) were assessed by using the Fisher's exact test or the Chi^2 test, depending on variable characteristics. The Mann-Whitney *U test* was used to test for statistically significant differences between groups with numerical data. Statistical significance was defined as $p < 0.5$. Sensitivity, specificity and likelihood ratios were calculated for each variable as a predictor of various outcomes with predetermined thresholds [16,17,19,23] (Table 1). Data were analysed by the principal investigator with the help of SPSS Version 28.

Institutional approval was obtained via the National Health Research Database (WC_202,005_011) and ethical approval from the HREC of the University of Cape Town (HREC 236/2020), which included a waiver of

Table 1
Markers to be assessed.

Marker	Definition	Thresholds assessed
Shock index (SI)	HR / SBP	≥0.7; ≥1.0 and ≥1.3
Modified shock index (MSI)	HR/MAP*	≥0.9 and ≥1.3
Age shock index (ASI)	SI x age (years)	≥50

SBP Systolic blood pressure HR Heart rate.
MAP Mean arterial pressure = (SBP-DBP)/3 + DBP.

consent.

Results

During the study period of 24 months, a total of 61 329 adult patients presented to the EC. Of the eligible cohort, 730 (1.2%) were excluded: 57 (7.8%) were dead on arrival, 510 (70.0%) absconded and 163 (22.3%) refused hospital treatment and left before completion of care. The final sample included 60 599 participants.

Clinical characteristics and outcomes

Hospitalisation and mortality were present in 29 594 (49%) of the sample with 26 033 (88%) being admitted, 510 (1,7%) died while under the care of the EC and 3 051 (10.3%) being transferred to ICU ($n = 123$), HCU ($n = 1\ 297$) or other department ($n = 1\ 531$) in a tertiary facility (Table 2). Although there was a female preponderance (51%), a bigger proportion of males died or required hospitalisation (51% vs 47%, $p<0.05$). Hospitalisation and mortality were more prevalent in the older population (≥56 years old). A total of 17% of presentations were trauma related but presentations with no trauma had a higher prevalence of hospitalisation and mortality (50% vs 44%, $p<0.05$). The Triage Early Warning Score (TEWS) categories were dominated by the Green (53%) and Yellow categories (30%), in contrast to the Yellow (42%) and Orange (51%) categories in the SATS categories. A higher prevalence of hospitalisation and mortality occurred in the Red and Orange TEWS categories, as opposed to the SATS Red and Orange categories (Orange: 72% vs 57% and Red: 90% vs 87%). The median age was statistically higher in those who died and required hospitalisation, even though not clinically relevant (40 vs 39 years, $p<0.001$) (Table 3). A SI≥1.3 was the least prevalent (2%) while a MSI≥0.9 was the most prevalent marker threshold observed (Supplementary Table 1). All vital signs and calculated markers were significantly different between the two groups ($p<0.001$). The largest difference occurred with the heart rate,(95 bpm vs 88 bpm, $p<0.001$). systolic BP (126 mm Hg vs 130mm Hg, $p<0.001$) and Age shock index (29.54 vs 25.56, $p<0.001$).

Table 3
Descriptive statistics for age, vital signs and clinical markers, Median (IQR).

		Hospitalisation or Mortality	
Median (IQR)	Overall	Yes	No
Age (years)	39 (29–56)	40 (29–57)*	39 (28–55)
RR (breaths/ minute)	18 (16–20)	18 (16–20)	18 (16–20)
HR (beats/ minute)	91 (78–105)	95 (80–110)*	88 (76–101)
SBP (mm Hg)	128 (114–144)	126 (111–143)	130 (117–146)*
DBP (mm Hg)	79 (69–90)	78 (67–89)	80 (71–90)*
Temperature (C)	36.5 (36.1–36.9)	36.5 (36.1–36.9)*	36.5 (36.2–36.8)
TEWS score	2 (1–4)	3 (2–5)*	2 (1–3)
MAP (mm Hg)	95.67 (85.00–107.33)	94.00 (82.67–106.33)	97.33 (87.00–108.00)*
Shock index (SI)	0.70 (0.57–0.85)	0.74 (0.60–0.92)*	0.67 (0.55–0.80)
Modified shock index (MSI)	0.94 (0.78–1.14)	1.00 (0.82–1.23)*	0.90 (0.76–1.07)
Age shock index (ASI)	27.30 (19.96–38.24)	29.54 (21.13–41.87)*	25.60 (19.14–34.94)

RR Respiratory rate. HR Heart rate. SBP Systolic blood pressure. DBP Diastolic blood pressure.
TEWS Triage early warning score. MAP Mean arterial pressure. IQR interquartile range (25th-75th).
All variables were significantly different at $p<0.001$ (Mann-Whitney *U test.*)
* Significantly higher median.

Value of markers to predict hospitalisation and mortality

Even though the specificity of the clinical markers is mostly very high (>95%), a red SATS triage category (+LR = 7.2) and SI ≥1.3 (+LR = 4.9) were the only two predictors of mortality and the need for hospitalisation with any significant clinical value (Table 4). The same two markers performed similarly for both patients with trauma and without

Table 2
Descriptive statistics for demographics, triage information and dispositions (Row%).

					Hospitalisation or Mortality	
n (row%)	Total n = 60 599	EC Mortality n = 510	Transfers to tertiary care n = 3 051	Admissions n = 26 033	Yes n = 29 594 (49%)	No n = 31 005 (51%)
Age (years)						
18–25	9 753	31 (0.3%)	507 (5%)	3 976 (41%)	4 514 (46%)	5 239 (54%)*
26–35	15 841	76 (0.5%)	807 (5%)	6 839 (43%)	7 722 (49%)	8 119 (51%)
36–45	11 007	76 (0.7%)	554 (5%)	4 688 (43%)	5 318 (48%)	5 689 (52%)
46–55	8 243	88 (1%)	423 (5%)	3 360 (41%)	3 871 (47%)	4 372 (53%)*
56–65	7 923	99 (1%)	425 (5%)	3 419 (43%)	3 943 (50%)	3 980 (50%)
66–75	5 304	89 (2%)	256 (5%)	2 492 (47%)	2 837 (54%)*	2 467 (47%)
>75	2 528	51 (2%)	79 (3%)	1 259 (50%)	1 389 (55%)*	1 139 (45%)
Gender						
Male	29 600	290 (1%)	1 949 (7%)	12 733 (43%)	14 972 (51%)*	14 628 (49%)
Female	30 999	220 (0.7%)	1 102 (4%)	13 300 (43%)	14 622 (47%)	16 377 (53%)*
TEWS Category						
Green	32 335	21 (0.1%)	885 (3%)	10 840 (34%)	11 746 (36%)	20 589 (64%)*
Yellow	18 062	91 (0.5%)	959 (5%)	8 998 (50%)	10 048 (56%)*	8 014 (44%)
Orange	7 592	107 (1%)	715 (9%)	4 627 (61%)	5 449 (72%)*	2 143 (28%)
Red	2 610	291 (11%)	492 (19%)	1 568 (60%)	2 351 (90%)*	259 (10%)
SATS Category						
Green	1 072	1 (0.1%)	12 (1%)	267 (25%)	280 (26%)	792 (74%)*
Yellow	25 276	26 (0.1%)	526 (2%)	8 259 (33%)	8 811 (35%)	16 465 (65%)*
Orange	31 073	165 (0.5%)	1 943 (6%)	15 628 (50%)	17 738 (57%)*	13 335 (43%)
Red	3 178	318 (10%)	570 (18%)	1 877 (59%)	2 765 (87%)*	413 (13%)
Trauma						
Yes	10 016	94 (0.9%)	935 (9%)	3 362 (34%)	4 391 (44%)	5 625 (56%)*
No	50 583	416 (0.8%)	2 116 (4%)	22 671 (45%)	25 203 (50%)*	25 380 (50%)

TEWS Triage early warning score. SATS South African Triage Scale.
Percentages may not add to 100% due to rounding.
* Significantly higher proportion ($p<0.05$).

Table 4
Accuracy of markers to predict hospitalisation and mortality.

	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Total sample						
SATS Red	9.3%	98.7%	87.0%	53.3%	7.2	0.9
SATS Orange	59.9%	57.0%	57.1%	59.8%	1.4	0.7
SI ≥0.7	57.4%	57.1%	56.1%	58.4%	1.3	0.7
SI ≥1	17.4%	93.3%	71.2%	54.2%	2.6	0.9
SI ≥1.3	3.9%	99.2%	82.7%	52.0%	4.9	1.0
ASI ≥50	14.8%	92.5%	65.4%	53.2%	2.0	0.9
MSI ≥0.9	63.4%	50.1%	54.8%	58.9%	1.3	0.7
MSI ≥1.3	19.6%	92.0%	69.9%	54.5%	2.5	0.9
Trauma						
SATS Red	13.1%	98.6%	88.3%	59.3%	9.4	0.9
SATS Orange	61.3%	59.3%	54.1%	66.3%	1.5	0.7
SI ≥0.7	52.9%	55.7%	48.3%	60.3%	1.2	0.8
SI ≥1	11.4%	94.8%	63.2%	57.8%	2.2	0.9
SI ≥1.3	2.6%	99.4%	76.9%	56.7%	4.3	1.0
ASI ≥50	4.6%	98.2%	66.9%	56.9%	2.6	1.0
MSI ≥0.9	59.2%	49.0%	47.6%	60.6%	1.2	0.8
MSI ≥1.3	14.2%	93.2%	62.2%	58.2%	2.1	0.9
No trauma						
SATS Red	8.7%	98.7%	86.7%	52.1%	6.7	0.9
SATS Orange	59.7%	56.5%	57.7%	58.5%	1.4	0.7
SI ≥0.7	58.2%	57.4%	57.6%	58.0%	1.4	0.7
SI ≥1	18.4%	93.0%	72.2%	53.4%	2.6	0.9
SI ≥1.3	4.1%	99.2%	83.4%	51.0%	5.1	1.0
ASI ≥50	16.6%	91.2%	65.3%	52.4%	1.9	0.9
MSI ≥0.9	64.1%	50.3%	56.2%	58.5%	1.3	0.7
MSI ≥1.3	20.5%	91.7%	71.0%	53.7%	2.4	0.9

PPV Positive predictive value. NPV Negative predictive value. LR+ Positive likelihood ratio. LR- Negative likelihood ratio. SATS South African Triage Scale. SI Shock index. ASI Age shock index. MSI Modified shock index.

Table 5
Accuracy of markers to predict individual patient outcomes.

	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Deceased						
SATS Red	62.4%	95.2%	10%	99.7%	13.0	0.4
SATS Orange	32.4%	48.6%	0.5%	98.8%	0.6	1.4
SI ≥0.7	51.0%	50.0%	0.9%	99.2%	1.0	1.0
SI ≥1	26.7%	88.2%	1.9%	99.3%	2.3	0.8
SI ≥1.3	11.4%	97.8%	4.2%	99.2%	5.2	0.9
ASI ≥50	30.2%	89.1%	2.3%	99.3%	2.8	0.8
MSI ≥0.9	53.5%	43.5%	0.8%	99.1%	0.9	1.1
MSI ≥1.3	28.6%	86.4%	1.7%	99.3%	2.1	0.8
Admission						
SATS Red	7.2%	96.2%	59.1%	57.9%	1.9	1.0
SATS Orange	60.0%	55.3%	40.3%	64.8%	1.3	0.7
SI ≥0.7	58.4%	56.3%	50.2%	64.3%	1.3	0.7
SI ≥1	17.7%	92.4%	63.8%	59.9%	2.3	0.9
SI ≥1.3	3.8%	98.8%	71.4%	57.7%	3.2	1.0
ASI ≥50	15.2%	92.0%	58.8%	59.0%	1.9	0.9
MSI ≥0.9	64.5%	49.5%	49.0%	64.9%	1.3	0.7
MSI ≥1.3	19.8%	91.0%	62.3%	60.1%	2.2	0.9
Transferred out						
SATS Red	18.7%	95.5%	17.9%	95.7%	4.2	0.9
SATS Orange	63.7%	49.4%	6.3%	96.2%	1.3	0.7
SI ≥0.7	50.1%	50.0%	5.1%	95.0%	1.0	1.0
SI ≥1	13.1%	88.2%	5.5%	95.0%	1.1	1.0
SI ≥1.3	3.3%	97.8%	7.2%	95.0%	1.5	1.0
ASI ≥50	9.3%	88.8%	4.2%	94.9%	0.8	1.0
MSI ≥0.9	55.5%	43.4%	4.9%	94.8%	1.0	1.0
MSI ≥1.3	15.9%	86.4%	5.9%	95.1%	1.2	1.0

PPV Positive predictive value. NPV Negative predictive value. LR+ Positive likelihood ratio. LR- Negative likelihood ratio. SATS South African Triage Scale. SI Shock index. ASI Age shock index. MSI Modified shock index.

trauma. A total of 87% of all patients with a Red SATS category died or required hospitalisation. An Orange triage category had very low positive predictive values (<60%) in all three categories and positive likelihood ratios (<2) to predict mortality or hospitalisation for all three cohorts.

Value of markers to predict individual outcomes

A red SATS triage category and SI>1.3 were the only markers with significant value (+LR = 13.3 and +LR = 5.2 respectively) for predicting mortality (Table 5). All other markers and triage categories did not change the likelihood for individual outcomes significantly. A total of 10% of all patients triaged RED died while under the care of the EC and 71% of all patients with a SI≥1.3 required admission.

A total of 3 174 (5.2%) of all patients had a Red SATS category and 1 319 (2.3%) of all patients had a SI≥1.3. Interestingly, of the patients who do not have a red SATS triage category, 1.4% had a SI≥1.3, indicating the population where a red SATS triage category could not predict hospitalisation or mortality. Fig. 1 graphically summarises the positive likelihood ratios of all variables for all included markers.

An area under the curve (AUROC) analysis (Supplementary Table 2) depicts very low discrimination across all markers for all outcomes.

Discussion

This study assessed the value of SI, MSI and ASI to predict mortality and hospitalisation in all adult patients presenting to a district level emergency centre in Cape Town, South Africa and demonstrated that patients with a SI≥1.3 have a significantly higher likelihood of dying or requiring hospitalisation (+LR = 4.9). This remains consistent whether or not patients present with trauma and is specifically true for patients who die while under the care of the EC (+LR = 5.2). Even though a red SATS triage category had the highest predictive value for most outcomes, an orange SATS category added little to no value in predicting hospitalisation and mortality. Whether incorporating SI in the triage process adds any tangible clinical value remains to be assessed but it is postulated that it may improve and expedite the identification of patients requiring hospitalisation or at risk of dying, especially if not triaged red.

The SATS tool was developed, amongst other, to expedite the delivery of time-critical treatment for patients with life-threatening conditions. Even though its primary function is not to identify the cohort of patients that may die or require hospitalisation, a Red SATS category did increase the likelihood significantly (+LR = 7.2). It is however not nearly as sensitive enough on its own as only 5.2% of all patients triaged red while nearly 50% of adults in this sample died or required hospitalisation. A SI≥1.3 as clinical marker and threshold will add another 2.3% to this cohort, and is especially valuable in patients who are not triaged red. This may enable a more judicious and timely decision-making process and apportioning of resources by identifying which patients have a high likelihood of dying or requiring hospitalisation.

When acute surge measures fail to meet capacity-demand mismatches and emergency centres are overwhelmed, a typical scenario usually ensues: several patients triaged predominantly Yellow and Orange with prolonged waiting times. As evident from the results from this study, a triage category of Orange (and presumably Yellow) has little to no value in predicting mortality or the need for hospitalisation. These situations result in clinicians either consulting patients chronologically (first come first serve) within a triage category or using their gestalt to 'sub-triage' patients. Neither however, with any evidence that it improves (or worsens) patient outcomes. Knowing the probability of a specific outcome at the time of triage could assist this process.

Incorporating calculated clinical markers like SI into existing triage tools may not be feasible if the application of complex calculations would create delays and complicate the triage process. Electronic patient management tools that incorporate the triage process is however prevalent and, on the rise, even in LMICs and therefore feasible in numerous settings [24–27]. These electronic systems could be programmed to calculate the markers routinely and alert clinical staff if certain thresholds are reached. Where electronic systems are not feasible

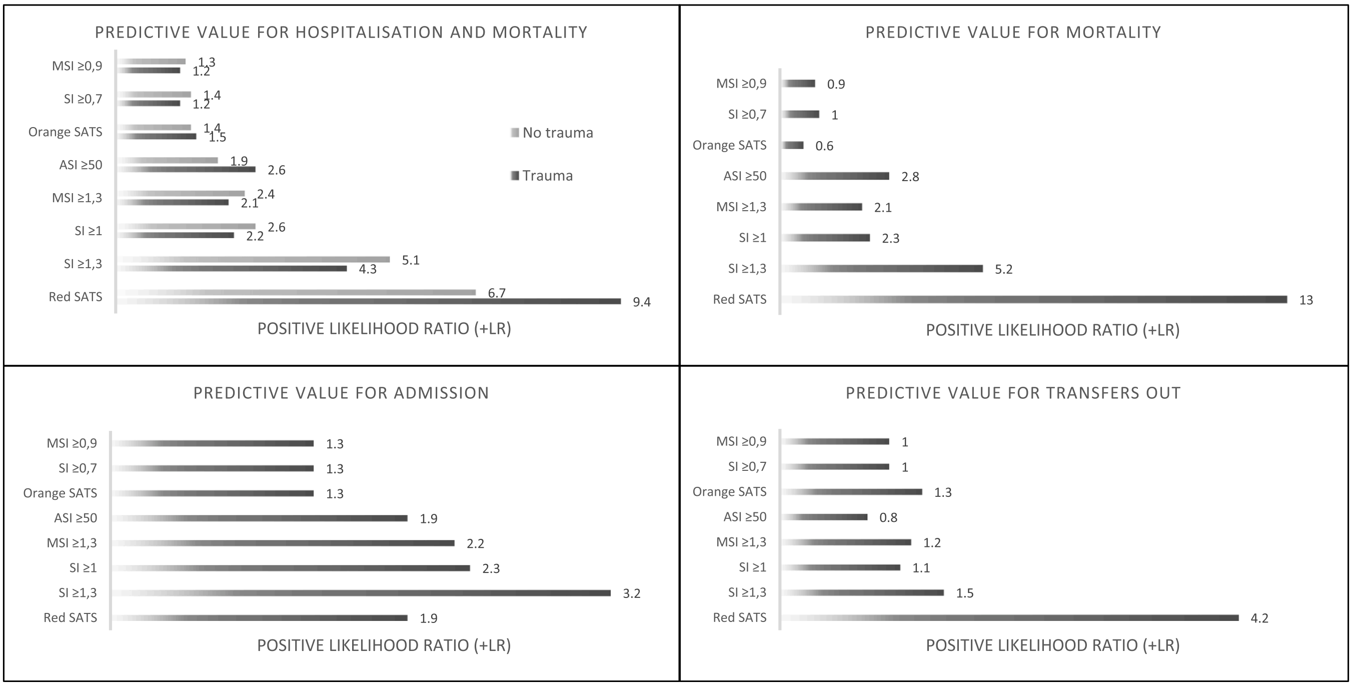

Fig. 1. Positive likelihood ratios of markers for selected outcomes.

(LMICs), applications on mobile devices could be considered. As example, triage alerts have been incorporated into the HopScore [28], an electronic outcomes-based emergency triage system developed at John Hopkins university to support objective triage decisions and to improve patient differentiation based on outcomes data. When compared to the ESI, it has been found to have improved risk stratification by identifying low risk patients, allowing healthcare workers to focus their time and attention on patents with a higher acuity. The time to disposition decision decreased by 58 min and overall waiting time by 10 min, however time from arrival to discharge was unchanged. McColl et al. (2017) [29] found that triage alerts of potentially septic patients together with other components of a new sepsis management bundle resulted in an expedited and more aggressive approach to sepsis management. This caused a dramatic increase in septic protocol use and substantial decrease in mortality amongst septic patients.

Utilising clinical markers as triage alerts to predict outcomes like mortality, hospital admission and transfers to HCU, and ICU confers great advantage straight from the initial patient-hospital contact. This advantage can even be extrapolated to the prehospital phase of emergency care where health care providers can be enabled to make critical decisions regarding which facility or level of care patients need to be transported to, based on predicted resources required. Relaying this information to the receiving facility also helps with planning and preparation for the patient's arrival. Activating the trauma team, cardiac catheterization laboratory and relevant specialties needed for a critically ill patient can then be done before arrival, potentially improving time to definitive care.

Even though this is one of the largest studies to date in LMICs that utilised electronic triage data to assess the predictive value of clinical markers at triage on patient outcomes, there are a few limitations. Triage accuracy depends on accurate data input and could have potentially affected the outcomes of this study. Triage accuracy at Mitchells Plain Hospital is however being monitored as part of a continuous quality improvement project and very few errors are expected: the vital signs are entered electronically, the TEWS calculated automatically, and the accuracy of the discriminators are double checked by the clinicians, with continuous feedback to senior nurses to facilitate corrective interventions. Admission practices are assumed to be generalisable at least within district hospitals and regional hospitals within the Western Cape as practices and treatment guidelines and referral pathways are standardised. The information herein is therefore expected to be externally valid for district and regional hospitals using SATS. Mortality only included patients who died while under the care of the EC and the true value of predicting short term mortality (~48 h) is therefore lost. This could have led to an underestimated effect size.

Future studies should expand this assessment to the paediatric and adolescent population as they were not included. More complex machine learning and systems utilising artificial intelligence should be utilised to identify alerts and triggers at triage to warn clinicians about potential critical outcomes. Future studies should investigate the ideal thresholds for these markers to enable uniformity and there should be further studies to validate the results of this study in different socio-economic and patient populations and investigate whether triage alerts actually impact patient care and improve patient throughput.

Conclusion

The study demonstrated that patients with a SI≥1.3 have a significantly higher likelihood of dying while under the care of the EC or requiring hospitalisation, whether or not the presenting complaint is trauma related. Incorporating this threshold into the triage process to generate patient alerts, could result in a change in behaviour – to prioritise the consultation and/or to intensify the treatment plan. The primary function of triage systems like the SATS is not to identify the cohort of patients that may have a critical outcome, even though there is a need for this. This could be particularly helpful in settings where there is a significant capacity-demand mismatch and where surge interventions have failed to meet the demand. With electronic triage tools becoming more prevalent, even in LMICs, incorporating triage alerts is both possible and feasible. Whether incorporating SI≥1.3 as alert in the triage process adds any tangible clinical value remains to be assessed but it is postulated that it may improve and expedite the identification of patients at risk of dying or those requiring hospitalisation, especially if not triaged red.

Dissemination of results

Results from this study was shared as a poster presentation at the African Conference on Emergency Medicine in Accra, Ghana in 2022 and with the staff members at the data collection site.

Authors' contributions

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: PA contributed 55%; CH 40%; and CvK 5% each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interests

CH is an associate editor of the African Journal of Emergency Medicine. CH was not involved in the editorial workflow for this manuscript. The African Journal of Emergency Medicine applies a double blinded process for all manuscript peer reviews. The authors declared no further conflicts of interest.

Acknowledgements

The authors acknowledge the HECTIS team, especially Dr Parak and Mr Jacques De Villiers for the integrity of the data.

Funding

This study was funded by the authors.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.afjem.2023.09.007.

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