Shock index in a rural setting: Can it predict mortality? A retrospective audit in two central hospitals in Limpopo Province, South Africa

S N Phaleng, MMed (Surg); **T C Hardcastle,** MMed (Surg), PhD

Department of Surgery, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, Durban, South Africa

Corresponding author: *S N Phaleng (phaleng@lantic.net)*

Background. Shock index is (SI) obtained by dividing heart rate by systolic blood pressure (SBP). Previous studies have shown that SI >0.9 is a predictor of mortality and of a need for blood transfusion in trauma patients.

Objective. To determine whether SI can predict mortality and the need for blood transfusion in a rural South African provincial referral hospital cohort.

Methods. A retrospective observational cross-sectional study of trauma patients with injury severity score (ISS)>15 in two central hospitals in a rural province was undertaken using data from January 2018 to December 2020. Data collection included demographics, heart rate, blood pressure, SI and modified shock index (MSI) at the time of admission to the emergency department. Univariate and multivariate analyses were performed to identify whether SI predicted death or need for transfusion.

Results. The cohort comprised 324 patients. Only emergency department SI and MSI were calculated. In multivariate analysis, χ^2 tests showed that SI was a good predictor of mortality ($p<0.011$) and need for blood transfusion ($p<0.001$). SI with area under curve 0.673 is a fair predictor of mortality. Student's *t*-test showed that patients who died had lower mean SI than those who survived, with a mean difference of −2.78 ($p=0.006$). In multivariate analysis, severe SI predicted the need for blood transfusion ($p=0.032$).

Conclusion. SI is a useful predictor of mortality and the need for blood transfusion in this cohort of referred patients to two central facilities in a rural province. There is likely an impact from resuscitation prior to arrival at the central hospitals.

Keywords: shock index, trauma, mortality, blood transfusion

S Afr Med J 2026;116(3):e3051. https://doi.org/10.7196/SAMJ.2026.v116i3.3051

Triage is one of the key principles of effective management of major emergencies. It is usually performed in three stages: primary (carried out at the scene); secondary (performed by an emergency doctor when the patient arrives at the hospital; and third (when the patient receives care services including intensive care unit (ICU) care and theatre services.[1] Various triage systems have been implemented around the world. Examples include the simple triage and rapid treatment (START) system, Australian Triage Scale and Canadian Trauma System.[2] The South African Triage System (SATS) was established in the Western Cape Province in 2012 and comprises a five-part system: red (life-threatening); orange (urgent); yellow (stretcher case); green (walking wounded); and blue (dead on arrival).[3]

Haemorrhagic shock is one of the leading causes of death during initial treatment. However, early recognition of shock can be challenging.[4] Shock index (SI) is defined as the ratio of heart rate to systolic blood pressure (SBP). The normal range is currently accepted as 0.5 - 0.7. SI>0.9 has been used to predict mortality and multiple transfusion protocol (MTP) requirement.[4,5] The accepted range is 0.7 - 1.3.[6,7] Modified shock index (MSI) is defined as the ratio of heart rate to mean arterial pressure (MAP). The traditional SI does not consider diastolic blood pressure (DBP). DBP can drop before SBP. MAP can represent tissue perfusion status, and is therefore a potentially better predictor of disease severity, while MSI reflects both stroke and systemic resistance.[8,9] It is thought to be a more reliable marker of haemodynamic status.

A number of low- to middle-income countries (LMICs) use the SATS.[10] SI as a parameter in trauma has not been studied extensively. In Cape Town, South Africa (SA), Aleka *et al.*[11] reported that patients with SI>1.3 had a significant likelihood of dying or requiring hospitalisation. In Johannesburg, SA, Crawford *et al.*[12] showed that in patients with SI>0.91, the odds ratio of death was 6.7 times higher, while injury severity score (ISS) was a stronger predictor of in-hospital mortality than SI. On the other hand, in the same study, SI and its derivatives and MAP did not reach a value of 0.8, which is a strong predictor of mortality, need for ICU and theatre and blood transfusion.[13] In Limpopo Province, SA, the under-researched province of interest, there are no studies reported on SI. The aim of the present study was to investigate whether SI can predict mortality and the need for blood transfusion in trauma patients in Limpopo Province, SA.

Methods

Design

This was a retrospective cross-sectional study of patients who sustained major trauma between 1 January 2018 and 31 December 2020.

Study setting

The study was conducted at Pietersburg and Mankweng hospitals. These are the two referral hospitals in Limpopo Province, which has a population of ~ 6 million people.

Participants

Patients of all ages who sustained major trauma with ISS >15 were included. These were trauma cases treated by general surgery, neurosurgery, urology, cardiothoracic surgery, maxillofacial surgery and orthopaedic surgery, as there is no trauma subspecialist unit in Limpopo.

Variables

Data were collected on demographics, admission and discharge date, mechanism of injury, types of injury, admission blood pressure (BP), admission Glasgow Coma Scale score, ISS, operative intervention, length of hospital stay and outcomes.

Ethical clearance

Ethics approval was obtained from the Biomedical Research Ethics Committee of University of KwaZulu-Natal (ref. no. 00003999/2022), and the Pietersburg Mankweng Research Ethics Committee (ref. no. REC 300408006) in Limpopo.

Statistical analysis

All data were analysed using SPSS version 30 (IBM, USA), and statistical significance was set at $p<0.05$. Descriptive statistics were used to describe the characteristics (demographic and clinical) of the study participants. Means and standard deviations were used to describe continuous variables (age, SBP, DBP, pulse, fluids received and length of stay). Frequencies and percentages were used to describe categorical variables (sex, mechanism of injury, injury type, SI, blood transfusion, ICU admission, procedures and mortality). The relationship between SI and binary outcomes (mortality and blood transfusion) was determined using χ^2 tests with cross-tabulations. For the bivariate analysis, independent-sample *t*-tests were used to compare SI means for each of the outcome groups (alive v. dead; blood transfused v. not transfused). Two binary logistic regression models were generated to identify predictors of mortality and blood transfusion. Covariates included age and sex, and adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported. To compare the discriminative ability of SI in predicting mortality and blood transfusion needs, a receiver operating characteristic (ROC) curve analysis was conducted, including the area under the ROC curve (AUROC) to interpret the predictive value.

Table 1. Descriptive statistics of continuous demographic and clinical characteristics of the study population (*N*=324)

Variable	Mean (SD)	Minimum	Maximum
Age, years	30.63 (13.64)	1	74
SBP	118.77 (21.360	58	177
DBP	73.89 (17.02)	27	146
Pulse	89.10 (24.31)	33	164
Fluid administered, mL	2 277.74 (705.4)	400	4 000
Length of stay, days	11.02 (11.02)	1	81

SD = standard deviation; SBP = systolic blood pressure; DBP = diastolic blood pressure.

Table 2. Descriptive statistics of categorical demographic and clinical characteristics of study participants (*N*=324)

Characteristic	*n* (%)
Sex	
Male	292 (90.10)
Female	32 (9.9)
Mechanism of injury	
Assault	180 (55.6)
MVC	71 (21.9)
Fall	42 (13.0)
PVC	29 (9.0)
Self-injury	1 (0.3)
Animal injury	1 (0.3)
Injury type	
Head injury	141 (43.5)
Penetrating abdominal trauma	59 (18.2)
Orthopaedic fractures	47 (14.5)
Blunt abdominal trauma	29 (9.0)
Injured limb	11 (3.4)
Chest injury	9 (2.8)
Head/chest	9 (2.8)
Neck injury	6 (1.9)
Head/limb	4 (1.2)
Mandible	2 (0.6)
Ortho/mandible	2 (0.6)
Ortho/abdomen	2 (0.6)
Head/abdomen	1 (0.3)
Abdomen/neck	1 (0.3)
Chest/abdomen	1(0.3)
Shock index	
Normal	78 (24.1)
Mild	189 (58.3)
Moderate	45 (13.9)
Severe	12 (3.7)
Blood transfusion	
No	229 (70.7)
Yes	95 (29.3)
ICU admission	
No	265 (81.8)
Yes	59 (18.2)
Mortality	
No	310 (95.6)
Yes	14 (4.4)

MVC = motor vehicle crash; PVC = pedestrian vehicle crash; ICU = intensive care unit.

Results

The review identified 324 patients, of whom 83% were male. The mean age was 30.6 years. The average fluid administered per patient was 2 277 mL, and the mean length of stay was 11 days, as shown in Table 1. The mean delay to arrival at the referral hospital was 12 hours 48 minutes.

The most common mechanism of injury was assault (55.6%), followed by motor vehicle crashes (21.9%). The head was the most commonly injured part of the body (43.4%). Only 18.2% of patients were admitted to ICU, while 29.3% received blood transfusion, as shown in Table 2. The overall mortality was 4.4%.

There was a significant association between SI and mortality ($p<0.011$), while $p<0.001$ for the association between SI and blood transfusion (Table 3).

Patients who died had a lower mean SI ($p<0.006$), and patients who received blood transfusion had a higher mean SI ($p<0.001$), as shown in Table 4.

SI was not a strong predictor of mortality, but the AUROC of 0.673 indicates that it has a fair capacity to predict mortality. Sex was a strong predictor, with males more likely to die ($p<0.001$). Both SBP and DBP were not predictors of mortality, with *p*-values 0.684 and 0.673, respectively. ICU admission was also a strong predictor of mortality, with a *p*-value of 0.005 (Table 5).

Severe SI is a significant predictor of the need for blood transfusion ($p=0.032$). SBP was also a significant predictor of blood transfusion, as shown in Table 6.

Discussion

Triage is crucial in the emergency department for classifying patients based on their treatment priorities, and reducing waiting times.[14] A study by Smith *et al.*[15] found overtriage by triage nurses to be 3.9%, while undertriage was 24%. Undertriage causes significant delays in patient management, while overtriage causes increased use of resources.[15] Haemorrhage is the most common reason for traumatic death, and shock contributes to organ failure.[16] Management of traumatic shock is an ideal target for intervention in the pre-hospital setting, because shock is often identifiable.[17] The SI has been a valuable predictor for haemodynamic instability and the need for blood transfusion in trauma.[18,19] Several studies have shown that SI>1 has been associated with higher mortality rates in trauma patients.[20,21] Similar to many previous studies, males seem to be the most commonly affected, consistent with findings by Evans *et al.*[22] (79%), Kristiansen *et al.*[23] 78% and Mbanjumucyo *et al.*[24] (77%).

The results in the present study show that SI was a predictor of mortality and the need for blood transfusion in the Limpopo setting. This is in contrast to a systematic review by Carsetti *et al.*,[25] which showed that SI was not accurate in predicting mortality owing to low sensitivity of 0.358 and specificity of 0.742. Similarly, a study from Pretoria by Milton *et al.*[26] showed that SI was not a good predictor of mortality, with sensitivity of 58% and specificity of 73%, when compared with trauma injury severity score and ISS at 87% and 68%, and 81% and 61%, respectively. These findings contrast with those of a systematic review of 38 articles by Vang *et al.*,[27] which found a four-fold risk of in-hospital mortality in adult trauma patients with SI>1.

In the current study, SI was found to be a good predictor of the need for blood transfusion. This is consistent with a previous finding in the USA, where patients with SI>1 had a 25% greater likelihood of requiring a blood transfusion.[28] In addition, a study in Spain found that an SI value of 0.9 in transfused patients demonstrated a specificity of 73% with sensitivity of 66% for pre-hospital SI, and specificity of 74% with a sensitivity of 80% for the in-hospital SI.[29] In our study, almost all SIs calculated were emergency department SIs. There were prolonged waiting times for patients before receiving services at the referral centres. These could be due to problems in communication and transport delays, which can have detrimental effects on patient outcomes. All patients received resuscitation before referral to the central hospitals, which could have had an influence on SI values. SATS was not well followed, as found in a previous Limpopo study.[14] The reality of the SA health system is that many patients referred

Table 3. X^2 tests showing association between shock index categories and mortality and blood transfusion of major trauma patients (*N*=324)

Variable	Shock index	No	Yes	Total	χ^2	df	*p*-value
Mortality							
	Normal	74	2	76	11.12	3	0.011
	Mild	183	5	188			
	Moderate	40	5	45			
	Severe	10	2	12			
Blood transfusion							
	Normal	19	59	78	21.81	3	<0.001
	Mild	46	143	189			
	Moderate	21	24	45			
	Severe	9	3	12			

df = degree of freedom.

Table 4. Independent-sample *t*-test comparing shock index by mortality and blood transfusion among trauma patients (*N*=324)

Variable	*t* (df)	Mean difference	*p*-value
Mortality	2.777 (319)	–0.546	0.006
Blood transfusion	3.882(322)	0.337	<0.001

df = degree of freedom.

Table 5. Logistic regression showing the predictors of mortality among trauma patients (*N*=324)

Variable	*p*-value	β
Shock index		
Mild	0.069	0.062
Moderate	0.086	0.090
Severe	0.537	0.435
Sex	<0.001	38.416
SBP	0.684	0.970
DBP	0.673	0.976
ICU admission	0.005	0.088
Injury type		
Blunt abdominal trauma	0.333	0.221
Penetrating abdominal	0.031	0.054
Trauma	0.998	0.000
Chest injury	0.996	0.000
Orthopaedic fractures		
Injured limb	0.999	0.000
Head/chest	0.999	0.000
Chest/abdomen	1.000	0.000
Mandible	1.00	0.000
Ortho/mandible	0.999	0.000
Ortho/abdomen	0.999	0.000
Abdomen/neck	1.000	0.000
Head/limb	0.037	28.6
Head/abdomen	1.000	0.00
Neck injury	0.999	0.00
Mechanism of injury		
MVC	0.031	0.084
PVC	0.433	0.385
Fall	0.997	0.000
Self injury	1.000	0.769
Animal injury	1.000	0.000
Blood transfusion	0.596	0.652

SBP = systolic blood pressure; DBP = diastolic blood pressure; ICU = intensive care unit; MVC = motor vehicle crash; PVC = pedestrian vehicle crash.

Table 6. Logistic regression showing the predictors of blood transfusion among trauma patients (*N*=324)

Variable	*p*-value	β
Shock index		
Mild	0.009	19.943
Moderate	0.084	24.218
Severe	0.032	11.617
Age	0.963	1.000
Sex	0.896	1.063
SBP	<0.001	1.022
DBP	0.216	1.009
ICU admission	0.011	2.525
Injury type		
Blunt abdominal trauma	0.905	0.934
Penetrating abdominal injury	0.062	0.466
Chest injury	0.492	0.576
Orthopaedic injury	0.412	0.622
Injured limb	0.057	0.255
Head/chest	0.183	4.434
Chest/abdomen	1.000	0.000
Mandible	0.463	0.333
Ortho injury/mandible	0.999	0.587
Ortho/abdomen	0.999	0.000
Abdomen/neck	1.000	0.000
Head/limb	0.144	0.213
Head/abdomen	1.000	0.000
Neck injury	0.045	0.142
Mechanism of injury		
MVC	0.504	0.747
PVC	0.589	0.750
Fall	0.610	0.723
Self injury	1.000	0.549
Animal injury	1.000	0.000

SBP = systolic blood pressure; DBP = diastolic blood pressure; ICU = intensive care unit; MVC = motor vehicle crash; PVC = pedestrian vehicle crash.

to centres with higher levels of care have received some degree of resuscitation already at a lower-level hospital, and the utility of these types of predictive tools is therefore potentially diminished. Studies on SI and its role in predicting mortality and the need for blood transfusion are very rare in LMICs. Therefore, more studies are needed to understand its role in these settings.

Future research should be directed at firstly investigating the role of SI in a larger cohort of patients in a rural setting, and secondly, investigating whether SATS is applied correctly in an emergency trauma setting.

Study limitations

Owing to its retrospective nature, the study is subject to selection bias. Compared with international studies, the sample size is quite small.

Conclusion

SI in this cohort in Limpopo Province, SA, fairly predicted in-hospital mortality as well as the need for blood transfusion. The triage system needs to better implemented, and there should be improvements in the referral system for emergency patients in Limpopo Province.

Data availability. Data used for this study are available on request from the lead author (SNP)

Declaration. This study is part of a group of studies towards the degree PhD in the Department of Surgery, University of KwaZulu-Natal.

Acknowledgements. We acknowledge the administrative staff of Pietersburg/Mankweng hospital for their assistance with the retrieval of files.

Author contributions. SNP conceptualised the study and obtained the ethics approval. SNP was responsible for data collection and drafting of the manuscript, and TCH was responsible for editing and supervising the manuscript.

Funding. None.

Conflicts of interest. None.

1. Vasallo J, Beavis J, Smith J, et al. Major triage incident: Derivation and comparative analysis of the modified physiology triage tool (MPTT). Injury 2017;48(5):992-999. https:/doi.org.ukzn.idm.oc/c.org/10.1016/j.injury.2017.01.038
2. Yancey CC, O'Rouke O. Emergency department triage 2024. StatPearls, 2023. https://www.ncbi.nlm.nih.gov/books/NBK557583/ (accessed 6 March 2026).
3. Dixon J, Burkholder T, Pigoga, J et al. Using the South African scale for pre-hospital triage: A qualitative study. BMC Emerg Med 2021;21:125. https://doi.org/10.1186/s12873-021-00522-3
4. Koch EK, Lovett SL, Nghiem T, et al. Shock index in the emergency department: Utility and limitations. Open Access Emerg Med 2019;11:179-199. https://doi.org/10.2147/OAEM.s178358

5. Vandromme MJ, Griffin RL, Kerby JD, McGwin G Jr, Rue IW III, Weinberg JA. Identifying risk for massive transfusion in the relatively normotensive patient: Utility of the prehospital shock index. J Trauma 2011;70(2);384-388. https://doi.org/10.1097/TA.0b013e3182095a0a
6. Linnaus ME, Notrica DM, Langlais CS, et al. Prospective validation of shock index-paediatric-adjusted (SIPA) in blunt and spleen trauma. An ATOMAC study. J Pediatr Surg 2017;52(2):340-344. https://doi.org/10.1016/j.jpedsurg.2016.09.060
7. Van der Walle RJ, Peceng JK, Doleys SC, et al. Trends in paediatric adjusted shock index predict morbidity and mortality in children with severe blunt injuries. J Pediatr Surg 2018;53(2):362-368. https://doi.org/10.1016/jpedsurg.2017.10.045
8. Liao TK, Ho CH, Cheng CC, Huang HY. Shock index to predict outcomes in patients with trauma following traffic collisions. A retrospective cohort study. Eur J Trauma Emerg Surg 2024;50(5):2191-2198. https;//doi.org/10.1007/500068-024
9. Sotello D, Shengpin Y, Nugent K. Comparison of shock index, modified shock index and age shock index in adult admissions to a tertiary hospital. S West Respir Crit Care Chr 2019;7(28):18-23. https://doi.org/10.12746/swrccc7i28.539
10. Dalwai M, Valles P, Twoney M, et al. Is South African Triage scale for use in Afghanistan, Haiti and Sierra Lione? BMJ Glob Health 2017;2(2)e000160. https://doi.org/10.1136/bmjgh-2016-000160
11. Aleka P, van Koningsbruggen C, Hendrikse C. The value of shock index to predict mortality and hospitalisation in a district level emergency centre. Afr J Em Med 2023;13(4):2877292. https://doi.org/10.1016/J.AFJEM.202309.007
12. Crawford R, Kruger D, Moeng M. Shock index as a prognosticator for emergent surgical intervention and mortality in trauma patients in Johannesburg. A retrospective cohort study. Ann Med Surg 2021;69:102710. https://doi.org/10.1016/j.amsu.2021.10710
13. Barnes R, Clarke D, Farina Z, et al. Vital sign based scores are poor at triaging South African patients. Am J Surg 2017;36(3):235-239. https://doi.org/10.1016/j.anjsurg.2017.07.025
14. Phukubye TA, Ntho TA, Muthelo L, Mbombi MA, Bopape MA, Mothiba TM. Is the triage system welcome in Limpopo province? A qualitative study on patients' perceptions. Nurse Rep 2023;13(1):351-364. https://doi.org/10.3390/nurserep13010033
15. Smith J, Filmater C, Masenge A, Heyns T. The accuracy of nurse-led triage of adult patients in the emergency department of urban private hospitals. Afr J Emerg Med 2022;12(2):112-116. https://doi.org/10.1016/j.afjem.2022.02.007
16. ATLS subcommittee, American College of Surgeons' Committee on Trauma, International ATLS working group. Advanced Trauma Life Support (ATLS): the ninth edition. J Trauma Acute Care Surg 2013;74(5):1363-1366. https://doi.org/10.1097/TA.ob.13e3182b82f5
17. Mould-Millan NK, Dixon J, Lamp A, et al. A single-site pilot implementation of a novel trauma program for prehospital providers in a resource-limited setting. Pilot Feasibility Stud 2019;5(1):143. https://doi.org/10.1186/5408-019-0536-0
18. El-Menyar A, Gopal P, Tiley E, Latifi R. The clinical utility of shock index to predict the need for blood transfusion and outcomes of trauma. J Surg Res 2018;217(7):52-59. https://doi.org/10.1016/j.jss.2018.02.013
19. Wang IJ, Bae BK, Park SW, et al. Prehospital modified shock index for prediction of massive transfusion and mortality in trauma patients. Am J Emerg Med 2019;38(2):187-190. https://doi.org/10/1016/ajem.2019.p1.056
20. Sahu N, Yee S, Das, et al. Shock index as a marker for mortality rates in those admitted to the medical intensive care unit from emergency department. Cureus 2020;12(4):e7903. https://doi.org/10.7759/cureus.7903
21. Jouini S, Jebali, Hedhli H, et al. Predictive value of SI>1 in severe trauma patients in emergency department. La Tunis Med 2019;97(6):802-807. https://pubmed.ncbi.nlm.nih.gov/31872412/ (accessed 6 March 2026).
22. Evans CCD, Wenbin L, Seitz D. Injury related deaths in Ontario provincial trauma system. A retrospective population based cohort analysis. CMAJ Open 2021;9(1):E208-E214. https://doi.org/10.9778/camj0.202000209
23. Kristiansen T, Lossius HM, Zehn M, et al. Epidemiology of trauma: A population-based study of geographical risk factors for injury deaths in the working age population of Norway. Injury 2014;45(1):25-30. https://doi.org/10.1016/j.injury.2013.07.007
24. Mbanjumucyo G, George N, Kearney A, et al. Epidemiology of injuries and outcomes among trauma patients receiving pre-hospital care at a tertiary hospital in Kigali, Rwanda. Afr J Emerg Med 2016;6(4):191-197. https://doi.org/10.1016.10.0001
25. Carsetti A, Antolin R, Casarotta E, et al. Shock index as predictor of massive blood transfusion and mortality in patients with trauma: A systematic review and meta-analysis. Crit Care 2023;27(85):27-85. https://doi.org/10.1186/s13054-023-04386
26. Milton M, Engelbrecht A, Geyser M. Predicting mortality in trauma patients. A retrospective comparison of six scoring systems applied to polytrauma patients from the emergency centre of a South African Central Hospital. Afr J Em Med 2021;11(4):453-458. https://doi.org/10.1016/j.afjem.2021.09.001
27. Vang M, Ostberg M, Steinmetz J, Rasmussen LS. Shock index as a predictor of mortality in trauma patients: A systematic review and meta-analysis. Euro J Trauma Emerg Med 2022;48(20):2559-2566. https://doi.org/10.1007/s00068-022-01932-z
28. Jehan F, Con J, Mcintyre M, et al. Pre-hospital shock index correlates with transfusion, resource utilisation and mortality. The role of first visits. Am J Surg 2019;218(6):1169-1171. https://doi.org/10.1016/j.amjsurg.2019.08.028
29. Juste LP, Gomez MK, Burguerra AB, et al. Pre-hospital and hospital shock indices as predictors of massive blood transfusion during initial treatment of polytrauma patients. Emergencias 2021;33(1):29-33. https://pubmed.ncbi.nlm.nih.gov/33496397/ (accessed 12 March 2026).

Received 24 January 2025; accepted 5 August 2025.