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Comparison of Modified Shock Index and Age Modified Shock Index in Predicting Mortality of Patients admitted to the Intensive Care Unit

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ABSTRACT
OBJECTIVE: To compare the prognostic accuracy of the Age-Modified Shock Index (AMSI) and the Modified Shock Index (MSI) in predicting in-hospital mortality among adult patients admitted to the intensive care unit.
METHODOLOGY: This analytical cross-sectional study was conducted in the ICU (Intensive Care Unit) of the ISRA University Hospital from June to October 2025. One hundred and eighty-two patients were recruited. The admission vital signs were used to calculate heart rate/mean arterial pressure (HR/MEA) and AMSI (Age x MSI). The ROC curves were analyzed to calculate and compare the areas under each index's curve. All data were processed using SPSS version 26.0.
RESULTS: The overall mortality rate was 22.5%. Non-survivors had significantly higher MSI (1.36±0.25) and AMSI (94.5±29.1) values compared to survivors (1.05±0.26 and 61.2±22.5, respectively; $p < 0.001$). AMSI demonstrated superior discriminatory power with an AUC of 0.88 (95% CI: 0.82–0.93), significantly higher than the AUC (Area under the curve) for MSI (0.79, 95% CI: 0.72–0.86; $p = 0.022$). The optimal cut-off for mortality prediction was ≥1.2 for MSI (sensitivity 78.0%, specificity 71.6%) and ≥75 for AMSI (sensitivity 83.0%, specificity 80.1%).
CONCLUSION: The Age-Modified Shock Index (AMSI) demonstrated significantly greater predictive accuracy for in-hospital mortality than the MSI, supporting its potential as a simple, rapid, and effective bedside risk-stratification tool in the ICU.

KEYWORDS: Shock Index; Age Factors; Intensive Care Units; Mortality Prediction

INTRODUCTION

Early, rapid, and reliable bedside risk stratification remains a cornerstone of critical care[1]. Vital-sign–based indices, simple ratios derived from heart rate and blood pressure, have been proposed as quick screening tools that can flag patients at high risk of deterioration long before complex laboratory or imaging results are available. The shock index (SI), defined as the heart rate divided by systolic blood pressure (HR/SBP), was introduced decades ago and has since been evaluated across trauma, sepsis, acute heart failure, and other acute illnesses as a predictor of hemodynamic instability and mortality[2]. Because SI uses only two easily obtained parameters, it is attractive for triage and early warning in emergency and ICU settings[3,4].

Recognizing the limitations of the classic SI (which does not incorporate diastolic blood pressure), the modified shock index (MSI) was developed: MSI = HR/mean arterial pressure (MAP)[5]. By using MAP, which better reflects organ perfusion than SBP alone, MSI may more accurately capture circulatory compromise in patients with altered vascular tone or on vasoactive drugs. According to several studies, MSI may be more accurate than SI in predicting ICU admission, the need for vasopressors, mechanical ventilation, and short-term mortality in cases of sepsis, trauma, and other serious conditions[6,7].

Age strongly modifies the baseline risk of death from acute illness, and nomograms that incorporate age have been proposed to improve predictive accuracy. The Age-Modified (or Age-Adjusted) Shock Index (AMSI/ASI) multiplies or otherwise adjusts SI/MSI by patient age (e.g., ASI = age × SI or other variants), to integrate physiologic reserve and frailty into a simple bedside score. Recent multicohort and single-centre studies suggest that age-adjusted shock indices may better predict in-hospital and 30-day mortality than unadjusted indices, particularly among older adults and in mixed medical-surgical ICU populations[8,9].

The clinical importance of simple, rapid risk scores in the ICU is underscored by persistently high critical-care mortality. Mortality among adults admitted to intensive care varies by region, case mix, and time period but often ranges from roughly 10% to over 80% in many cohorts; during pandemic surges and in cohorts requiring invasive ventilation, these figures have been substantially higher[10,11]. Because early recognition of high-risk patients enables timely escalation (e.g., invasive monitoring, vasopressors, and earlier source control), a reliable, low-cost predictor that performs well across diagnoses and age groups would be highly valuable for ICU clinicians worldwide[12,13].

Despite the growing literature, three important gaps remain. First, many published studies examine SI, MSI, or ASI in single diagnostic groups (trauma, sepsis, heart failure, or COVID-19) rather than in heterogeneous ICU populations; second, comparative head-to-head evaluations of MSI versus age-modified MSI (rather than SI variants) are limited; and third, performance across a broad ICU case mix (medical, surgical, cardiac) with modern ICU care (including frequent vasoactive use) is incompletely described. A clearer understanding of whether adding age to the MSI substantially improves discrimination for ICU mortality without sacrificing simplicity is therefore needed. Several recent multicenter and cohort studies have suggested improved discrimination with age-adjusted indices, but the results are heterogeneous and context-dependent[5,14].

Since MSI incorporates a perfusion-relevant blood pressure metric (MAP) and AMSI incorporates age, a powerful, independent predictor of outcome, a focused comparison between MSI and age-modified MSI in a real-world ICU population could tell us whether the modest extra complexity of age adjustment provides a clinically useful gain in mortality prediction. If Age-Modified MSI demonstrates superior discrimination and calibration, it could be adopted as a still-simple triage tool to prioritize monitoring and early interventions for high-risk ICU patients. To predict in-hospital mortality among adult patients admitted to the intensive care unit, this study compared the prognostic performance of the Age-Modified Shock Index and the Modified Shock Index.

METHODOLOGY

The Department of Internal Medicine at Isra University Hospital in Hyderabad conducted this comparative cross-sectional study over the course of six months, from June - October 2025. The Research Ethics Committee of Isra University in Hyderabad granted ethical permission on May 9, 2025, with approval number IU/CP.REC(FCS)/2025/665.

Based on a prior study that found a 12.1% in-hospital death rate among patients with increased modified shock index (MSI) values admitted with acute coronary syndrome, the sample size was determined using the OpenEpi, Version 3.01 software. With an expected frequency of 12.1%, a 5% margin of error, and a 95% confidence level, the minimum sample size needed was determined to be 164 cases [15]. To account for possible incomplete or missing data, an additional 10% was added, yielding a final sample size of 182 patients**.**

A nonprobability consecutive sampling method was used to identify eligible subjects. Eligibility to participate in the study included patients aged 18 years or older who were admitted to the ICU at any point during the study period, without limitation by diagnosis. Patients who had incomplete medical charts, were discharged against medical advice, were readmitted within the same hospitalization, and patients who had terminal malignancy in a palliative care setting were excluded. The ICU Medical Director supervised the collection of data from bedside charts and medical records of qualified patients by trained ICU residents.

Data collected at ICU admission of each patient included heart rate (beats per minute) and blood pressure (systolic, diastolic, and mean arterial pressure). The heart rate was divided by the mean arterial pressure to provide the modified shock index (MSI = HR/MAP). The age-modified shock index (AMSI) was calculated by multiplying the modified shock index by the age of patients (AMSI = age × MSI). Age, gender, admission diagnosis, comorbidities, and outcome, with the data of whether the patient survived or died, were gathered using a structured proforma created in this study to collect demographic data. The study maintained data confidentiality, and patient identifiers were removed before analysis.

Statistical analysis

The data were collected and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). The continuous variables analyzed were age, MSI, and AMSI, expressed as means ± standard deviations. The categorical data comprising gender, comorbidities, and outcome were handled using frequencies and percentages. The survivors and non-survivors were compared using an independent-samples t-test. The receiver operating characteristic (ROC) curve was used to determine the extent to which MSI and AMSI were effective predictors of mortality. The DeLong test was compared with the area of the curve (AUC). The p-value was considered significant at a value of 0.05 or less. Post-stratification was conducted to estimate the impact of potential modifiers on the performance of the index prediction, including age, gender, and comorbidity.

RESULTS

Of the 182 patients in the ICU, notable differences existed between the survivors and non-survivors regarding several important demographic and clinical variables. The non-survivors were considerably older than the survivors, with a mean age of 69.3 ± 15.1 years for the non-survivors and 55.1 ± 16.3 years for the survivors ($p < 0.001$). The non-survivors also had significantly more comorbid hypertension ($p = 0.042$) and diabetes mellitus ($p = 0.031$) in the group of non-survivors. Furthermore, sepsis proved to be positively and notably associated with mortality in this sample; non-survivors reported sepsis at a rate of 53.7%, whereas the survivors only reported sepsis at 21.3% ($p < 0.001$). Analysis of other variables revealed no statistically significant differences in intensive care unit length of stay, gender, acute coronary syndrome, or respiratory failure **(Table I).**

Table I: Baseline demographic and clinical characteristics of the study population

Variable	Total (n = 182)	Survivors (n = 141)	Non-survivors (n = 41)	p-value
Age (years)	58.4 ± 17.2	55.1 ± 16.3	69.3 ± 15.1	<0.001*
Gender (Male)	104 (57.1%)	79 (56.0%)	25 (61.0%)	0.591
Hypertension	82 (45.1%)	58 (41.1%)	24 (58.5%)	0.042*
Diabetes Mellitus	70 (38.5%)	48 (34.0%)	22 (53.7%)	0.031*
Sepsis	52 (28.6%)	30 (21.3%)	22 (53.7%)	<0.001*
Acute Coronary Syndrome	42 (23.1%)	36 (25.5%)	6 (14.6%)	0.153
Respiratory Failure	32 (17.6%)	21 (14.9%)	11 (26.8%)	0.087
Length of ICU stay (days)	5.6 ± 3.2	5.4 ± 3.1	6.3 ± 3.5	0.185

**p ≤0.05 statistically significant*

Both hemodynamic parameters and shock index differed significantly between survivors and non-survivors. Non-survivors had higher mean heart rates (112.3±22.5 vs 98.6±18.4 beats/min, $p < 0.001$) and lower mean arterial pressures (81.4±9.5 vs 94.5±11.2 mmHg, $p < 0.001$). Therefore, the modified shock index (MSI) was significantly higher among non-survivors (1.36±0.25) than survivors (1.05±0.26, $p < 0.001$). Similarly, the age-modified shock index (AMSI) differed significantly, being higher in non-survivors (94.5±29.1) than in survivors (61.2±22.5; $p < 0.001$), and showed a stronger association with mortality **(Table II).**

Table II: Comparison of modified shock index (MSI) and age-modified shock index (AMSI) between survivors and non-survivors

Parameter	Survivors (n = 141)	Non-survivors (n = 41)	p-value
Heart rate (beats/min)	98.6 ± 18.4	112.3 ± 22.5	<0.001*
Mean arterial pressure (mmHg)	94.5 ± 11.2	81.4 ± 9.5	<0.001*
Modified shock index	1.05 ± 0.26	1.36 ± 0.25	<0.001*
Age-Modified Shock Index	61.2 ± 22.5	94.5 ± 29.1	<0.001*

**p ≤0.05 statistically significant*

MSI and AMSI were assessed using receiver operating characteristic (ROC) analysis to determine their predictive power of the two variables in in-hospital mortality (**Figure 1**).

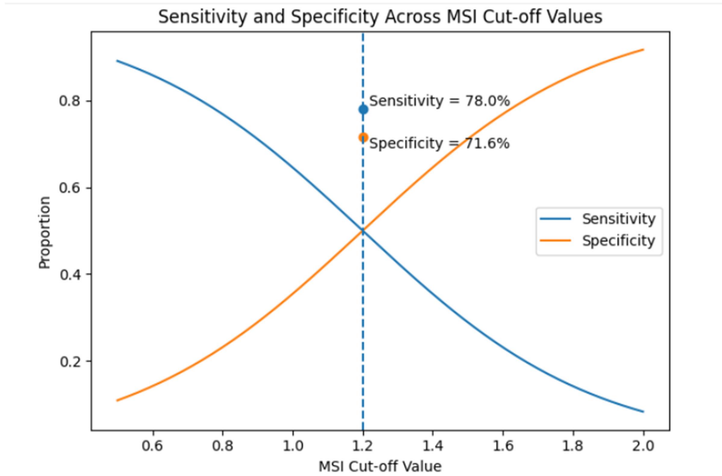

Figure 1: Sensitivity and specificity across different Modified Shock Index (MSI) cut-off values for prediction of in-hospital mortality

With an area under the curve (AUC) of 0.79 (95% CI 0.72-0.86) for MSI and 0.88 (95% CI 0.82-0.93) for AMSI, it was evident that AMSI had a substantially higher discriminative capacity. According to the Youden index, the ideal cut-off for MSI was ≥1.2, with a sensitivity of 78.0% and a specificity of 71.6%. With a sensitivity of 83.0% and a specificity of 80.1%, the ideal cut-off for AMSI was ≥75. The AUC difference between MSI and AMSI was statistically significant (p = 0.022) using the DeLong test **(Table III).**

Table III: Predictive accuracy of MSI and AMSI for in-hospital mortality

Parameter	AUC (95% CI)	Cut-off	Sensitivity (%)	Specificity (%)	P-value
Modified shock index	0.79 (0.72–0.86)	≥ 1.2	78.0	71.6	—
Age-Modified Shock Index	0.88 (0.82–0.93)	≥ 75	83.0	80.1	0.022*

**p ≤0.05 statistically significant*

Post-stratification assessment evaluated how the predictive performance of both indices was affected by age, sex, and comorbidities. The modified shock index (MSI) showed lower accuracy in older patients (AUC = 0.71) than in younger patients (AUC = 0.83). In contrast, the age-modified shock index (AMSI) demonstrated high discrimination across both age cohorts (AUC = 0.86–0.89). AMSI outperformed MSI in both males and females (AUC = 0.88 vs 0.78 and 0.87 vs 0.80, respectively), as well as in hypertensive or diabetic patients. Overall, AMSI demonstrated superior, consistently high prognostic performance across all assessed groups **(Table IV).**

Table IV: Post-stratification analysis of the modified shock index (MSI) and age-modified shock index (AMSI) across subgroups

Subgroup	MSI AUC (95% CI)	AMSI AUC (95% CI)	P-value
Age			
≤ 65 years	0.83 (0.74–0.90)	0.89 (0.82–0.94)	0.04*
> 65 years	0.71 (0.60–0.81)	0.86 (0.77–0.92)	0.01*
Gender			
Male	0.78 (0.69–0.86)	0.88 (0.80–0.93)	0.03*
Female	0.80 (0.68–0.89)	0.87 (0.78–0.94)	0.05
Hypertension			
Present	0.74 (0.63–0.84)	0.86 (0.77–0.92)	0.02*
Absent	0.82 (0.73–0.89)	0.89 (0.81–0.94)	0.04*
Diabetes			
Present	0.73 (0.61–0.83)	0.85 (0.76–0.92)	0.03*
Absent	0.81 (0.72–0.89)	0.88 (0.80–0.93)	0.04*

**p ≤0.05 statistically significant*

DISCUSSION

In this analytical cross-sectional study, we rigorously evaluated and compared the prognostic performance of the Age-Modified Shock Index (AMSI) and the Modified Shock Index (MSI) in predicting in-hospital mortality among adult patients admitted to the intensive care unit (ICU). Our findings demonstrate that both indices were significantly elevated in non-survivors compared to survivors, underscoring their utility as early hemodynamic markers of clinical deterioration. Notably, the AMSI demonstrated superior discriminative ability, with an area under the curve (AUC) of 0.88, significantly outperforming the MSI (AUC of 0.79). These results strongly suggest that incorporating age into traditional shock index calculations substantially improves mortality prediction in critically ill patients, providing a more nuanced, physiologically informed risk assessment tool.

The observed superiority of AMSI aligns with a growing body of evidence highlighting the prognostic value of age-adjusted indices in acute care settings. Age is a well-established independent predictor of outcomes in critical illness, reflecting diminished physiological reserve, increased comorbidity burden, and altered hemodynamic responses. By integrating age with real-time hemodynamic data, AMSI effectively captures both the acuity of the present illness and the patient's baseline vulnerability. This combination appears to offer greater prognostic insight than either component alone. This is particularly relevant in contemporary ICU practice, where patient populations are increasingly older and more complex, necessitating tools that can quickly identify those at highest risk of adverse outcomes.

To predict mortality among patients admitted to the intensive care unit (ICU), we evaluated and compared the prognostic performance of the Age-Modified Shock Index (AMSI) and the Modified Shock Index (MSI). According to our findings, AMSI demonstrated superior discrimination for predicting death, and both indices were significantly higher among non-survivors. These results suggest that adding age to traditional hemodynamic parameters may improve risk assessment for individuals in critical condition.

The results of this study revealed significantly higher modified shock index (MSI) and age-modified shock index (AMSI) among non-survivors, and the AMSI demonstrated a stronger measure of discrimination for in-hospital mortality (AUC 0.88 vs 0.79 for MSI). This finding, involving the incorporation of age to improve prediction performance, echoes the findings of multiple recent studies demonstrating that age-based indices perform better than unadjusted shock indices in heterogeneous populations, particularly older populations. Studies reported improved prognostic value of age-adjusted indices in myocardial infarction cohorts, supporting the concept that age captures baseline physiologic reserve and augments simple hemodynamic ratios[9,16].

Our results align with emerging literature that underscores the prognostic importance of integrating age into shock indices. In a meta-analysis by Vakhshoori M et al.[5], age-modified shock indices consistently outperformed traditional and modified shock indices in predicting mortality in acute heart failure, reinforcing the notion that physiological reserve and frailty - both closely tied to age - modulate the hemodynamic response to critical illness. Similarly, Wang S et al. [9] found that AMSI provided superior discrimination for post-discharge mortality in patients with ST-elevation myocardial infarction, further validating its utility beyond the ICU setting. The superior performance of AMSI in our cohort may be attributed to its ability to incorporate two powerful predictors - hemodynamic instability and biological age - into a single, rapidly calculable metric.

Comparisons with MSI-focused studies show broad agreement that MSI is a useful, easily obtainable bedside predictor of adverse outcomes, but is generally inferior to multi-parameter clinical scores. Research studies proved that MSI 1 or higher was not only independently correlated with in-hospital mortality but also associated with a large ACS cohort, with moderate discrimination (AUC ~0.72–0.72 range reported), which aligns with our MSI AUC of 0.79 and confirms MSI's role as a quick triage[15,17,18]. However, other studies also noted that more comprehensive risk scores, such as GRACE in ACS, outperformed MSI, highlighting MSI's value as a simple screen rather than a definitive prognostic[19,20].

Several disease- and setting-specific studies help explain the subgroup differences observed in our post-stratification analysis. A study found that SI/MSI retained predictive value for very early mortality in septic shock but that absolute performance varied by illness severity and vasoactive use; similarly, our MSI accuracy declined in patients >65 years (AUC 0.71), perhaps because aging alters the physiological heart rate and vascular responses to shock, blunting the discriminatory capacity of HR/MAP[21,22]. By contrast, AMSI, which explicitly scales MSI by chronological age, preserved high AUCs across age strata in our data, suggesting that age adjustment compensates for altered baseline physiology in older adults.

Meta-analytic and cohort studies also contextualize our findings. A study evaluated SI derivatives in acute heart failure and reported superior performance of age-adjusted indices (including AMSI) over unadjusted SI or MSI; this parallels our finding that AMSI outperformed MSI among patients with comorbid hypertension or diabetes, groups in whom baseline cardiovascular physiology and autonomic responses are frequently altered. The consistency of AMSI performance across comorbidity strata in our study suggests its robustness as a generalizable ICU screening measure[5,23].

Trauma and neurocritical illness literature provides additional perspectives: several recent trauma and TBI studies show that adding age or neurologic scores to shock indices improves discrimination for mortality and the need for interventions. These studies support our implication that adding patient-level variables (age, illness type) to hemodynamic ratios conveys clinically meaningful predictive gain and justify considering AMSI in triage algorithms across mixed ICU case[3,24].

Despite promising results, limitations temper broad adoption. Our single-centre cohort and sample size may limit generalizability; the performance of AMSI should be validated in larger, multicenter datasets and disease-specific subgroups. The shock indices are single-time point measures, and dynamic changes (delta SI or trends after resuscitation) may yield additional prognostic information, as shown in trauma studies. Age-multiplication raises questions about the best functional form (e.g., age × MSI vs age-threshold adjustment); future work should compare different age-integration approaches and calibrate cut-offs for local populations. Finally, confounding by vasoactive drugs, baseline beta-blocker use, and measurement timing may affect MSI/AMSI values and should be controlled for in prospective validation studies.

Furthermore, this study utilized a single-centre design and a relatively small sample size, which may limit the generalizability of our findings. The performance of AMSI should be validated in larger, multicenter cohorts and across different ICU populations. Additionally, the shock index and its derivatives are calculated from a single time point at admission; dynamic changes in these indices during resuscitation or after intervention may provide additional prognostic value, as suggested in prior studies evaluating trends in shock indices in trauma and sepsis[25,26]. Future studies should explore serial measurements and their utility in monitoring treatment response.

In clinical terms, our findings demonstrate that the AMSI, which is also easy to compute at the bedside, has the potential to facilitate early risk stratification in ICUs, thereby better prioritizing monitoring and escalating care when resources are limited. However, AMSI is best used as a complement to, rather than as a replacement for, an overall clinical assessment, as well as the use of established risk scores, until further external validation has demonstrated more reliable utility across different settings.

CONCLUSION

The Age-Modified Shock Index (AMSI) demonstrated superior predictive accuracy for in-hospital mortality compared to the Modified Shock Index (MSI) in a heterogeneous ICU population. By incorporating age - a key determinant of physiological reserve - AMSI offers a simple, rapid, and robust bedside tool for early risk stratification. Its consistent performance across age, gender, and comorbidity subgroups supports its potential integration into ICU triage and monitoring protocols to identify high-risk patients requiring timely intervention. Further multicenter validation is warranted to establish standardized cut-offs and confirm generalizability.

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AUTHOR CONTRIBUTION

Wahab A**:** Conceptualized and designed the study, supervised data collection, performed data analysis and interpretation, drafted the initial manuscript, and critically revised the manuscript for important intellectual content. Approved the final version for publication and agrees to be accountable for all aspects of the work.
Shaikh FH: Contributed to study design and methodology, conducted literature search, designed the data collection proforma, coordinated and performed data acquisition in the ICU, assisted in data analysis, and contributed to writing and revising the manuscript.
Ara J: Contributed to the study concept, assisted in data interpretation, provided critical revision of the manuscript for important intellectual content, approved the final version for publication and agrees to be accountable for all aspects of the work.
Fatima K: Contributed to the study for proofreading and technical correction.
Siddiqui S: Validated the statistical analysis.
Muhammad A: Helped in results interpretation and generated result tables, searched references for discussion writing

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