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Peripheral Perfusion Index-Shock Index-Emergency Severity Index in Prediction of Outcome of Patient In Tertiary Care Hospital

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ABSTRACT
As increasing emergency care demand, it puts pressure on the ED hampering the patient care. Multiple systems are working on triaging of the patients worldwide. Emergency Severity Index is the most used system in western countries increasing the influence in other parts of the world also. Objective. Evaluation of correlation between indices like PPI, SI and ESI in patients who presents to the Emergency Department. A cross-sectional study was conducted by department of pediatrics at Shri BM Patil Medical College Hospital and Research Centre. The study included hospital-based patients coming in Emergency Department. Data was collected via triage examination of the patients and the in-hospital status of the patients. The study evaluated the integration of the PPI-Peripheral Perfusion Index and SI-Shock Index with the ESI-Emergency Severity Index to improve triage accuracy in emergency departments. The findings indicated that PPI and SI significantly enhance the predictive power of ESI, leading to better identification of high-risk patients and more timely interventions. Peripheral Perfusion Index and Shock Index significantly enhance the predictive power of Emergency Severity Index, leading to better identification of high-risk patients and more timely interventions. The study suggests that incorporating these objective indices can optimize resource allocation and improve patient care.

INTRODUCTION

In recent years, emergency departments (EDs) globally have experienced a substantial increment in patient admissions, necessitating the implementation of efficient and effective triage systems. These systems are crucial for prioritizing patient care, facilitating quick decision-making and managing the overwhelming influx of patients. The primary goal of triage systems is to identify high-or low-risk patients, guiding different care trajectories and risk identification for hospital complications[1]. Although many Indian systems still rely on conventional triage systems that categorize patients using color codes-green, yellow and red-several evidence-based triage systems are using globally. Notable among these are the Emergency Severity Index (ESI), the Canadian Triage Acuity Scale, the Soterion Rapid Triage System[2]. Among all of these, the ESI has gained widespread acceptance, particularly in the United States and is increasingly utilized in non-English-speaking countries[3]. The increasing demand for emergency care has placed immense pressure on EDs to efficiently manage patient flow and prioritize care[4]. Triage systems play a pivotal role in this process, enabling healthcare providers to quickly assess patient severity and make informed decisions regarding treatment priorities[5,6]. The ESI categorizes patients on the emergency of their clinical condition and the resources they require. However, its reliance on subjective assessments and the potential for normal vital signs to mask underlying conditions highlight the need for supplementary objective measures. The study aims to evaluate the correlation between the PPI, SI, and ESI in patients presenting to the triage.

MATERIALS AND METHODS

This Prospective observational study, designed to investigate the prognostic performance of the PPI, SI, with Emergency Severity Index (ESI) in predicting hospital outcomes such as ventilator need and clinical improvement or deterioration of the patient. Conducted in the Emergency Medicine Department of BLDE, Shri B M Patil Medical College Hospital and Research Centre, Vijayapura, this study planned from August 2022 till April 2024.

The present study included all patients aged 18 years old age and older who presented to the E M Department during the study period.

Exclusion Criteria: were established to eliminate potential confounding factors that could bias the study's results. Specifically, patients were excluded if they were pronounced dead on arrival, transferred to another hospital immediately after initial assessment, had consumed alcohol or sedative narcotics prior to measurement, had unobtainable PPI measurements, or were moribund with terminal malignancy.

Sample Size: Sample size for current study was calculated using [G*Power ver. 3.1.9.4 software]. Based on the assumption that the proportion of 30-day mortality is 7.9%, the software calculated that a minimum size with 136 patients, required to achieve the power of 99% for detecting a difference in proportion with a 5% level of significance. However, to enhance the robustness and reliability of the findings, the study aimed to enroll a total of 600 patients.

Study Variables: Primary variables in this study were the Peripheral Perfusion Index-PPI, Shock Index-SI and Emergency Severity Index-ESI. These indices were selected for their potential to provide critical insights into patient status and prognosis. Additional variables measured included:

Shock Index (SI): Calculated by the ratio of heart rate divided by systolic blood pressure, It is used for an indicator of hemodynamic stability. All parameters were recorded after the patient had rested for five minutes upon arrival at the Emergency Medicine Department to ensure stable and accurate measurements.

Data Sources/Measurement: Data were sourced from patient records maintained in the Emergency Medicine Department. The PPI was measured using photoelectric plethysmography pulse-oximetry, a non-invasive technique that assesses peripheral blood flow by detecting changes in blood volume in the skin. The SI was measured with recorded heart rate and systolic blood pressure values. The ESI was determined by trained emergency department personnel using standardized assessment protocols that evaluate the clinical condition of the patient and the resources required in their care.

Data Collection Procedure: Upon patient arrival at the Emergency Medicine Department, initial assessments were conducted by trained emergency medical staff. This initial assessment included recording like heart rate, systolic and diastolic blood pressures, and calculating SI. The PPI was measured using a pulse oximeter equipped with photoelectric plethysmography capabilities, ensuring a non-invasive and continuous assessment of peripheral perfusion. All measurements were taken after the patient had rested for five minutes to ensure accuracy and consistency. The ESI was assigned based on a detailed assessment of the patient's vital signs, presenting symptoms and overall clinical picture by trained personnel, ensuring uniformity and reliability in triage categorization.

The primary quantitative variables in this study included the PPI, SI along with Emergency Severity Index (ESI).

Shock Index (SI): Calculated as ratio of heart rate divided by systolic blood pressure, serving as a quick indicator of circulatory health.

Statistical Analysis: Statistical analysis was done using SPSS (Version 20). Descriptive statistics were employed to summarize the data, presenting means, medians, standard deviations (SD), counts and percentages to provide a clear overview of the patient demographics and clinical characteristics. For comparing groups, an independent sample t-test was used for normally distributed continuous variables, ensuring accurate comparison of means between two groups.
The correlation between PPI, SI and ESI was assessed using Pearson or Spearman correlation coefficients, depending on the normality of the data distribution. The prognostic value of PPI, SI and ESI in predicting adverse outcomes was further assessed using receiver operating characteristic (ROC) curve analysis and the area under the curve (AUC).

RESULTS AND DISCUSSIONS

Majority of participants were aged between 31-45 years (26.7%), followed closely by those over 60 years (29.2%). Subjects aged 15-30 years consist of 24.8% of the sample, while those aged 46-60 years made up 19.3%. In terms of gender distribution, males represented a significant majority at 66.9%, with females accounting for 33.1%. The study population was predominantly Hindu (92.5%), with Muslims constituting 6.7% of the participants.

Table 1: Factors Associated with Emergency Severity Index (ESI) Outcomes (n=610)

Factors	Emergency Severity Index (ESI)		p-value
	<3 (poor)	>3 (good)	
Age (in years)			
15 - 30	55 (36.4)	96 (63.6)	<0.001
31 - 45	86 (52.8)	77 (47.2)	
46 - 60	77 (65.3)	41 (34.8)	
>60	117 (65.7)	61 (34.3)	
Sex			
Male	240 (58.8)	168 (41.2)	0.006
Female	95 (47.0)	107 (53.0)	
Religion			
Hindu	305 (54.1)	259 (45.9)	0.018
Muslim	30 (73.2)	11 (26.8)	
ICU admission			
Yes	307 (98.7)	4 (1.3)	<0.001
No	28 (9.4)	271 (90.6)	
Mechanical Ventilation			
Yes	154 (96.9)	5 (3.1)	<0.001
No	181 (40.1)	270 (59.9)	
PI			
PI at admission	2.0 (2.2)	4.9 (1.7)	<0.001
PI at 12 hours	2.9 (3.2)	5 (1.9)	<0.001
PI at 48 hours	1.6 (4.4)	5.9 (2.0)	<0.001
SI			
SI at admission	0.8 (0.3)	0.6 (0.1)	<0.001
SI at 12 hours	0.9 (0.3)	0.5 (0.1)	<0.001
SI at 48 hours	0.9 (0.6)	0.4 (0.1)	<0.001

Table-1 provides an in-depth analysis of factors associated with the Emergency Severity Index (ESI) outcomes among 610 study participants. The results reveal significant associations between ESI outcomes and various demographic and clinical factors. Age emerges as a crucial determinant, with younger participants (15-30 years) showing better ESI outcomes, as 63.6% of individuals in this age group had a good ESI (>3). In contrast, older age groups, particularly those aged 46-60 years and over 60 years, predominantly had poor ESI outcomes (65.3% and 65.7%, respectively), highlighting a significant age-related disparity (p<0.001).
Gender differences were also notable, with males exhibiting a higher proportion of poor ESI outcomes (58.8%) compared to females, where the majority achieved good ESI outcomes (53.0%) (p=0.006). This suggests a potential gender influence on emergency care outcomes. Additionally, religion was significantly associated with ESI outcomes. Hindus showed a more balanced distribution of ESI outcomes (54.1% poor, 45.9% good), while Muslims had a higher prevalence of poor ESI outcomes (73.2%), indicating a significant religious disparity (p=0.018). Clinical factors further emphasized the critical nature of ICU admission and mechanical ventilation. A striking 98.7% of patients requiring ICU admission had poor ESI outcomes (p<0.001) and 96.9% of those needing mechanical ventilation also fell into the poor ESI category (p<0.001). These findings underscore the severity of conditions requiring such intensive interventions and their impact on ESI outcomes.

Table 2: Factors with 48-Hour Outcomes Among Study Participants (n=610)

Factors	48-hour outcome		
	Deteriorated	Improved/ Discharged	p-value
Age (in years)			
15 - 30	20 (13.3)	131 (86.8)	<0.001
31 - 45	38 (23.3)	125 (76.7)	
46- 60	42 (35.6)	76 (64.4)	
>60	72 (40.5)	106 (59.5)	
Sex			
Male	124 (30.4)	284 (69.6)	0.087
Female	48 (23.8)	154 (76.2)	
Religion			
Hindu	154 (27.3)	410 (72.7)	0.023
Muslim	18 (43.9)	23 (56.1)	
ICU admission			
Yes	172 (28.2)	139 (44.7)	<0.001
No	0 (0.0)	299 ((100.0)	
Mechanical Ventilation			
Yes	126 (79.3)	33 (20.8)	<0.001
No	46 (10.2)	405 (89.8)	
PI			
PI at admission	1.7 (0.9)	4.0 (1.9)	<0.001
PI at 12 hours	1.1 (1.0)	4.6 (1.9)	<0.001
PI at 48 hours	0.1 (0.1)	5.0 (2.3)	<0.001
SI			
SI at admission	0.9 (0.2)	0.6 (0.1)	<0.001
SI at 12 hours	1.0 (0.1)	0.5 (0.1)	<0.001
SI at 48 hours	1.2 (0.3)	0.5 (0.2)	<0.001

Continuous monitoring of Patient Index (PI) and Shock Index (SI) scores revealed significant correlations with

ESI outcomes. Patients with poor ESI outcomes had consistently lower PI scores at admission, 12 hours, and 48 hours (2.0, 2.9 and 1.6, respectively) compared to those with good ESI outcomes (4.9, 5.0 and 5.9, respectively) (p<0.001 for all). Similarly, higher SI scores at these time points were associated with poor ESI outcomes (0.8, 0.9 and 0.9) compared with good outcomes (0.6, 0.5, and 0.4) (p<0.001 for all). The analysis of 48-hour outcomes among study participants reveals significant associations between patient deterioration and various demographic and clinical factors. Age emerged as a critical determinant, with older patients more likely to deteriorate. Specifically, 40.5% of participants over 60 years deteriorated, compared to only 13.3% of those aged 15-30 years (p<0.001). This suggests that older age is a strong risk factor for poor outcomes. Gender differences were observed, with males having a higher rate of deterioration (30.4%) compared to females (23.8%), although this was not statistically significant (p=0.087). Religious affiliation also played a role, with Muslims experiencing higher deterioration rates (43.9%) compared to Hindus (27.3%), indicating a notable disparity (p=0.023).

Clinical factors, particularly ICU admission and mechanical ventilation, were closely linked to patient deterioration. A striking 98.7% of patients who deteriorated were admitted to the ICU, compared to none in the improved/discharged group, reflecting a significant association (p<0.001). Similarly, mechanical ventilation was a critical factor, with 79.3% of ventilated patients deteriorating, compared to just 10.2% of those not ventilated (p<0.001). These findings underscore the importance of ICU resources and ventilation support in the prognosis of patients within the first 48 hours.

PPI and SI indices provided further insight into patient outcomes. Patients who deteriorated had significantly lower PI scores at admission (1.7 vs. 4.0), 12 hours (1.1 vs. 4.6) and 48 hours (0.1 vs. 5.0), all with p-values <0.001. Higher SI scores were also linked to deterioration at admission (0.9 vs. 0.6), 12 hours (1.0 vs. 0.5) and 48 hours (1.2 vs. 0.5), with all comparisons yielding p-values <0.001.

Age was significantly associated with the need for mechanical ventilation. Participants over 60 years had the highest rate of ventilator use (35.4%), while those aged 15-30 years had the lowest (12.5%) (p<0.001). This indicates a strong age-related trend, with older individuals being more likely to require ventilator support. Gender differences were observed, though not statistically significant, with 27.5% of males and 23.3% of females needing ventilation (p=0.268). Regarding religious affiliation, Muslims had a higher rate of ventilator use (41.5%) compared to Hindus (25.2%), showing a significant association (p=0.022). ICU admission was strongly correlated with ventilator use, where 49.8% of those admitted to the ICU required ventilation compared to only 1.3% of those not admitted (p<0.001). This underscores the critical condition of ICU patients and their higher likelihood of needing mechanical ventilation. Additionally, physiological indices (PI and SI) were significant predictors of ventilator use. Patients on ventilators had lower PI scores at admission (1.7 vs. 4.0), 12 hours (1.1 vs. 4.5) and 48 hours (0.1 vs. 5.0), with all comparisons showing p-values<0.001. Similarly, higher SI scores were associated with ventilator use at admission (0.9 vs. 0.6), 12 hours (1.0 vs. 0.6) and 48 hours (1.2 vs. 0.5), all with p-values <0.001. Overall, the analysis highlights that older age, ICU admission, religious affiliation and lower PI and higher SI scores are significantly associated with the need for mechanical ventilation.

Table 3: Factors Associated with Ventilator Use Among Study Participants (n=610)

Factors	Ventilator		
	Yes	No	p-value
Age (in years)			
15 - 30	19 (12.5)	132 (87.4)	<0.001
31- 45	39 (23.9)	124 (76.1)	
46 - 60	38 (32.2)	80 (67.8)	
>60	63 (35.4)	115 (64.6)	
Sex			
Male	112 (27.5)	296 (72.5)	0.268
Female	47 (23.3)	155 (76.7)	
Religion			
Hindu	142 (25.2)	422 (74.8)	0.022
Muslim	17 (41.5)	24 (58.5)	
ICU admission			<0.001
Yes	155 (49.8)	156 (50.2)	
No	4 (1.3)	295 (98.7)	
PI			
PI at admission	1.7 (1.0)	4.0 (2.1)	<0.001
PI at 12 hours	1.1 (1.1)	4.5 (1.9)	<0.001
PI at 48 hours	0.1 (0.9)	5.0 (2.3)	<0.001
SI			
SI at admission	0.9 (0.2)	0.6 (0.1)	<0.001
SI at 12 hours	1.0 (0.2)	0.6 (0.2)	<0.001
SI at 48 hours	1.2 (0.4)	0.5 (0.3)	<0.001

This table presents the factors associated with a poor Emergency Severity Index (ESI) category (<3) among the study participants. Age showed a significant association with poor ESI stages. Participants between 31-45 years had almost twice the odds (OR: 1.95, 95% CI: 1.24-3.06) of have a poor ESI compared to those aged 15-30 years. This risk increased substantially with age, with participants aged 46-60 years (OR: 3.27, 95% CI: 1.98-5.42) and those over 60 years (OR: 3.34, 95% CI: 2.12-5.26) showing more than threefold increased odds of poor ESI outcomes (p<0.001 for both). Sex was another significant factor, with males having 1.60 times higher odds of poor ESI outcomes compared to females (OR: 1.60, 95% CI: 1.15-2.25, p=0.006). Religious affiliation also played a role, where Muslims had more than double the odds of poor ESI outcomes compared to Hindus (OR: 2.31, 95% CI: 1.13-4.71, p=0.021).

Table 4: Factors Associated with ESI Category (<3) Among Study Participants

Variables	ESI Category (<3) OR (95%CI)	p-value
Age (in years)		
15 - 30	Ref	
31 - 45	1.95 (1.24 - 3.06)	0.004
46 - 60	3.27 (1.98 - 5.42)	<0.001
>60	3.34 (2.12 - 5.26)	<0.001
Sex		
Female	Ref	
Male	1.60 (1.15 - 2.25)	0.006
Religion		
Hindu	Ref	
Muslim	2.31 (1.13- 4.71)	0.021
Need of ventilator		
No	Ref	
Yes	45.94 (18.48 - 114.17)	<0.001
PPI 0	0.26 (0.21 - 0.32)	<0.001
PPI12	0.33 (0.28 - 0.40)	<0.001
PPI48	0.45 (0.40 - 0.52)	<0.001
SI 0	1.10 (1.08- 1.12)	<0.001
SI12	1.15 (1.12 - 1.19)	<0.001
SI48	1.15 (1.12 - 1.18)	<0.001

The need for ventilator support was the most significant predictor of poor ESI outcomes, with those requiring ventilation having drastically higher odds (OR: 45.94, 95% CI: 18.48-114.17, p<0.001). Physiological parameters (PPI and SI) were also significantly associated with ESI outcomes. Lower PPI scores at admission, 12 hours and 48 hours were associated with poor ESI outcomes (all p<0.001). Conversely, higher SI scores at admission, 12 hours and 48 hours were significantly corelates with poor ESI levels (all p<0.001).

Table 5: Factors Associated with clinical Deterioration at 48 hours Among Study Participants (n=610)

Variables	Outcome - Deteriorated OR (95%CI)	p-value
Age (in years)		
15 - 30	Ref	
31 - 45	1.99 (1.09 - 3.60)	0.023
46 - 60	3.62 (1.98 - 6.61)	<0.001
>60	4.44 (2.54 - 7.77)	<0.001
Sex		
Female	Ref	
Male	1.40 (0.95 - 2.06)	0.088
Religion		
Hindu	Ref	
Muslim	2.08 (1.09 - 3.96)	0.025
Need of ventilator		
No	Ref	
Yes	33.61 (20.59 - 54.86)	<0.001
PPI 0	0.24 (0.19 - 0.30)	<0.001
PPI12	0.19 (0.15 - 0.25)	<0.001
PPI48	0.19 (0.14 - 0.25)	<0.001
SI 0	1.07 (1.06 - 1.09)	<0.001
SI12	1.09 (1.08 - 1.11)	<0.001
SI48	1.09 (1.07 - 1.10)	<0.001

This table presents the factors associated with deterioration among the study participants. Age was a significant predictor, with participants aged 31-45 years having nearly twice the odds of deterioration compared to those aged 15-30 years (OR: 1.99, 95% CI: 1.09-3.60, p=0.023). Risk of deterioration increased substantially with age, with those aged 46-60 years (OR: 3.62, 95% CI: 1.98-6.61) and those over 60 years (OR: 4.44, 95% CI: 2.54-7.77) showing significantly higher odds of deterioration (both p<0.001). Sex did not show a statistically significant difference, although males has slightly increased odds of deterioration compared to females (OR: 1.40, 95% CI: 0.95-2.06, p=0.088). Religious affiliation revealed that Muslims had more than double the odds of deterioration compared to Hindus (OR: 2.08, 95% CI: 1.09-3.96, p=0.025).

The need for ventilator support was the most significant predictor of deterioration, with participants requiring ventilation having dramatically higher odds (OR: 33.61, 95% CI: 20.59-54.86, p<0.001). Physiological parameters (PPI and SI) were also significantly associated with deterioration. Lower PPI scores at admission, 12 hours and 48 hours were strongly associated with deterioration (all p<0.001). Conversely, higher SI scores at admission, 12 hours, and 48 hours were significantly associated with deterioration (all p<0.001).

This table presents the factors associated with the need for ventilator support among study participants. Age significantly impacted the need for ventilator support, with participants aged 31-45 years having over twice the odds (OR: 2.18, 95% CI: 1.19-3.98, p=0.011) compared to those aged 15-30 years. The likelihood increased further for those aged 46-60 years (OR: 3.30, 95% CI: 1.78-6.11) and those over 60 years (OR: 3.80, 95% CI: 2.15-6.73), both showing a highly significant association (p<0.001). Sex did not show a significant difference, although males had slightly higher odds of needing ventilator support compared to females (OR: 1.24, 95% CI: 0.84-1.84, p=0.268). However, religious affiliation revealed that Muslims had more than double the odds of requiring ventilator support compared to Hindus (OR: 2.10, 95% CI: 1.09-4.03, p=0.025).

Physiological parameters were also significantly associated with the need for ventilator support. Lower PPI scores at admission, 12 hours and 48 hours were strongly associated with the need for ventilator support (all p<0.001). Similarly, higher SI scores at admission, 12 hours and 48 hours were significantly associated with an increased need for ventilator support (all p<0.001).

The study explains a comprehensive analysis of indicators influencing Emergency Severity Index (ESI) outcomes, clinical deterioration within 48 hours and the need for ventilator support among patients ended up to the emergency department. The strong association of ICU admission and mechanical ventilation with poor ESI outcomes is a reflection of the severity and complexity of the conditions requiring these interventions. Patients admitted to the ICU typically present with life-threatening conditions that require intensive monitoring and aggressive management. These conditions often involve multi-organ dysfunction, severe infections, or major trauma, all of which carry a high risk of morbidity and mortality. Mechanical ventilation is an indicator of respiratory failure, which can arise from various underlying causes such as acute respiratory distress syndrome (ARDS), sepsis, or severe pneumonia. The need for mechanical ventilation signifies a critical level of illness, with a high likelihood of complications and prolonged recovery periods.

Table 6: Factors Associated with the Need for Ventilator Support

Variables	Need for Ventilator OR (95%CI)	p-value
Age		
15 - 30	Ref	
31 - 45	2.18 (1.19 - 3.98)	0.011
46 - 60	3.3 (1.78 - 6.11)	<0.001
>60	3. 8 (2.15 - 6.73)	<0.001
Sex		
Female	Ref	
Male	1.24 (0.84 - 1.84)	0.268
Religion		
Hindu	Ref	
Muslim	2.10 (1.09 - 4.03)	0.025
PPI 0	0.36 (0.30 - 0.43)	<0.001
PPI12	0.31 (0.26 - 0.37)	<0.001
PPI48	0.46 (0.41 - 0.51)	<0.001
SI 0	1.07 (1.06 - 1.08)	<0.001
SI12	1.07 (1.06 - 1.08)	<0.001
SI48	1.05 (1.04 - 1.05)	<0.001

The association with poor ESI outcomes underscores the critical condition of these patients and the intensive care required to manage their illnesses. The significant correlations of PPI and SI with ESI outcomes, clinical deterioration, and ventilator use highlight the importance of continuous physiological monitoring in the ED. The PPI is an indicator of peripheral circulation, reflecting the perfusion status of tissues. It provides real-time data on the adequacy of blood circulation, which is crucial in detecting early signs of shock or hemodynamic instability. Low PPI values indicate poor peripheral perfusion, which can be a result of hypovolemia, vasoconstriction, or cardiac dysfunction. In the context of emergency care, early detection of reduced peripheral perfusion allows for timely interventions such as fluid resuscitation, vasopressor support, or other measures to restore adequate tissue perfusion and prevent further deterioration. The SI, calculated as the division of heart rate by systolic blood pressure, serves as a quick and effective indicator of hemodynamic stability. An elevated SI suggests a state of shock, where the heart rate is disproportionately high relative to the blood pressure, indicating compromised cardiac output and circulatory failure. The association of higher SI values with poor ESI outcomes and increased need for ventilator support reflects the critical nature of hemodynamic instability in these patients.

Clinical deterioration within 48 hours among patients in the ED is precipitated by a combination of agents, counting underlying comorbidities, the severity of the presenting illness and the effectiveness of initial management. The high rate of deterioration among older patients can be attributed to their reduced physiological reserves and the presence of multiple comorbid statuses, which can complicate the clinical course and response to treatment. The need for mechanical ventilation and Intensive Care Unit admission are strong indicators of the severity of illness. Patients requiring these interventions are at a higher risk of deterioration due to the underlying critical conditions that necessitate such intensive support. The high odds of deterioration associated with mechanical ventilation underscore the complexity and severity of respiratory failure and the need for vigilant monitoring and management to prevent further decline.

CONCLUSION

The study evaluated the integration of the PPI-Peripheral Perfusion Index and SI-Shock Index with the ESI-Emergency Severity Index to improve triage accuracy in emergency departments. The findings indicated that PPI and SI significantly enhance the predictive power of ESI, leading to better identification of high-risk patients and more timely interventions.

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