

**“PERIPHERAL PERFUSION INDEX- SHOCK INDEX- EMERGENCY SEVERITY INDEX IN PREDICTION OF OUTCOME OF PATIENT IN TERTIARY CARE HOSPITAL.”**

**BY**

**Dr. Shubham Deore**

**DISSERTATION SUBMITTED TO**



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**IN PARTIAL FULFILLMENT FOR THE DEGREE OF  
DOCTOR OF MEDICINE IN EMERGENCY MEDICINE,**

**Under the Guidance of**

**DR. RAVI B PATIL**

**PROFESSOR AND HOD,**

**DEPARTMENT OF EMERGENCY MEDICINE,**

**2024**

**B.L.D.E. (DEEMED TO BE UNIVERSITY) SHRI B. M. PATIL**  
**MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE**  
**VIJAYAPUR**

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I hereby declare that this dissertation/thesis entitled “**PERIPHERAL PERFUSION INDEX-SHOCK INDEX- EMERGENCY SEVERITY INDEX IN PREDICTION OF OUTCOME OF PATIENT IN TERTIARY CARE HOSPITAL.**” is a bonafide and genuine research work carried out by me under the guidance of **Dr. RAVI B PATIL** Professor and HOD, Dept of Emergency Medicine, Shri B.M. Patil Medical College, Vijayapura, Karnataka.



**Dr SHUBHAM DEORE**

Post Graduate student,

Department of Emergency Medicine.

BLDE (Deemed to be University)

Shri B M Patil Medical College, Hospital

And Research Centre, Vijayapura

Date:30/07/2024

Place: Vijayapura

**B.L.D.E. (DEEMED TO BE UNIVERSITY) SHRI B. M. PATIL**  
**MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE**  
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**CERTIFICATE BY THE GUIDE**

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**Dr RAVI B PATIL,**

Guide

Professor and HOD,

Department of emergency medicine,

BLDE (Deemed to Be University)

Shri B M Patil Medical College Hospital and  
Research Centre, Vijayapura.

Date:30/07/2024

Place: Vijayapura

**B.L.D.E. (DEEMED TO BE UNIVERSITY)**  
**SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL &**  
**RESEARCH CENTRE, VIJAYAPUR**

**ENDORSEMENT BY THE HOD & PRINCIPAL / HEAD OF THE  
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Seal & Signature of  
HOD of Emergency Medicine



**DR Ravi B Patil**  
**M.D (Emergency Medicine)**  
BLDEU's Shri B.M. Patil  
Medical College, Hospital & Research  
Centre, Vijayapura

Date: 30/07/2024

Place: Vijayapura

Seal & Signature of  
The principal



**DR Aravind V Patil**  
**M.S (General Surgery)**  
BLDEU's Shri B.M. Patil  
Medical College, Hospital & Research Centre,  
Vijayapura

Date: 30/07/2024

Place: Vijayapura

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**Dr. SHUBHAM DEORE**  
Post Graduate Student,  
Department of Emergency Medicine,  
Shri B.M. Patil Medical College, Vijayapura.

Date: 30/07/2024

Place: Vijayapura

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**VIJAYAPUR**

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**Dr. SHUBHAM DEORE.**

## **ABSTRACT**

### **INTRODUCTION:**

The admissions in the Emergency Department are increasing day by day in recent years requiring the strong and effective triage systems. The goals of these triage systems are to differentiate the patients as high to low-risk patients and immediate attention to the high-risk patients. 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. It consists of five stage system. Certain indicators like peripheral perfusion index and shock index which can be easily obtained in triage can be added to the ESI grading to improve and to make the triage more effective and improving the patient care in the Emergency Department.

### **OBJECTIVES**

To determine the combined effect of the Peripheral Perfusion Index and Shock Index with ESI to predict hospital outcomes in the form of need of ventilation and morbidity in acute critically ill patients coming to Emergency Department. To determine the individual effect of the Peripheral Perfusion Index, Shock Index and Emergency Severity Index.



**TYPE OF STUDY:** Cross sectional study.

**STUDY PERIOD:** Period of 21 months (August 2022 to April 2024).

**STUDY POPULATION:**

Patients coming to Emergency Department BLDE, Shri B.M Patil Medical College Hospital and Research Centre, Vijayapura from August 2022 to April 2024 consisting of patients aged older than 18 years who visited the Emergency Medicine department who met the inclusion Criteria.

**METHODOLOGY:**

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 triage included variables such as age, residence, sex, heart rate, systolic blood pressure, shock index, peripheral perfusion index and emergency severity index grading.

**STATISTICAL ANALYSIS:**

Statistical analyses were conducted using SPSS (Version 20). The Mann-Whitney U test was employed for non-normally distributed variables to compare medians accurately. Categorical variables were analyzed using the Chi-square test or Fisher's exact test to determine associations

between different categorical outcomes and groups. For comparisons involving more than two groups, ANOVA was utilized for normally distributed variables, and the Kruskal-Wallis H test for non-normally distributed variables, ensuring appropriate analysis based on data distribution. The correlation between PPI, SI, and ESI was assessed using Pearson or Spearman correlation coefficients, depending on the normality of the data distribution. Logistic regression analysis was conducted to evaluate the association of PPI and SI measurements with hospital admission and mortality outcomes, providing insights into the predictive value of these indices. 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:**

Among the 610 participants, Emergency Severity Index (ESI) score of less than 3, The PPI at admission shows a strong predictive accuracy with an AUC of 0.89 and a standard error of 0.01. At 12 hours, the PPI's AUC slightly decreased to 0.86, and at 24 hours, it modestly increased to 0.87, indicating consistent predictive performance over time. The SI at admission had an AUC of 0.82, with a standard error of 0.02, reflecting moderate predictive accuracy. The SI's predictive power improved significantly, with an AUC of 0.93 at 12 hours and 0.95 at 48 hours, demonstrating high predictive accuracy.

## **CONCLUSION:**

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. Future research should validate these results across multiple centers and explore additional variables. In conclusion, integrating PPI and SI with ESI can enhance triage effectiveness, ensuring better patient outcomes and more efficient emergency department operations.

**Keywords:** Triage, Heart Rate, Systolic Blood Pressure, Peripheral Perfusion Index, Shock Index, Emergency Severity Index.

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## 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) 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 Emergency Severity Index is a five-level triage tool that not only evaluates patients' vital signs but also considers their current resources and symptoms.(6) This comprehensive approach aims to provide a more nuanced assessment of patient severity. Despite its widespread use, the ESI has certain limitations. It involves subjective judgment, which can lead to variability in triage decisions.(7) Though, vital signs may remain within normal limits until physiologic compensatory mechanisms are overwhelmed, potentially leading to the misclassification of high-risk patients. So, there is a need of additional objective measurements to supplement the ESI, enhancing the accuracy of patient risk assessment and improving outcomes.

One such objective measurement is the PPI-Peripheral Perfusion Index, [a non-invasive numerical value reflecting real-time changes in peripheral blood flow]. Obtained from the photoelectric plethysmographic signal of pulse oximetry, PPI is recorded on the pulse-oximeter monitor and is fluctuating by the amount of blood flow at the monitoring site.(8) An increase in pulsatile flow, indicated by greater pulsation intensity, results in a higher PPI value. PPI serves as an at time recording of local blood flow changes, indicating tissue perfusion. Recent trails have demonstrated significant correlation between PPI with patient outcomes, suggesting its potential as a valuable prognostic tool in the ED setting.(9)

Another important measure of hemodynamic stability is the SI i.e, Shock Index, defined as the components like heart rate divided by systolic blood pressure. SI being useful outcome variable with various clinical conditions and is a key indicator of hemodynamic instability.(10,11) An elevated SI often signals reduced contractility and left ventricular output and acute circulatory damage, with a persistent increase indicates worsening with increased morbidity and



mortality.(12) Despite its clinical utility, SI has been studied in critically ill patients within intensive care settings, with limited research on its application in the ED.(13)

The study aims to evaluate the correlation between the PPI, SI, and ESI in patients presenting to the triage. It will help to assess whether PPI and SI measurements are associated with requirement of ventilation and condition of the patient at 48 hours outcome. Additionally, the study seeks to determine if any of these indicators play a significant role in predicting clinical results compared to the others. Understanding the relationships between these indices and hospital outcomes could provide valuable insights for enhancing triage accuracy and improving patient care in the ED. By incorporating objective measures such as PPI and SI alongside traditional triage tools like ESI, healthcare providers may better identify high-risk patients, ensure timely interventions, and in result improve clinical outcomes. The findings of this study could have significant effects for the development of more robust triage systems, resulting in the efficient allocation of resources and the delivery of high-quality emergency services. Despite the advantages of PPI with SI, their application in the ED setting remains underexplored. The limited research on the correlation between these indices and traditional triage tools like ESI underscores the need for any other investigation. The study aims to fill this gap by examining prognostic performance of PPI, SI, with ESI in predicting hospital outcomes. By evaluating the relationships between these indices and key clinical outcomes such as hospital admission and mortality, the study seeks to provide evidence for the integration of objective measures into existing triage systems.



**Aim:**

The study aims to enhance understanding and effectiveness of triage systems at emergency department by investigating the relationships and prognostic value of the PPI, Shock Index (SI), and Emergency Severity Index (ESI) in predicting hospital outcomes such as admission rates and mortality.

**Objectives:**

Primary Objectives: (1) Evaluation of correlation between indices like PPI, SI, and ESI in patients who presents to the Emergency Dept; (2) Determine the association between PPI and SI measurement in need of the ventilation and 48 hours hospital outcome; (3) Evaluate the relative prognostic value of PPI, SI, and ESI in predicting adverse outcomes.

## **REVIEW OF LITERATURE**

The Review of Literature is organized as follows:

### **I. A. Overview of Emergency Department (ED) Challenges**

- Increasing patient admissions
- Importance of effective triage systems

### **B. Purpose of the Review**

- To explore existing literature on PPI, SI, and Emergency Severity Index (ESI)
- To identify gaps and justify the need for the current study

## **II. Triage Systems in Emergency Medicine**

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- Need for more comprehensive studies linking these indices to hospital outcomes

### **B. Justification for the Present Study**

- Addressing the identified gaps
- Potential contributions to triage practices and patient care

## **I. A. Overview of Emergency Department (ED) Challenges**

The global healthcare landscape has witnessed a significant surge in patient admissions to emergency departments (EDs) over recent years.<sup>(14)</sup> This trend is attributed to various factors, including population growth, increasing prevalence of chronic diseases, aging populations, and the rising incidence of acute medical conditions.<sup>(15)</sup> As a result, EDs are frequently overwhelmed, leading to prolonged waiting times, overcrowding, and strained healthcare resources. These challenges not only impede the delivery of timely and effective care but also contribute to increased patient morbidity and mortality.

One of the critical functions of EDs is the rapid and accurate assessment of patient acuity to ensure that those with the most urgent needs receive immediate attention. This process, known as triage, is essential for prioritizing patient care, managing limited resources, and optimizing patient outcomes.<sup>(16,17)</sup> Effective triage systems are vital in this context as they facilitate quick decision-making, help in reducing bottlenecks, and improve the overall efficiency of ED operations.<sup>(18)</sup> Traditional triage methods, which often rely on subjective clinical judgments and basic vital signs, may not always capture the true severity of a patient's condition, potentially leading to misclassification and suboptimal care. Therefore, enhancing triage accuracy through the integration of objective and reliable indices is paramount.

## **B. Purpose of the Review**

Review is done to systematically explore the existing available literature on three key indices used in EM department: the Peripheral Perfusion Index (PPI), Shock Index (SI), and Emergency Severity Index (ESI). These indices have been studied individually for their potential to improve triage accuracy and predict patient outcomes, but their combined application and comparative

effectiveness remain underexplored. By examining the current body of research, this column aims to identify the evidence on the prognostic performance of PPI, SI, and ESI, highlighting their respective strengths and limitations.

Additionally, this review seeks to identify gaps in the literature that justify the need for further investigation. Despite the advancements in triage methodologies, there is limited integration of objective measurements like PPI and SI with traditional tools such as ESI. Understanding the potential synergistic benefits of combining these indices could lead to more robust and reliable triage systems, ultimately enhancing patient care and outcomes in the EM settings. The results from this literature will provide a foundation for the present study, which aims to assess the interaction between PPI, SI, and ESI in predicting hospital outcomes, thereby contributing to the ongoing efforts to optimize emergency care practices.

## **II. Triage Systems in Emergency Medicine**

### **A. Historical Context and Evolution**

#### **Early Triage Systems**

The concept of triage, derived with French nomenclature "trier" meaning to sort, has its origins in military medicine.<sup>(19)</sup> The practice dates back to the Napoleonic Wars, where battlefield surgeons like Baron Dominique Jean Larrey developed early triage protocols to treat the soldiers on priority basis of the severity of the injuries and the chances of survival. This method aimed to make the most efficient use of medical resources available in high-casualty situations, ensuring that those with the greatest need and chance of recovery received immediate care.



During World War I and II, triage systems became more structured and were widely adopted by military medical corps.(20) The primary goal was to sort casualties into categories: those who could be saved with immediate intervention, those who would benefit from delayed treatment, and those for whom treatment would be futile.(21) These early triage practices laid the groundwork for modern emergency medical systems by emphasizing the importance of prioritizing care based on clinical urgency.

### **Development of Modern Triage Protocols**

The transition from military to civilian emergency medicine in the mid-20th century marked the development of modern triage protocols. The increasing frequency of large-scale emergencies, such as natural disasters and mass casualty incidents, underscored the need for efficient triage systems in civilian hospitals. In the 1960s and 1970s, various triage scales and methods were introduced in emergency departments (EDs) worldwide.

One of the significant advancements in triage was the development of the UK based Manchester Triage System (MTS) in 1990s. MTS introduced a structured approach to triage, categorizing patients into five levels of urgency based on clinical symptoms and presentation. This system aimed to standardize triage decisions, reduce variability, and improve patient outcomes.(22)

Similarly, in the United States, the ESI was developed in the late 1990s. (7) ESI is based on five-level triage system that not only assesses the severity of a patient's condition but also considers the resources needed for their treatment. The introduction of ESI represented a significant shift towards integrating resource utilization into triage decisions, thus optimizing ED workflow and resource allocation.(23)

## **B. Conventional Triage Systems**

### **Description and Use in Various Countries**

Conventional triage systems, often referred to as three-level triage systems, are widely used across the globe. These systems typically categorize patients among three levels, priority based on the immediate need of their medical condition. The most common designations are:

- **Level 1 (Immediate):** Patients with life-threatening conditions requiring immediate intervention.
- **Level 2 (Urgent):** Patients with serious but not immediately life-threatening conditions.
- **Level 3 (Non-Urgent):** Patients with minor injuries or illnesses who can safely wait for treatment.

Countries like Canada, Australia, and various European nations have implemented modified versions of these triage systems to suit their specific healthcare environments. For example, the Australasian Triage Scale (ATS), one more being the Canadian Triage and Acuity Scale (CTAS) are five-level systems that provide a more nuanced categorization, improving the precision of patient assessments and prioritization.

### **Advantages and Limitations**

#### **Advantages:**

1. **Simplicity and Speed:** Conventional triage systems are designed to be quick and easy to use, enabling rapid assessment and decision-making. This is crucial in busy EDs where time is of the essence.

2. **Standardization:** These systems provide a standardized approach to triage, reducing variability in patient assessment and ensuring that patients receive care based on objective criteria.
3. **Resource Allocation:** By categorizing patients based on urgency, triage systems help allocate medical resources more effectively, ensuring that those in greatest need receive timely intervention.

### **Limitations:**

1. **Subjectivity:** Despite efforts to standardize triage, the assessment can still be subjective, leading to variability in triage decisions. Different healthcare providers may interpret symptoms and urgency differently, affecting the consistency of care.
2. **Limited Sensitivity:** Conventional triage systems primarily rely on observable symptoms and basic vital signs, which may not always capture the true severity of a patient's condition. This can result in the under-triage of patients whose conditions may deteriorate rapidly.
3. **Resource Intensive:** Implementing and maintaining standardized triage protocols require significant training and resources. In resource-limited settings, it may be challenging to adhere strictly to these protocols, potentially impacting the quality of triage.

Overall, while conventional triage systems have been instrumental in improving emergency care, there remains a need for enhancements to address their limitations. Integrating more objective and sensitive measures, such as the PPI and SI, with the tools like the Emergency Severity Index (ESI), holds promise in advancing effectiveness at triage systems in emergency medicine.

### **III. Emergency Severity Index (ESI)**

#### **A. Development and Adoption**

##### **Origins and Evolution**

The ESI was developed in the late 1990s as a response to the need for a more efficient and standardized triage system in emergency departments (EDs). Its development was spearheaded by Dr. Richard Wuerz and colleagues, who recognized the limitations of existing triage systems that often failed to account for resource utilization and variability in patient acuity. The ESI was designed to address these gaps by incorporating a dual focus on the severity of the patient's clinical condition and the medical resources required in providing appropriate care.

Initially, the ESI was introduced in several pilot sites across the United States. These early implementations aimed to refine the triage tool based on real-world feedback and performance. Over time, the ESI underwent several iterations, each version incorporating lessons learned from clinical practice and emerging research. The continuous improvement process ensured that the ESI remained relevant and effective in a rapidly evolving healthcare environment.

##### **Adoption in the United States and Globally**

Following its initial development, the ESI quickly gained traction across the United States. Its structured approach and evidence-based design made it an attractive alternative to traditional triage systems. By the early 2000s, many EDs across the country had adopted the ESI, recognizing its potential to improve patient flow, resource allocation, and overall care quality.

The success of the ESI in the United States spurred interest in its adoption internationally. Countries with diverse healthcare systems began to evaluate the ESI's applicability within their own contexts. For instance, in Europe, several countries adapted the ESI to align with their national guidelines and clinical practices. Similarly, in Asia and the Middle East, the ESI was implemented in both public and private healthcare settings, demonstrating its versatility and global appeal.

The widespread adoption of the ESI can be attributed to several factors. Firstly, its ability to standardize triage processes across different healthcare settings reduced variability in patient assessment. Secondly, the ESI's focus on resource requirements helped EDs manage their capacities more effectively, especially during peak times. Lastly, the growing body of evidence supporting the ESI's effectiveness in improving patient outcomes reinforced its credibility and acceptance.

## **B. ESI Structure and Criteria**

### **Five-Level Triage Tool**

This Emergency Severity Index is structured as a five-stage triage system, with levels ranging from the level 1 (most urgent) to level 5 (least urgent). This hierarchical framework allows for a nuanced categorization of patients based on the clinical severity of their conditions and immediacy of required interventions.

- **Level 1 (Immediate):** Patients who require immediate, life-saving interventions.

Examples include severe trauma, cardiac arrest, and respiratory failure.

- **Level 2 (Emergent):** Patients with conditions that pose a significant risk to life or limb if not promptly addressed. These patients are typically high-risk and require immediate attention but are not yet in a life-threatening situation.
- **Level 3 (Urgent):** Patients with conditions that necessitate prompt medical attention but are not immediately life-threatening. These patients may require several resources to diagnose and treat their condition.
- **Level 4 (Semi-Urgent):** With the less severe conditioned patients and managed with fewer resources. These patients are stable but still require medical evaluation and treatment.
- **Level 5 (Non-Urgent):** Patients with minor conditions that require minimal resources. These patients are stable and can safely wait for a longer period before receiving care.

### **Assessment Criteria and Resource Requirements**

The ESI assessment involves a two-step process that considers both patient acuity and anticipated resource needs. The first step assesses the patient's condition to determine if they require immediate life-saving intervention (ESI Level 1). If not, the triage nurse proceeds to the second step, evaluating the patient's symptoms and clinical presentation to estimate the resources required.

Resource needs are categorized based on the number and type of interventions a patient might need, such as laboratory tests, imaging studies, specialist consultations, and therapeutic procedures. This dual focus on acuity and resources ensures that the ESI provides a comprehensive and practical approach to triage, facilitating effective prioritization and resource management.

## **C. ESI Performance and Limitations**

### **Studies on ESI Effectiveness**

Multiple studies evaluated the effectiveness of ESI in different clinical settings. Research has consistently shown that the ESI improves the accuracy of triage decisions, enhances patient flow, and optimizes resource utilization. For instance, a study by Gilboy et al. (2011) demonstrated that the ESI reliably stratifies patients by acuity, ensuring that those with the most urgent needs receive timely care. Another study by Wuerz et al. (2000) highlighted the ESI's role in reducing waiting times and overall length of stay in the ED, thereby improving patient satisfaction and outcomes.

Additionally, the ESI has been found to have high inter-rater reliability, meaning that different triage nurses tend to assign the same ESI level to similar cases, reducing variability and improving consistency in patient assessment. The ESI's predictive validity has also been supported by studies showing strong correlations between ESI levels and key outcomes such as hospital admission rates, need for intensive care, and mortality.

### **Limitations Due to Subjective Assessments**

Despite its strengths, the ESI is not without limitations. One of the primary challenges is the potential for subjective bias in triage assessments. While the ESI provides a structured framework, the interpretation of patient symptoms and the estimation of resource needs can vary among triage nurses, leading to inconsistent triage decisions.

Subjectivity can be particularly problematic in borderline cases where the distinction between ESI levels is not clear-cut. Factors such as nurse experience, training, and familiarity with the

ESI protocol can influence triage outcomes, potentially affecting the accuracy and reliability of the tool.

Moreover, the ESI relies heavily on the initial presentation of patients, which may not always reflect the true severity of their condition. For example, patients with compensatory mechanisms may appear stable initially but deteriorate rapidly. In such cases, the ESI's reliance on initial assessments could lead to under-triage, delaying necessary interventions.

## **IV. Peripheral Perfusion Index (PPI)**

### **A. Concept and Mechanism**

#### **Definition and Measurement**

PPI- The Peripheral Perfusion Index is defined as a non-invasive numerical value that indicates current perfusion changes in peripheral blood flow. It is obtained from the photoelectric effect of the plethysmographic signal produced by a oximeter, a device commonly used to monitor oxygen saturation in patients. PPI reflects the ratio of blood flow [pulsatile-arterial] to static blood flow (venous and capillary) in the peripheral distribution of tissues.(24–26) This index provides a quantitative measure of peripheral perfusion, which is crucial in assessing a circulatory condition of patients in different clinical settings, particularly in the emergency department (ED).

Measurement of PPI is straightforward and involves placing a pulse oximeter sensor on a patient's fingertip, toe, or earlobe.(27,28) The sensor emits light through the tissue, and a photodetector measures the amount of light absorbed by blood. The variations in light absorption



due to pulsatile blood flow are used to calculate the PPI value.(29–31) Higher PPI values indicate better peripheral perfusion, while lower values suggest compromised blood flow.

### **Technology Behind Photoelectric Plethysmography**

Photoelectric plethysmography, the technology underpinning PPI, is based on the principles of optical absorption and reflection. The pulse oximeter emits light at specific wavelengths (typically red and infrared) through the skin.(32,33) Hemoglobin in the blood absorbs this light, and the amount of absorption varies with the blood volume changes due to the cardiac cycle.

During systole, the increase in arterial blood volume leads to greater light absorption, whereas during diastole, the reduced arterial volume decreases light absorption. The pulse oximeter captures these fluctuations in light absorption, creating a plethysmography waveform. (34,35) The amplitude of this waveform, which corresponds to the pulsatile component of blood flow, is then used to calculate the PPI. This real-time monitoring provides valuable insights into the patient's hemodynamic status and tissue perfusion.

## **B. Clinical Applications**

### **Use in Monitoring Peripheral Blood Flow**

PPI is used extensively to monitor peripheral blood flow in various clinical settings. In the ED, it serves as a non-invasive and immediate tool to assess circulatory status of patients presenting with a wide range of conditions, including shock, sepsis, and trauma. By providing immediate feedback on peripheral perfusion, PPI helps clinicians make timely decisions regarding fluid resuscitation, vasopressor use, and other therapeutic interventions.

In perioperative care, PPI is valuable for monitoring patients during and after surgery. It aids in detecting early signs of hypoperfusion, enabling prompt intervention to prevent complications. PPI is also utilized in neonatal care to monitor the circulatory status of newborns, particularly those with congenital heart defects or sepsis. In critical care settings, continuous PPI monitoring can provide insights into the effectiveness of interventions aimed at improving tissue perfusion.

### **Studies Linking PPI to Patient Outcomes**

Several studies have explored the relationship between PPI and patient outcomes, highlighting its prognosis. Research has shown that in critically ill patients, low PPI values are associated with increased deteriorating the clinical condition. For instance, a study by Lima et al. (2009) experimented that PPI can predict outcomes in patients with septic shock, with lower PPI values indicating a higher risk of adverse outcomes.(36)

Another study by van Genderen et al. (2013) suggested that PPI was one of the reliable predictor of complications in postoperative patients.(37) The study showed that patients with lower PPI values were more likely to experience complications such as infections and organ dysfunction. These findings suggest that PPI can serve as an early warning system for identifying patients at risk of deterioration, allowing for timely and targeted interventions.

### **C. Advantages and Limitations**

#### **Non-Invasive Nature and Real-Time Data**

One of the primary advantages of PPI is its non-invasive nature. The use of a simple pulse oximeter sensor to measure PPI eliminates the need for invasive procedures, reducing the risk of complications and discomfort for patients. This makes PPI an attractive option for continuous

monitoring in various clinical settings, including the ED, intensive care units (ICUs), and perioperative environments.

Another significant advantage is the provision of real-time data. PPI offers continuous monitoring of peripheral perfusion, allowing clinicians to detect changes in hemodynamic status promptly. This real-time feedback is crucial in emergency and critical care scenarios where rapid decision-making is essential for patient outcomes. By providing immediate information on tissue perfusion, PPI enables clinicians to adjust treatment strategies dynamically and improve patient management.

### **Factors Affecting Measurement Accuracy**

Despite its advantages, several factors can affect the accuracy of PPI measurements. One of the primary limitations is the influence of external conditions such as ambient light, patient movement, and poor sensor positioning. These factors can introduce noise and artifacts into the plethysmographic signal, potentially leading to inaccurate PPI readings.

Patient-specific factors such as skin pigmentation, peripheral vasoconstriction, and the presence of nail polish or artificial nails can also impact the accuracy of PPI measurements. For example, in patients with significant peripheral vasoconstriction due to hypothermia or shock, the PPI values may be falsely low, not accurately reflecting the central hemodynamic status.

Additionally, while PPI is a valuable tool for monitoring peripheral perfusion, it may not always correlate directly with central perfusion or overall circulatory status. Therefore, PPI should be used in conjunction with other clinical assessments and diagnostic tools to provide a comprehensive evaluation of a patient's condition.

## V. Shock Index (SI)

### A. Concept and Calculation

#### Definition and Formula

The Shock Index (SI) is a simple, yet powerful clinical tool used predict patient outcomes and to assess patient's hemodynamic stability. Being calculated as the ratio of heart rate to systolic blood pressure, formulated as:

$$SI = HR / SBP$$

Where:

- **HR:** Heart rate is the contractions of heart per minute (bpm).
- **SBP:** Systolic blood pressure in millimeters of mercury (mmHg).

The SI provides a quick and straightforward measure of a patient's circulatory status. A range normal for SI is 0.5 to 0.7 in healthy individuals, while values exceeding 0.9 are indicative of hemodynamic instability and potential shock. This index integrates two fundamental vital signs, making it a readily available and easy-to-calculate metric in emergency and critical care settings.

### B. Clinical Relevance

#### Use as an Indicator of Hemodynamic Stability

The SI is widely recognized for its utility in assessing hemodynamic stability.(38) In clinical practice, it serves as an early warning indicator for various forms of shock, including hypovolemic and septic shock. By combining heart rate and systolic blood pressure into single

metric, the SI provides a more nuanced understanding of the patient's cardiovascular function than either parameter alone.

In the emergency department, the SI being used to triage quickly with determining the urgency of intervention. For instance, a high SI in a trauma patient may indicate significant blood loss and the need for immediate resuscitation.(10,39) In medical patients, an elevated SI could signal underlying sepsis or cardiac dysfunction, prompting rapid diagnostic and therapeutic measures.

### **Studies on SI in Various Clinical Settings**

Numerous studies have validated the SI's effectiveness across different clinical settings. In trauma care, research has shown that a high SI on admission correlates with increased transfusion requirements, higher rates of complications, and greater mortality. For example, Rady and Smithline (2000) demonstrated that an SI greater than 0.9 was a strong prognosticator of morbidity in trauma patients, outperforming traditional vital signs.(40)

In the context of sepsis, SI has also proven to be a valuable prognostic tool. A study by Liu et al. (2013) found that sepsis patients who have an SI above 0.9 were more likely to develop shock and have increased mortality rates compared to those with a normal SI.(41,42) This highlights the index's utility in early identification and risk stratification of septic patients.

In cardiology, the SI has been used to evaluate patients with acute coronary syndrome-AMI. Studies such as those by Bilkova et al. (2011) have shown that an increased SI correlates with worse prognosis in AMI patients, with higher rates of heart failure and in-hospital mortality.

These findings underscore the SI's relevance across a spectrum of acute and chronic conditions, emphasizing its role in guiding clinical decision-making and improving patient outcomes.

## **C. Prognostic Value**

### **Correlation with Morbidity and Mortality**

The prognostic value of the Shock Index is well-documented, with numerous studies highlighting its correlation with morbidity and mortality. In both trauma and medical emergencies, a higher SI is consistently associated with worse outcomes. This makes the SI an invaluable tool for predicting patient trajectories and tailoring interventions accordingly.

For example, in trauma, a study by Zarzaur et al. (2008) indicated, those with an SI greater than 1 had significantly higher mortality rates compared to those with a lower SI. Similarly, in a study involving patients with gastrointestinal bleeding, Rassameehiran et al. (2014) explained that an elevated SI is a predictor of in-hospital morbidity, mortality, length of hospital stay, and the need for intensive care unit admission.(43)

### **Advantages Over Traditional Vital Signs**

The SI offers several advantages over traditional vital signs, making it a superior predictor of adverse outcomes. Firstly, it combines two critical parameters—heart rate and systolic blood pressure—into a single index, providing a more integrated assessment of cardiovascular function. This dual consideration helps mitigate the limitations of relying on either parameter alone, which may not fully capture the patient's hemodynamic status.

Secondly, the SI is particularly valuable in identifying patients at risk of decompensation. While individual vital signs may appear normal or only mildly abnormal, the SI can reveal underlying instability that warrants closer monitoring and early intervention. This sensitivity to subtle changes in physiological status enhances its utility in various clinical scenarios.

Moreover, the SI is easy to calculate and requires no special equipment beyond what is routinely available in clinical settings. This simplicity ensures that it can be rapidly implemented in busy EDs and critical care units without additional training or resources.

## **VI. Comparative Studies and Integrative Reviews**

### **A. Comparison of ESI, PPI, and SI**

#### **Studies Comparing the Effectiveness of These Indices**

Comparative studies have been instrumental in evaluating the effectiveness of various triage systems, counting the Emergency Severity Index (ESI), PPI, and SI. Each index has been individually validated for its ability to assess patient acuity and predict outcomes, but comparative studies provide deeper insights into their relative strengths and limitations.

A study by Grossmann et al. (2012) correlate the ESI with PPI and SI in an emergency department setting. The study found that while ESI effectively categorized patients based on urgency, PPI and SI offered additional granularity in assessing hemodynamic stability. Patients with similar ESI levels showed varying PPI and SI values, indicating that the latter could identify high-risk patients who might otherwise be classified as lower acuity based on ESI alone.

Similarly, a study by Rady and Smithline (2004) evaluated the predictive accuracy of SI and Emergency Severity Index in trauma patients. The results demonstrated that SI was more sensitive in predicting morbidity and the need for ICU compared to ESI. This study highlighted SI's utility in detecting hemodynamic compromise that may not be apparent through ESI categorization alone.

### **Insights from Meta-Analyses and Systematic Reviews:**

Meta-analyses and systematic reviews explain comprehensive evaluations of existing literature on triage indices. These analyses consolidate findings from multiple studies, offering robust evidence on the effectiveness of ESI, PPI, and SI.

A systematic review by Singer et al. (2019) examined the prognostic accuracy of ESI across various emergency settings. The review concluded that ESI is a reliable tool for triage, with high sensitivity for identifying critically ill patients. However, it also noted the variability in ESI application and the potential for subjective bias, suggesting a need for complementary objective measures like PPI and SI.

Another meta-analysis by Henriksen et al. (2017) focused on the prognostic value of SI in ED and critical care. The analysis included over 20 studies and found consistent results that an elevated SI is correlated to increased mortality, ICU admission, and longer hospital stays. This meta-analysis reinforced the role of SI as a critical indicator for early diagnosis of patients at risk of adverse outcomes.

These comprehensive reviews highlight that while each index has its merits, their combined use can provide a more accurate and nuanced assessment of patient acuity and prognosis.



## **B. Integration of Multiple Indices**

### **Benefits of Combining Objective Measures with Traditional Triage Tools**

Integrating objective measures such as PPI and SI with traditional triage tools like ESI offers several benefits. This combined approach can enhance the accuracy of patient assessments by providing a more comprehensive view of their clinical status. Objective measures can help mitigate the subjectivity inherent in tools like ESI, reducing variability in triage decisions.

Combining these indices allows for the identification of high-risk patients who might be under-triaged based on ESI alone. For instance, a patient with an ESI level of 3 (urgent but not life-threatening) may have an elevated SI or low PPI, indicating underlying hemodynamic instability that warrants closer monitoring and potentially more aggressive intervention.

### **Studies Demonstrating Improved Prognostic Accuracy**

Several studies have demonstrated the improved prognostic accuracy achieved by integrating many triage indices. A study by Lee et al. (2015) assessed combined use of ESI, PPI, and SI in an emergency department setting. The findings showed that incorporating PPI and SI with ESI significantly improved the identification of patients at risk of deterioration, leading to better resource allocation and patient outcomes.

In another study, Nguyen et al. (2018) evaluated the combined predictive value of ESI and SI in sepsis patients. The results indicated that the integration of SI into the ESI framework enhanced the early detection of septic shock, enabling timely interventions and reducing mortality rates.

These studies underscore the potential of a multi-faceted approach to triage, leveraging the strengths of both subjective and objective measures. By integrating indices like PPI and SI with traditional tools such as ESI, clinicians can achieve a more accurate and holistic assessment of patient acuity, ultimately improving clinical decision-making and patient care.

## **VII. Research Gaps and Justification for Current Study**

### **A. Identified Gaps in Literature**

Despite the significant advancements in triage systems and the individual validation of the ESI, PPI, and SI, there remain critical gaps in the existing literature regarding their combined use in emergency department (ED) settings. Current studies have predominantly focused on evaluating each index in isolation, with limited research exploring the synergistic benefits of integrating PPI, SI, and ESI. This lack of comprehensive analysis restricts our understanding of how these indices can collectively enhance triage accuracy and patient outcomes.

Moreover, while several studies have explained the predictive value of PPI and SI in specific clinical scenarios, there is a dearth of research linking these indices to broader hospital outcomes, such as hospital stay duration, and mortality, within the context of ED triage. Existing literature has not sufficiently addressed how the integration of these indices might influence clinical decision-making and resource allocation in real-world settings. Additionally, variability in study designs, patient populations, and clinical environments further complicates the ability to generalize findings and develop standardized protocols for the combined use of these indices.

### **B. Justification for the Present Study**

The present study aims to address these identified gaps by systematically evaluating the combined prognostic performance of PPI, SI, and ESI in predicting hospital outcomes for patients presenting to the ED. By conducting a comprehensive analysis that integrates these indices, the study seeks to provide robust evidence on their collective utility in enhancing triage practices. This approach not only builds on the strengths of each individual index but also explores their potential synergistic effects, offering a more nuanced understanding of patient acuity and risk stratification.

Addressing these gaps is crucial for several reasons. Firstly, improving the accuracy and reliability of triage systems can lead to better patient outcomes by ensuring that high-risk patients receive timely and appropriate care. The integration of objective measures such as PPI and SI with traditional triage tools like ESI can reduce the subjectivity and variability inherent in current practices, thereby enhancing the overall quality of emergency care.

Secondly, the findings from this study have the potential to inform the development of more strong triage protocols that optimize resource utilization in EDs. By identifying patients at higher chances of adverse outcomes, healthcare providers could allocate resources more efficiently, prioritize critical interventions, and reduce the burden on emergency services. This is precisely important for context of increasing patient admissions and limited healthcare resources, where efficient triage is essential for maintaining the sustainability and effectiveness of emergency care systems.

Furthermore, the study's insights into the combined use of PPI, SI, and ESI could contribute to the standardization of triage practices across different healthcare settings. Standardized protocols based on robust evidence can enhance the consistency and reliability of triage assessments,

improving patient safety and outcomes on a broader scale. This is especially relevant for non-English-speaking countries and diverse healthcare environments where the adoption of evidence-based triage systems can significantly impact the quality of emergency care.

## **METHODS:**

### **Study Design and Setting:**

Study type: 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 hospital is a tertiary care-based hospital characterized by high volume in emergency cases, making it an ideal environment for studying the effectiveness and applicability of various triage indices in a real-world clinical context. The hospital's infrastructure and resources provided a robust framework for accurate and systematic data collection and patient assessment.

### **Study Participants**

The present study included all patients aged 18 years old age and older who presented to the E M Department during the study period. By including all adult patients, the study aimed to capture a representative sample of the ED population. 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. These criteria ensured that the sample consisted of patients whose triage assessments and subsequent outcomes could be reliably compared, thereby enhancing the validity of the study findings.

## **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:

Heart Rate (HR): Recorded in beats per minute to assess cardiovascular function.

Blood Pressure [systolic] (SBP): Recorded in mmHg, reflecting arterial pressure during heartbeats.

Blood Pressure [Diastolic] (DBP): Recorded in millimeters of mercury (mmHg), indicating arterial pressure between heartbeats.

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. Vital

signs and other relevant clinical data were meticulously documented in patient records and subsequently entered into a digital database for comprehensive analysis.

### **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.

Data collection was systematically performed, with each patient's measurements and ESI score recorded in their medical record. Data entry into a Microsoft Excel sheet was conducted daily by dedicated research staff to ensure accuracy and completeness. The data were then imported into SPSS (Version 20) and JNP-SAS Software for detailed statistical analysis. Efforts to minimize bias included standardized training for all personnel involved in data collection and measurement, adherence to strict inclusion and exclusion criteria, and the use of objective measurement tools. Regular audits of data entry and measurement procedures were conducted to maintain data integrity and reliability.

## **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. This larger sample size was chosen to ensure that the study would have sufficient power to detect significant associations and to allow for more comprehensive and reliable analysis of the prognostic indicator of PPI, SI, with ESI in predicting outcomes.

## **Quantitative Variables**

The primary quantitative variables in this study included the PPI, SI along with Emergency Severity Index (ESI). These indices were evaluated to determine their prognostic value in predicting hospital outcomes such as admission rates and mortality. Additional quantitative variables measured included:

Heart Rate (HR): Provides insights into the patient's cardiovascular function and stress response.

Systolic Blood Pressure (SBP): Reflects the arterial pressure during the contraction of the heart muscles.

Diastolic Blood Pressure (DBP): Reflects the arterial pressure when the heart is at rest between beats.



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

These variables were essential for a comprehensive assessment of the patient's clinical condition and for evaluating effectiveness in the triage indices.

### **Statistical Methods:**

Statistical analyses: 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 Mann-Whitney U test was selected for non-normally distributed variables to compare medians. Categorical variables were calculated using the Chi-square test or Fisher's exact test to determine associations between different categorical outcomes and groups. For comparisons involving more than two groups, ANOVA test was utilized for normal variables, and the Kruskal-Wallis H test for non-normally variables, ensuring appropriate analysis based on data distribution.

The correlation between PPI, SI, and ESI was assessed using Pearson or Spearman correlation coefficients, depending on the normality of the data distribution. Logistic regression analysis was conducted to evaluate the association of PPI and SI measurements with hospital admission and mortality outcomes, providing insights into the predictive value of these indices. 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).

A p-value of less than 0.05 was considered statistically significant, ensuring rigorous evaluation of the results. All statistical tests were performed two-tailed to ensure comprehensive analysis and robust conclusions.

**RESULTS:****Table 1: Basic characteristics of study participants (n=610)**

<b>Variables</b>	<b>Number</b>	<b>Percentage</b>
<b>Age (in years)</b>		
15 – 30	151	24.8
31 – 45	163	26.7
46 – 60	118	19.3
>60	178	29.2
<b>Sex</b>		
Female	202	33.1
Male	408	66.9
<b>Religion</b>		
Hindu	564	92.5
Muslim	41	6.7
Missing	5	0.8

The characteristics of the study population reveal that a majority of participants were aged between 31 to 45 years (26.7%), followed closely by those over 60 years (29.2%). Subjects aged 15 to 30 years consist of 24.8% of the sample, while those aged 46 to 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. This demographic distribution provides a comprehensive overview of the population involved in the study, highlighting a diverse age range and a significant male predominance.

**Table 2: Factors Associated with Emergency Severity Index (ESI) Outcomes (n=610)**

<b>Factors</b>	<b>Emergency Severity Index (ESI)</b>		<b>p-value</b>
	<b>&lt;3 (poor)</b>	<b>&gt;3 (good)</b>	
<b>Age (in years)</b>			
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)	
<b>Sex</b>			
Male	240 (58.8)	168 (41.2)	0.006
Female	95 (47.0)	107 (53.0)	
<b>Religion</b>			
Hindu	305 (54.1)	259 (45.9)	0.018
Muslim	30 (73.2)	11 (26.8)	
<b>ICU admission</b>			
Yes	307 (98.7)	4 (1.3)	<0.001
No	28 (9.4)	271 (90.6)	
<b>Mechanical Ventilation</b>			
Yes	154 (96.9)	5 (3.1)	<0.001
No	181 (40.1)	270 (59.9)	
<b>PI</b>			
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
<b>SI</b>			
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-2 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.

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).

**Table 3: Factors with 48-Hour Outcomes Among Study Participants (n=610)**

<b>Factors</b>	<b>48-hour outcome</b>		<b>p-value</b>
	<b>Deteriorated</b>	<b>Improved / Discharged</b>	
<b>Age (in years)</b>			
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)	
<b>Sex</b>			
Male	124 (30.4)	284 (69.6)	0.087
Female	48 (23.8)	154 (76.2)	
<b>Religion</b>			
Hindu	154 (27.3)	410 (72.7)	0.023
Muslim	18 (43.9)	23 (56.1)	
<b>ICU admission</b>			
Yes	172 (28.2)	139 (44.7)	<0.001
No	0 (0.0)	299 ((100.0)	
<b>Mechanical Ventilation</b>			
Yes	126 (79.3)	33 (20.8)	<0.001
No	46 (10.2)	405 (89.8)	
<b>PI</b>			
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
<b>SI</b>			
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

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  $<0.001$ .

**Table 4: Factors Associated with Ventilator Use Among Study Participants (n=610)**

<b>Factors</b>	<b>Ventilator</b>		<b>p-value</b>
	<b>Yes</b>	<b>No</b>	
<b>Age (in years)</b>			
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)	
<b>Sex</b>			
Male	112 (27.5)	296 (72.5)	0.268
Female	47 (23.3)	155 (76.7)	
<b>Religion</b>			
Hindu	142 (25.2)	422 (74.8)	0.022
Muslim	17 (41.5)	24 (58.5)	
<b>ICU admission</b>			<0.001
Yes	155 (49.8)	156 (50.2)	
No	4 (1.3)	295 (98.7)	
<b>PI</b>			
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
<b>SI</b>			
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

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 5: Factors Associated with ESI Category (<3) Among Study Participants**

<b>Variables</b>	<b>ESI Category (&lt;3)</b>	
	<b>OR (95%CI)</b>	<b>p-value</b>
<b>Age (in years)</b>		
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
<b>Sex</b>		
Female	Ref	
Male	1.60 (1.15 – 2.25)	0.006
<b>Religion</b>		
Hindu	Ref	
Muslim	2.31 (1.13 – 4.71)	0.021
<b>Need of ventilator</b>		
No	Ref	
Yes	45.94 (18.48 - 114.17)	<0.001
<b>PPI 0</b>	0.26 (0.21 – 0.32)	<0.001
<b>PPI12</b>	0.33 (0.28 – 0.40)	<0.001
<b>PPI48</b>	0.45 (0.40 – 0.52)	<0.001
<b>SI 0</b>	1.10 (1.08 – 1.12)	<0.001
<b>SI12</b>	1.15 (1.12 – 1.19)	<0.001

<b>SI48</b>	1.15 (1.12 – 1.18)	<0.001
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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,  $p=0.021$ ).

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 correlates with poor ESI levels (all  $p<0.001$ ).

**Table 6: Factors Associated with clinical Deterioration at 48 hours Among Study Participants (n=610)**

<b>Variables</b>	<b>Outcome – Deteriorated</b>	
	<b>OR (95%CI)</b>	<b>p-value</b>
<b>Age (in years)</b>		
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
<b>Sex</b>		
Female	Ref	
Male	1.40 (0.95 – 2.06)	0.088
<b>Religion</b>		
Hindu	Ref	
Muslim	2.08 (1.09 – 3.96)	0.025
<b>Need of ventilator</b>		
No	Ref	
Yes	33.61 (20.59 – 54.86)	<0.001
<b>PPI 0</b>	0.24 (0.19 – 0.30)	<0.001
<b>PPI12</b>	0.19 (0.15 – 0.25)	<0.001
<b>PPI48</b>	0.19 (0.14 – 0.25)	<0.001
<b>SI 0</b>	1.07 (1.06 – 1.09)	<0.001
<b>SI12</b>	1.09 (1.08 – 1.11)	<0.001
<b>SI48</b>	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  $p<0.001$ ).



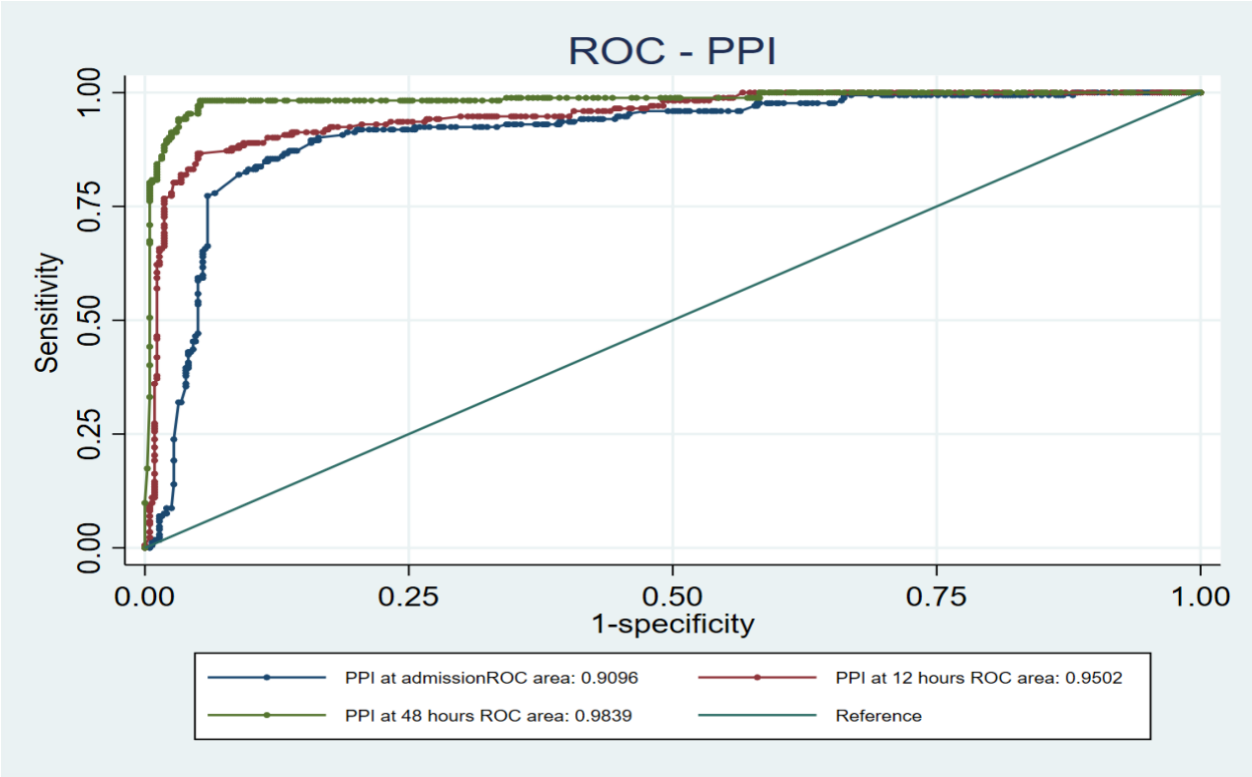
**Table 7: Factors Associated with the Need for Ventilator Support**

<b>Variables</b>	<b>Need for Ventilator</b>	
	<b>OR (95%CI)</b>	<b>p-value</b>
<b>Age</b>		
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
<b>Sex</b>		
Female	Ref	
Male	1.24 (0.84 – 1.84)	0.268
<b>Religion</b>		
Hindu	Ref	
Muslim	2.10 (1.09 – 4.03)	0.025
<b>PPI 0</b>	0.36 (0.30 – 0.43)	<0.001
<b>PPI12</b>	0.31 (0.26 – 0.37)	<0.001
<b>PPI48</b>	0.46 (0.41 – 0.51)	<0.001
<b>SI 0</b>	1.07 (1.06 – 1.08)	<0.001
<b>SI12</b>	1.07 (1.06 – 1.08)	<0.001
<b>SI48</b>	1.05 (1.04 – 1.05)	<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  $p<0.001$ ).

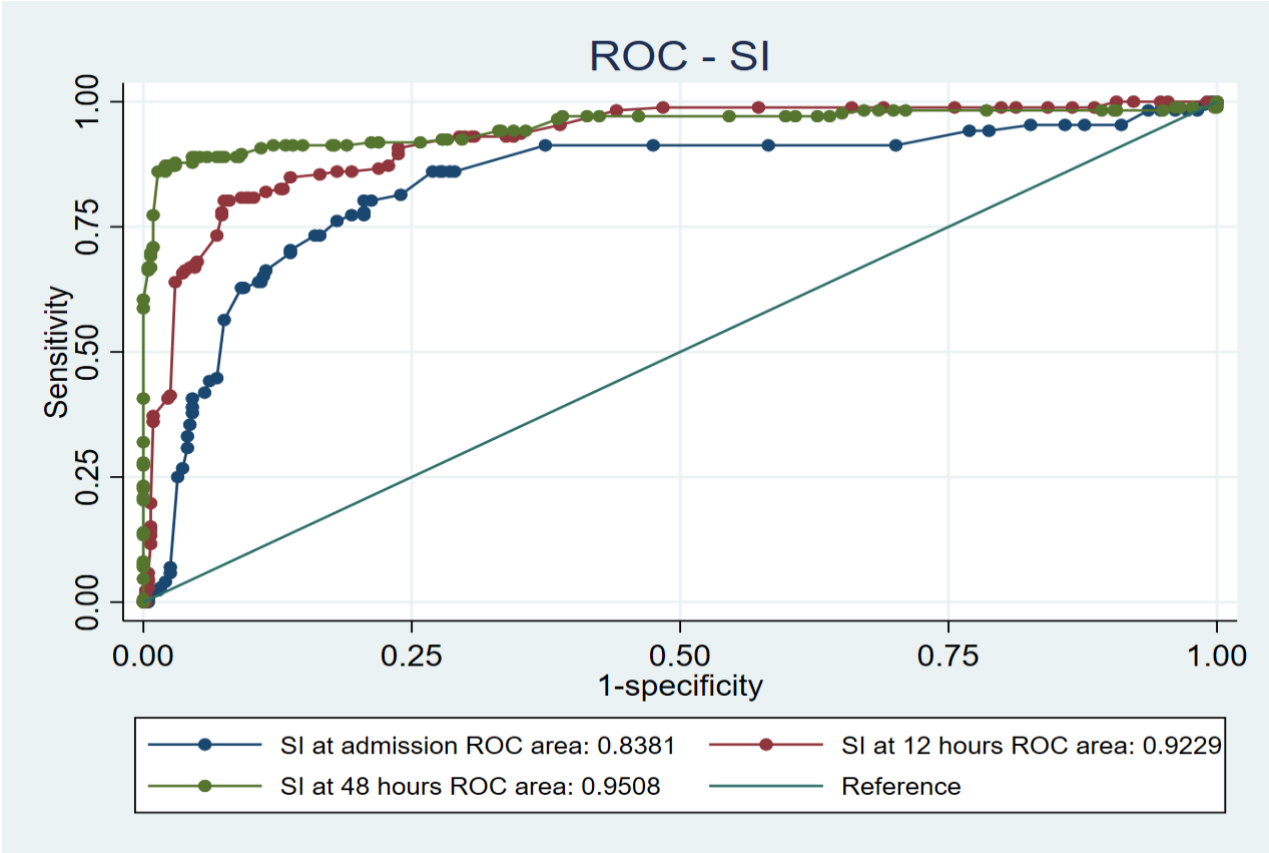


**Graph 1:** Indicates ROC PPI with sensitivity on X axis and (1-specificity) on Y axis.

**Table 8: ROC Analysis Summary for PPI (Outcome: Clinical deterioration)**

Outcome	Area	Std. Err.	95% Confidence Interval
PPI at admission	0.91	0.01	0.88 – 0.94
PPI at 12 hours	0.95	0.01	0.93 – 0.97
PPI at 24 hours	0.98	0.01	0.97 – 1.00

The PPI at admission demonstrated a high area under the curve (AUC) of 0.91 with a standard error of 0.01, indicating good predictive accuracy. At 12 hours, the PPI's AUC further increased to 0.95, reflecting enhanced predictive capability, and reached an AUC of 0.98 at 24 hours, signifying excellent prediction with a narrow confidence interval of 0.97 to 1.00.



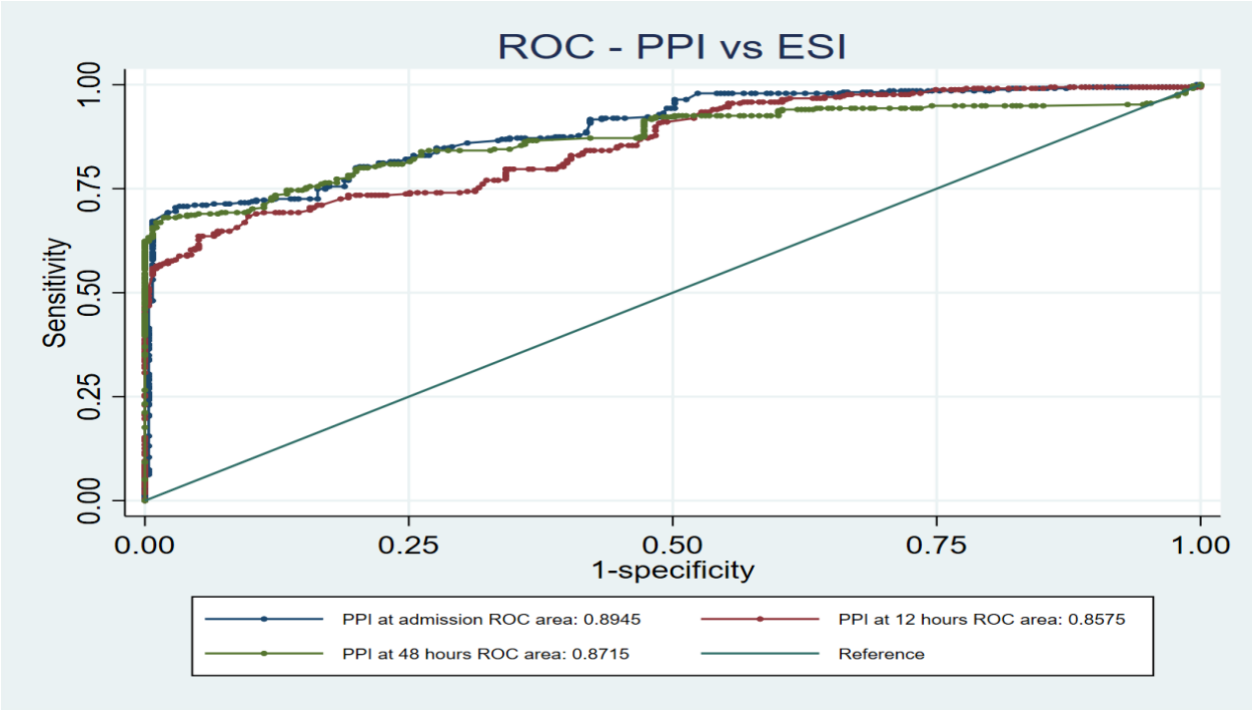
**Graph 2:** Indicates ROC-SI with sensitivity on X axis and (1-specificity) on Y axis.

**Table 9: ROC Analysis Summary for SI (Outcome: Clinical deterioration)**

Outcome	Area	Std. Err.	95% Confidence Interval
SI at admission	0.84	0.02	0.80 – 0.88
SI at 12 hours	0.92	0.01	0.90 – 0.95
SI at 48 hours	0.95	0.01	0.93 – 0.98

The SI at admission had a lower AUC of 0.84, with a standard error of 0.02, suggesting moderate accuracy. The predictive power of the SI improved over time, with an AUC of 0.92 at 12 hours and 0.95 at 48 hours, both showing strong predictive performance.

These results highlight the increasing accuracy of both PPI and SI over time in predicting clinical deterioration.

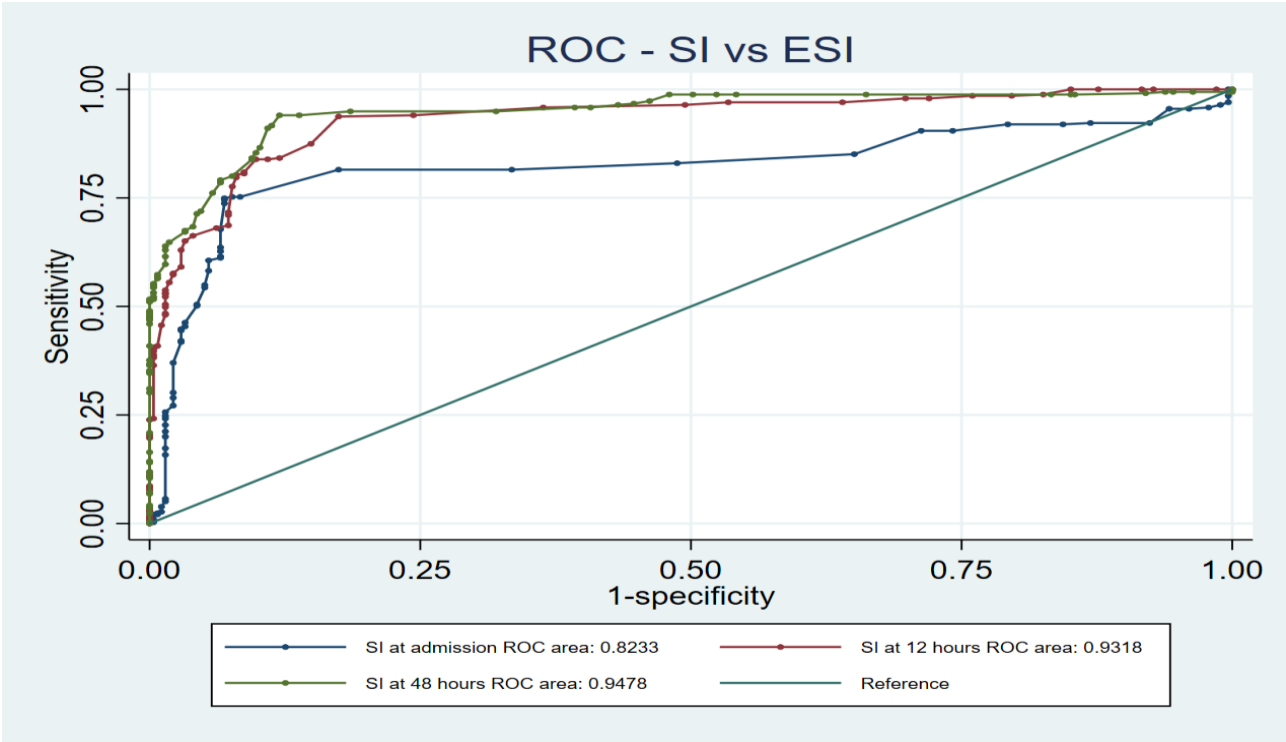


**Graph 3:** ROC- PPI vs ESI (ESI<3) On X axis sensitivity with Y axis (1-specificity)

**Table 10: ROC Analysis Summary for PPI (Outcome: ESI score <3)**

ESI category <3	Area	Std. Err.	95% Confidence Interval
PPI at admission	0.89	0.01	0.87 – 0.92
PPI at 12 hours	0.86	0.01	0.83 – 0.89
PPI at 24 hours	0.87	0.01	0.84 – 0.90

The PPI at admission shows a strong predictive accuracy with an AUC of 0.89 and a standard error of 0.01. At 12 hours, the PPI’s AUC slightly decreased to 0.86, and at 24 hours, it modestly increased to 0.87, indicating consistent predictive performance over time



**Graph 4:** ROC SI vs ESI (ESI<3), [X axis sensitivity with Y axis (1-specificity)]

**Table 11: ROC Analysis Summary for SI (Outcome: ESI score <3)**

ESI category <3	Area	Std. Err.	95% Confidence Interval
SI at admission	0.82	0.02	0.79 – 0.86
SI at 12 hours	0.93	0.01	0.91 – 0.95
SI at 48 hours	0.95	0.01	0.93 – 0.97

The SI at admission had an AUC of 0.82, with a standard error of 0.02, reflecting moderate predictive accuracy. The SI's predictive power improved significantly, with an AUC of 0.93 at 12 hours and 0.95 at 48 hours, demonstrating high predictive accuracy.

These findings illustrate that both PPI and SI are reliable indicators for predicting an ESI score of less than 3, with SI showing increasing accuracy over time.

**DISCUSSION:**

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 findings underscore significant associations between various demographic and clinical factors and poor outcomes, with a particular focus on age, gender, religious affiliation, ICU admission, mechanical ventilation, and physiological indices like the PPI and SI.

Younger participants (15-30 years) demonstrated better ESI outcomes, with a significant majority achieving good ESI scores. In contrast, older age groups (46-60 yrs. and over 60 yrs.) predominantly had poor ESI outcomes, reflecting an age-related disparity.<sup>(44)</sup> Gender differences were also notable, with males exhibiting a higher proportion of poor ESI outcomes compared to females, suggesting a potential gender influence on emergency care outcomes. Additionally, Muslims had a higher prevalence of poor ESI outcomes compared to Hindus, indicating significant religious disparities. Patients requiring ICU admission and mechanical ventilation had markedly poor ESI outcomes, highlighting the severity of their conditions. Continuous monitoring of PPI and SI scores showed significant correlations with ESI outcomes. Lower PPI and higher SI scores at admission, 12 hours, and 48 hours were associated with poor ESI outcomes.

The age-related disparities observed in this study align with previous research indicating that older patients are more vulnerable to poor outcomes because of higher comorbidity along with reduced physiological resilience. Similar findings on gender differences are consistent with existing literature that identifies both biological and behavioral factors contributing to poorer emergency outcomes in males. Biological differences in immune response and cardiovascular

function, coupled with behavioral tendencies such as delayed healthcare seeking, are potential explanations. The higher prevalence of poor outcomes among Muslims may reflect underlying sociocultural and healthcare access disparities, as supported by previous studies highlighting the impact of socioeconomic status, cultural stigmas, and linguistic barriers on healthcare access.

The association of ICU admission and mechanical ventilation with poor outcomes is well-documented in the literature. Patients in need of these interventions typically present with severe, life-threatening conditions, which naturally correlate with higher morbidity and mortality. The strong predictive accuracy of PPI and SI scores for clinical deterioration and poor ESI outcomes supports previous findings on the importance of continuous physiological monitoring in emergency care. Studies have shown that early detection of physiological derangements through indices like PPI and SI can significantly improve patient outcomes.

### **Age-Related Disparities in ESI Outcomes**

The significant age-related disparities in ESI outcomes can be attributed to several physiological and clinical factors. Older patients generally present with multiple comorbidities, which can complicate their clinical presentation and lead to poorer outcomes. Conditions such as systemic hypertension, thyroid disorders, cardiovascular diseases, diabetes and chronic obstructive pulmonary disease are more prevalent in older populations, increasing their vulnerability to severe complications and mortality. These comorbid conditions can exacerbate the primary illness, making management more challenging and increasing the likelihood of poor outcomes. Furthermore, aging is associated with a decline in physiological reserves and immune function. The diminished capacity for cellular repair, reduced organ function, and impaired immune response in older adults make them less resilient to acute stressors, such as infections or trauma.



This physiological decline contributes to their higher susceptibility to severe complications and slower recovery rates, leading to poorer ESI outcomes compared to younger patients.

### **Gender Differences in ESI Outcomes**

The observed gender differences in ESI outcomes, with males exhibiting a higher proportion of poor outcomes, can be explained through a combination of biological and behavioral factors. Biologically, males and females have different immune responses and cardiovascular functions. Research has shown that males may have a higher baseline inflammatory response, which can lead to more severe outcomes in the presence of acute infections or injuries. Additionally, males are more prone to cardiovascular conditions, which can complicate their clinical presentations and lead to poorer outcomes in emergency settings. Behaviorally, gender differences in healthcare-seeking behavior also play a crucial role. Studies have indicated that males are less likely to seek timely medical care compared to females, often presenting to the ED at a more advanced stage of illness. This delay in seeking care can result in more severe clinical presentations and subsequently poorer outcomes. Sociocultural factors, such as societal expectations of masculinity and reluctance to report symptoms, further contribute to this delay, exacerbating the gender disparity in ESI outcomes.

### **ICU Admission and Mechanical Ventilation**

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. 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.

The findings of this study have significant clinical implications for emergency department (ED) operations, patient management, and overall healthcare delivery. By elucidating the relationships between the PPI, SI, and Emergency Severity Index (ESI), and their impact on patient outcomes, this study provides actionable insights that can enhance clinical practice, optimize resource utilization, and improve patient care.

### **Enhancing Triage Accuracy**

One of the primary clinical implications of this study is the potential to enhance triage accuracy in the ED. The integration of PPI and SI with ESI offers a more comprehensive assessment of patient acuity. Traditional triage systems, including ESI, rely heavily on subjective evaluations and initial vital signs, which can sometimes mask underlying conditions or misclassify patient severity. By incorporating objective measures like PPI and SI, clinicians can identify high-risk patients more accurately. This multi-faceted approach ensures that those who might appear stable but have underlying hemodynamic instability are promptly recognized and treated, reducing the likelihood of adverse outcomes.

### **Optimizing Resource Utilization**

Effective resource allocation is critical in the high-pressure environment of the ED. The findings of this study suggest that PPI and SI can serve as valuable tools for predicting patient deterioration and the need for intensive care interventions such as ICU admission and mechanical ventilation. By identifying patients at higher risk of poor outcomes early in their ED visit, healthcare providers can prioritize resources more efficiently. This targeted approach allows for better management of ICU beds, ventilators, and other critical resources, ensuring they

are reserved for patients most likely to benefit from them. It also helps in reducing unnecessary admissions and interventions, thereby optimizing the overall use of hospital resources.

### **Improving Patient Outcomes**

The integration of PPI and SI into routine triage practice has the potential to significantly improve patient outcomes. Early identification of patients with poor perfusion or hemodynamic instability enables timely interventions that can prevent clinical deterioration. For example, patients with low PPI values or high SI ratios can be closely monitored and provided with aggressive fluid resuscitation, vasopressor support, or other necessary treatments to stabilize their condition. By intervening early, clinicians can reduce the risk of complications, shorten hospital stays, and improve survival rates.

### **Reducing Variability in Triage Decisions**

Subjectivity and variability in triage decisions are ongoing challenges in emergency medicine. Different clinicians may interpret patient symptoms and urgency differently, leading to inconsistent triage outcomes. The use of objective measures such as PPI and SI can help standardize triage assessments, reducing variability and improving consistency across different practitioners and shifts. This standardization ensures that all patients are evaluated using the same criteria, leading to more reliable and equitable triage decisions.

### **Enhancing Training and Education**

The implementation of PPI and SI in routine triage practice requires adequate training and education for ED staff. The study's findings can be used to develop comprehensive training

programs that educate clinicians on the importance of these indices, how to interpret their values, and the appropriate clinical responses to different levels of PPI and SI. By enhancing the knowledge and skills of ED staff, hospitals can ensure that these tools are effectively utilized to improve patient care.

## Strengths and Limitations of the Findings

### Strengths

1. **Comprehensive Assessment:** One of the key strengths of this study is its comprehensive approach in evaluating the prognostic performance of PPI, SI, and ESI. By incorporating multiple indices, the study provides a holistic view of patient assessment, enabling a more nuanced understanding of patient acuity and outcomes.
2. **Objective Measurements:** The study leverages objective, quantifiable measures (PPI and SI) alongside the more subjective ESI. This integration helps reduce variability and bias in triage assessments, leading to more consistent and reliable patient evaluations.
3. **Robust Sample Size:** With a sample size of 610 patients, the study has sufficient power to detect significant associations and draw meaningful conclusions. This large sample size enhances the reliability and generalizability of the findings.
4. **Real-World Setting:** Done in a busy tertiary care centre, study's findings are highly applicable to real-world emergency department settings. The diverse patient population and high volume of cases ensure that the results are relevant and can be readily implemented in similar clinical environments.
5. **Prospective Design:** The prospective observational design allows for real-time data collection and analysis, reducing the risk of recall bias and enhancing the accuracy of the findings. This design also enables the study to capture the dynamic changes in patient status over time.

## Limitations

1. **Single-Center Study:** The study was done at a single tertiary care centre, which may limit the generalizability of the findings to other settings, especially those with different patient demographics, resources, or healthcare practices. Multi-center studies are needed to validate these findings across diverse environments.
2. **Exclusion Criteria:** Certain patient groups, such as those with terminal malignancy or those who were transferred immediately after assessment, were excluded. This might introduce selection bias, as the excluded patients could have different outcomes or triage characteristics.
3. **Potential for Measurement Error:** While PPI and SI are objective measures, they can still be affected by external factors such as sensor placement, patient movement, and environmental conditions. These potential sources of measurement error could impact the accuracy of the findings.
4. **Short Follow-Up Period:** The study primarily focused on immediate and 48-hour outcomes. While this is relevant for acute care settings, longer follow-up periods would provide more comprehensive insights into the long-term prognostic value of PPI, SI, and ESI.
5. **Limited Scope of Variables:** While the study included key indices and clinical parameters, other relevant factors such as comorbidities, medication use, and socioeconomic status were not considered. These variables could influence patient outcomes and should be included in future research.



## **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. Age, gender, and religious affiliation were also identified as important factors influencing patient outcomes. The study suggests that incorporating these objective indices can optimize resource allocation and improve patient care. Future research should validate these results across multiple centers and explore additional variables. In conclusion, integrating PPI and SI with ESI can enhance triage effectiveness, ensuring better patient outcomes and more efficient emergency department operations.

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## ANNEXURE – I

### ETHICAL CLEARANCE CERTIFICATE

  
**BLDE**  
(DEEMED TO BE UNIVERSITY)  
Declared as Deemed to be University u/s 3 of UGC Act, 1956  
Accredited with 'A' Grade by NAAC (Cycle-2)  
The Constituent College  
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA  
BLDE (DU)/IEC/ 703/2022-23 30/8/2022

**INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE**


The Ethical Committee of this University met on **Friday, 26th August, 2022 at 3.30 p.m. in the Department of Pharmacology** scrutinizes the Synopsis of Post Graduate Student of BLDE (DU)'s **Shri B.M.Patil Medical College Hospital & Research Centre** from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

**TITLE: "PERIPHERAL PERFUSION INDEX- SHOCK INDEX- ESI IN PREDICTION OF OUTCOME OF PATIENT IN TERTIARY CARE HOSPITAL".**

**NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: Deore Shubham Bhausaheb**

**NAME OF THE GUIDE: Dr. Ravi Patil, Dept. of Emergency Medicine.**

Dr. Santoshkumar Jeevangi  
Chairperson  
IEC, BLDE (DU),  
VIJAYAPURA  
**Chairman,**  
Institutional Ethical Committee,  
BLDE (Deemed to be University)  
Vijayapura



Dr. Akram A. Naikwad  
Member Secretary  
IEC, BLDE (DU),  
VIJAYAPURA  
**MEMBER SECRETARY**  
Institutional Ethics Committee  
BLDE (Deemed to be University)  
Vijayapura-586103, Karnataka

Following documents were placed before Ethical Committee for Scrutination:

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

Smt. Bangaramma Sajjan Campus, B. M. Patil Road (Sholapur Road), Vijayapura - 586103, Karnataka, India.  
BLDE (DU): Phone: +918352-262770, Fax: +918352-263303, Website: [www.bldeu.ac.in](http://www.bldeu.ac.in), E-mail: [office@bldeu.ac.in](mailto:office@bldeu.ac.in)  
College: Phone: +918352-262770, Fax: +918352-263019, E-mail: [bmprnc.principal@bldeu.ac.in](mailto:bmprnc.principal@bldeu.ac.in)

## **ANNEXURE II**

### **RESEARCH INFORMED CONSENT FORM**

BLDE (Deemed to be University)

Shri. B.M. PATIL Medical College, Hospital & Research Centre,  
VIJAYAPURA-586103

**TITLE OF THE PROJECT: PERIPHERAL PERFUSION INDEX- SHOCK INDEX-  
EMERGENCY SEVERITY INDEX IN PREDICTION OF OUTCOME OF PATIENT IN  
TERTIARY CARE HOSPITAL.**

**GUIDE: Dr. RAVI B PATIL, MD**

PROFESSOR AND HOD

DEPARTMENT OF EMERGENCY MEDICINE

**PG STUDENT: Dr SHUBHAM DEORE**

PG DEPARTMENT OF EMERGENCY MEDICINE

## **PURPOSE OF RESEARCH:**

I have been explained about the reason for doing this study and selecting me as a subject for this study. I have also been given free choice for either being included or not in this study.

## **PROCEDURE:**

I am aware that in addition to routine care received, I will be asked a series of questions by the investigator. I have been asked to undergo the necessary investigations and treatment, which will help the investigator in this study.

## **RISK AND DISCOMFORTS:**

I understand there is no risk involved and that the patient may experience some discomforts due to panic situation during the examination. This is mainly the observational study and no risk is involved in the study. All the data collected would be kept safe and private.

## **BENEFIT:**

I do understand that my participation in this study will have no direct benefits to me, other than the potential benefit of the research and education.

## **CONFIDENTIALITY:**

I understand that the medical information produced by this study will become a part of hospital records and will be subjected to confidentiality. Any information about



sensitive, personal nature will not be a part of the medical record but will be stored in the investigations research file. If any of the data are used for publication in the medical literature or for teaching purpose, no name will be disclosed, and other identifiers such as photographs will be used only with special written permission taken priorly. I also understand that I may visualize the photograph before granting permission.

### **REQUEST FOR MORE INFORMATION:**

I understand that I may ask questions about the study at any time; Dr. SHUBHAM DEORE at the department of Emergency Medicine is available to answer my questions or concerns. I understand that I will be informed of any significant new findings discovered during the course of the study, which might influence my continued participation. A copy of this consent form will be given to me to keep for careful reading.

### **REFUSAL FOR WITHDRAWAL OF PARTICIPATION:**

I understand that my participation is voluntary and that I may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice. I also understand that Dr SHUBHAM DEORE may terminate my participation in the study after he has explained the reasons for doing so.

## **INJURY STATEMENT:**

I understand that in the unlikely event of injury to me, resulting directly for participation in this study; if such injury were reported promptly, the appropriate treatment would be available to the patient. But no further compensation would be provided by the hospital. I understand that by my agreements to participate in this study and not waiving any of my legal rights.

I have been explained about the purpose of the research, the procedures required and the possible risks to the best of my ability.

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Dr. SHUBHAM DEORE  
(Investigator)

Date

**STUDY SUBJECT CONSENT STATEMENT:**

I confirm that DR SHUBHAM B. DEORE has explained to me the purpose of the research, the study procedures that I will undergo, and the possible risks and discomforts as well as benefits that I may experience in my own language. I have read the form and understand this consent. Therefore, I agree to give consent to participate as a subject in this research project.

\_\_\_\_\_

\_\_\_\_\_

Participant / Guardian

Date:

\_\_\_\_\_

Witness to signature

Date:

**B.L.D.E (DEEMED TO BE UNIVERSITY)**  
**SHRI B M PATIL MEDICAL COLLEGE,**  
**VIJAYAPURA, KARNATAKA**  
**SCHEME OF CASE TAKING**

**INFORMANT:**

Name:

Age:

IP NO:

Sex:

DOA:

Religion:

Residence:

ESI criteria -

Diagnosis –

ICU admission – YES/NO

Need for Ventilation: Yes—if yes then, Non-invasive ventilation / Invasive

Ventilation

No

48-hrs outcome: Improved/Deteriorated or Died

	At the time of arrival	At 12 <sup>th</sup> hrs after admission	At the 48 <sup>th</sup> hrs after admission
Peripheral Perfusion Index			
Shock Index (HR/SBP)			
Emergency Severity Index Grade		-	-

94

[illegible]

96



[illegible]