The Association Between Patient Outcomes and the Initial Emergency Severity Index Triage Score in Patients with Suspected Acute Coronary Syndrome.

BY

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ABSTRACT (250 words)

Background: The Emergency Severity Index (ESI) is a widely used tool to triage patients in Emergency Departments. Although it is used in most patient populations, its accuracy in triaging those with suspected acute coronary syndrome (ACS) is questionable. **Objective**: We aimed to evaluate the accuracy of ESI in classifying dire outcomes in suspected ACS, and to assess the incremental re-classification performance if ESI is supplemented with other established clinical tools. **Methods**: We used existing-data from an observational cohort study of chest pain patients in the U.S. We abstracted ESI scores documented by triage nurses during routine medical care. The primary outcome, incidence of 30-day major adverse cardiac events (MACE), was adjudicated by two independent reviewers. We then computed a well-established score referred to as modified HEAR/T (patient History, Electrocardiogram, Age, Risk factors, but without Troponin). **Results**: The sample included 750 patients (age 59 ± 17 years, 43% female, 40% black). A total of 145 patients (19%) experienced MACE. The area under the ROC curve for ESI score for predicting MACE was 0.656, compared to 0.796 for the modified HEAR/T score ($p<0.01$). Using the modified HEAR/T score, 181 out of the 391 (46%) false positives and 16 out of the 19 (84%) false negatives assigned by ESI could be reclassified correctly. **Conclusion**: The ESI score is poorly associated with dire outcomes in patients with suspected ACS. Supplementing the ESI tool with input from other validated clinical tools can greatly improve the accuracy of triage in patients with suspected ACS.

Keywords: Emergency severity index; triage; chest pain; acute coronary syndrome; emergency department

What's New and Important? (2-3 highlights of the manuscript)

- Emergency Severity Index score has a low positive predictive value to identify chest pain patients at greatest risk for dire outcomes.
- By incorporating relevant patient predictors from the modified HEAR/T score, there is potential to easily develop a cardiac triage tool that could aid nurses in differentiating high-risk patients.

1. Background

Emergency department (ED) nurses triage nearly 137 million patients per year in the United States.[1] The goal of triage is to assess and identify clinical conditions to prioritize those with the most significant risk of morbidity and mortality. This is important because time-sensitive clinical conditions need to be recognized early to reduce negative patient outcomes while minimizing over-triage of patients that are unlikely to have serious disease. Unfortunately, ED overcrowding is widespread and triage tools that are both accurate and efficient are sorely needed. Presence of overcrowding has been associated with delays in recognizing high morbidity conditions such as acute coronary syndrome (ACS) and septic shock.[2,3] As such, nurses are tasked with the unique job characteristic of being able to pick out a clinically critical condition among a group of undifferentiated patients. ACS is a condition that is commonly encountered in ED settings and recognizing patients with ACS in the ED can be very challenging. Unfortunately, prior studies have shown that nurses' accuracy in accurately triaging ACS is as low as 56%.[4]

The Emergency Severity Index (ESI) tool is the most commonly used triage tool in EDs across the United States.[5] It is a five-level ordinal scale used to categorize patients based on resource utilization in the ED and likelihood of admission.[6] It is easy to use and can be universally applied to any patient that presents to the ED. Unfortunately, this tool has significant limitations. ESI scores are not patient outcome driven; the tool is validated against predicting ED resource utilization and hospital admission.[6] ESI scores are highly subjective; different nurses can assign different scores based on their personal clinical judgement.[6] Also, the ESI tool provides poor discrimination for middle acuity patients; more than 50% of patients are classified with an ESI score of 3.[5,7,8] Furthermore, while the ESI is a generalizable tool that facilitates the triage of undifferentiated patients regardless of chief compliant, it may not be effective for triaging the specific subset of patients where the greatest concern is the identification of ACS.

On the other hand, multiple clinical tools exist that can be used to risk-stratify patients with symptoms that are concerning for ACS. The widely used HEART score (**H**istory, **E**lectrocardiogram, **A**ge, **R**isk Factors, **T**roponin) is highly accurate in identifying suspected ACS patients at increased risk for adverse outcomes.[9,10] Although both the ESI and HEART score are meant to help clinicians risk-stratify patients to identify those patients in greatest need of immediate evaluation, both scores have never been compared. Therefore, the purpose of this study was to 1) evaluate the accuracy of the initial ESI score in identifying those at increased risk of adverse events among patients evaluated for suspected ACS, and then to 2) assess the incremental re-classification performance if ESI is supplemented with other established clinical tools like the modified HEAR/T score.

2. Methods

2.1 Study Design

We conducted a secondary analysis of patients from the EMPIRE (Electrocardiogram Methods for the Prompt Identification of Coronary Events) study.[11] This was an observational cohort study of patients with non-traumatic chest pain with the chief compliant of chest pain or equivalent (i.e., shortness of breathing, palpitation, syncope). Enrolled patients were 18 years of age or older and were transported via ambulance by Emergency Medical Services (EMS) to one of three participating affiliated tertiary care centers with 24-hour cardiac catheterization centers. The EMS agency is a municipal, third-service EMS agency which responded to emergency calls with a dual paramedic team during the study period. All consecutive eligible patients were enrolled under a waiver of informed consent and there were no restrictions to sex and race. This study had institutional internal review board approval. For this secondary analysis, we used the initial cohort of the EMPIRE study that enrolled patients transported between May 2013 and August 2014 (n=750).

2.1.1 Data Collection

In-hospital electronic health records were manually examined by independent reviewers to extract pertinent clinical data. Each reviewer received data collection training from an expert user of the electronic health record. For data extraction, reviewers used a standardized data collection tool with well-defined variables. Basic demographics and clinical characteristics for each patient (e.g. age, sex, past medical history, etc.) were collected per an a prior defined data coding scheme that has been described in detail previously.[11]

2.1.2 ESI Score

Patients underwent retrospective electronic chart review by study investigators (SOF, BL) to obtain the ESI score. If the score was missing, this was observed as missing data. The 5-level ESI score is a triage tool that asks 3 questions including: (1) Is the patient dying?; (2) Can the patient wait in the waiting room?; and (3) What resources will the patient use?[6] The tool takes into account the patient's vital signs and the nurse's intuition, which affords the nurse the subjectivity and leniency to increase the acuity score. The original ESI triage tool was validated with associations with the following patient outcomes: ED resource consumption, inpatient admission, ED length of stay and 60-day mortality.[12-15] The ESI scores range from 1-5; level 1- means the patient needs an immediate life-saving intervention, level 2- means that the patient is considered high risk and level 5- means the patient has a non-urgent condition. For example, to be an ESI level 1, a patient requires an airway, emergency medications, or another intervention to maintain life; these patients are considered unstable and need a team response to initiate immediate care.[6] In contrast, ESI level-5 is a low acuity patient that does not require any immediate resources, such as a patient with a simple rash or who is in need of a prescription refill.[6] For our analysis, we considered ESI scores 1 and 2 to represent high-acuity and ESI scores 3–5 to represent low-to-intermediate acuity.

2.1.3 HEART Score

Patients underwent retrospective electronic chart review conducted by study investigators (ZF, SA) to calculate the HEART score. We have previously reported the calculations and the clinical value of the HEART score on this dataset.[16] However, given that the original HEART score[9,10,17] incorporates laboratory data on troponin that are not typically available for early triage by nurses and EMS providers, we recalculated the HEART score after dropping the troponin score. This modified *HEAR/T score* (i.e. without the "T" component) has been previously validated for application in the prehospital setting by emergency medical service providers and has been shown to have equivalent positive likelihood ratio (95% confidence interval) of 1.37 (1.18- 1.55) versus 1.47 (1.33- 1.61) as the original HEART score .[18] For our analysis, we considered modified HEAR/T scores 1–3 to represent low risk and scores 4–10 to represent high risk.

2.1.4 Adjudication of Primary Study Outcome

The primary study outcome was 30-day major adverse cardiac event (MACE) defined as a composite endpoint of one of the following conditions as previously described in the literature:[17] 1) all-cause death; 2) acute coronary syndrome; 3) coronary revascularization; 4) post-admission pulmonary embolus; 5) fatal ventricular arrhythmia; 6) cardiogenic shock; and 7) acute heart failure during the indexed hospitalization or within 30 days, as determined by electronic health record review. Acute coronary syndrome was defined as per the American Heart Association (AHA) / American College of Cardiology (ACC) Universal Definition.[16] Two independent reviewers examined all available in-hospital and out-of-hospital medical records to adjudicate the outcome and disagreement was resolved by a third reviewer.

2.2 Statistical Analysis

All data analyses were performed using SPSS® software version 25 (IBM, Armonk, NY) and an alpha of 0.05 or less was considered to be significant. Detailed descriptive statistics were used to report demographic and clinical characteristics. The sensitivity and specificity for

both ESI score and modified HEAR/T score were calculated for the primary outcome. The positive and negative predictive value of the ESI score for MACE were examined. The area under the receiver operating characteristic (ROC) curve was calculated for both ESI score and modified HEAR/T score for the outcome of MACE.

3. Results

Our sample included 750 patients (age 59 ± 17 years, 43% female, and 40% black). Overall, we observed a total of 259 MACE events in 145 patients (19%), including ACS (n=115), death (n=9), cardiac arrest (n=12), ventricular tachyarrhythmia (n=13), coronary revascularization (n=74), post-admission pulmonary embolism (n=2), post-admission acute heart failure (n=11), and 30-day re-infarction (n=23). Of note, most of those experiencing MACE (n=119/145, 83%) had their event during the indexed hospitalization. Table 1 compares the demographics and clinical characteristics between those with or without MACE. Those who experienced MACE were more likely to be older and Caucasian, as well as to have a past medical history of diabetes, coronary artery disease, old myocardial infarction, known heart failure, and prior coronary revascularization procedure.

The distribution of ESI scores of 1 to 5 in this sample were 18%, 48%, 28%, 0.3%, and 0% respectively. Those who had an ESI score of 4 (n=2) were collapsed with the group of ESI 3 in subsequent analysis. The ESI scores were missing for 39 patients (5%) in this sample and our analysis showed that these were not missing at random based on the association of MACE as an outcome. As such, we kept these patients in our analysis and labeled that ESI group as “Not reported”. Figure 1 compares the distribution of MACE events to each ESI triage score. As shown in Figure 1-A, approximately 36% of patients with initial ESI score of 1 had a MACE event, compared to 16% for ESI score 2 and 9% for ESI score 3. Conversely, 80% of all patients assigned ESI score 1 or 2 were event-free. On the other hand, Figure 1-B compares

the distribution of MACE events to each modified HEAR/T score. There was a smooth gradual increase in the rate of MACE events as the risk score increases.

Figure 2 compares the classification performance between ESI score and the modified HEAR/T score in predicting the primary study outcome. The area under the ROC curve for ESI score vs. modified HEAR/T score was 0.656 vs. 0.796 ($p< 0.01$). The sensitivity and specificity of ESI score ≤2 vs. modified HEAR/T score ≥4 for predicting MACE were 75% and 32% vs. 83% and 51%, respectively.

Figure 3 compares the association between the patient acuity levels assigned by ESI score versus the reclassification performance using the modified HEAR/T score. A total of 391 patients were assigned high acuity level by ESI but did not experience a MACE event (false positives). Of those, 181 (46%) were reclassified correctly as low-risk by the modified MEAR/T score. Similarly, a total of 19 patients were assigned low acuity level by ESI but did experience a MACE event (false negatives). Of those, 16 (84%) were reclassified correctly as high-risk by the modified MEAR/T score.

4. Discussion

In this study, we sought to evaluate the accuracy of the initial ESI score in identifying those at increased risk of adverse events among patients with suspected ACS. We also aimed to assess the incremental re-classification performance if ESI is supplemented with other established clinical tools. Overall, the ESI failed to well-differentiate the acuity of illness in patients with suspected ACS (i.e., ~50% of the sample had an ESI score of 2). Importantly, the ESI score had poor classification performance in predicting MACE in this population (i.e., area under the ROC curve < 70%). The ESI also had low positive predictive value where 80% of those classified as high acuity level (ESI scores 1 and 2) were event-free. When compared to the modified HEAR/T score, we noticed that nearly 40% of patients with high ESI scores were over-triaged (i.e., unnecessary cost) and around 40% of patients with middle-acuity ESI scores

were under-triaged (i.e., potential patient harm). When the ESI was supplemented by the modified HEAR/T score, more than 50% of false positives and false negatives were re-classified correctly. These findings demonstrate both that the ESI tool is inadequate in triaging patients with suspected ACS, and that there is room for substantial improvement in how nurses triage this vulnerable patient population. To our knowledge, this is one of few studies that evaluate the performance of the ESI score to predict cardiac patient outcomes and compares its performance to the modified HEAR/T score.

An article by DeLaney, Neth and Thomas (2017) investigated current chest pain triage trends in the United States, but failed to include the Emergency Severity Index score.[19] Mirhaghi contributed in follow-up commentary that the Emergency Severity Index score could help understand the current state of triage for chest pain patients as it is the most widely used triage tool in the United States.[20] Similar to the Emergency Severity Index, the Canadian Triage and Acuity Scale is a five-level triage tool where score III, IV and V (corresponding to urgent, less urgent and nonurgent, respectively) are considered low acuity triage scores. A study by Atzema et al. (2009) found that 50% of acute myocardial infarction patient were given an inappropriate low triage score.[21] This low acuity score was associated with substantial delays in door-to-ECG and door-to-needle time. These results raise concern about the process of triage and the tools that nurses are currently using to quickly and accurately identify patients that have significant risk for acute coronary syndrome.

Current triage evaluation using the ESI tool may not always accurately identify those patients who would be best served by early care. In our study, 8% of patients with MACE at 30 days were triaged to an ESI category of 3. This mid-level triage assessment means that some high-risk patients may have been under triaged. This potentially incorrect triage acuity may cause delays in treatment and ultimately compromise patient outcomes.[22,23] Further, of those patients that were triaged with an ESI score of 1 or 2, 80% did not develop MACE. This may be

an indication of being over-triaged, taking scarce and valuable resources away from patients that could potentially use them.

When comparing the area under the ROC curve, the modified HEAR/T score performs better, with an area under the curve (AUC) of 0.796 [95% confidence interval, (0.754, 0.837), p= <0.001]. This classification is a very good classification compared to the ESI score AUC= 0.656,(0.602, 0.710), p=< 0.001, which is fair. This is important to note because the modified HEAR/T score assesses the past medical **H**istory, **E**CG findings, **A**ge and **R**isk factors of a patient and formulates a number which deems the patient at low versus intermediate to high-risk of developing MACE. We combined ESI scores 1 and 2 to represent high-acuity patients, we were able to identify the ESI score's false positive cases. False positive cases can represent over-triaging patients to a high-acuity because they did not develop MACE. These cases have potential to be prioritized to use scare ED resources that other high-risk patients could use. From the data, our middle-acuity ESI score of 3 represented the nineteen false negative cases. False negative cases are concerning because it may jeopardize patient care and potentially delay patient treatment. By using the modified HEAR/T score, we reclassified 16 (46%) cases to be truly intermediate to high-risk according to HEAR/T assessment criteria.

Information contained in the modified HEAR/T score can be obtained in the prehospital setting and upon arrival to the emergency department. Nurses' application of an ESI score could be informed by an initial calculation of a modified HEAR/T score, thus potentially improving the deployment of resources in working-up and treating the patient. This addition could alert nurses to patients at high risk for developing MACE, lead to better assessments of patient acuity at triage, and potentially lead to improved patient outcomes.

Limitations

A limitation of this study was the retrospective calculation of the modified HEAR/T score. This score was assigned solely upon review of all progress notes in the electronic health record

and could be bias based on what was documented by clinicians. Another possible limitation was loss of follow-up in adjudicating the primary 30-day composite outcome of MACE, due to the observational nature of our study. While we reviewed all in-patient and out-patient electronic health records within a large 40-hospital regional health system and are likely to have captured most repeat visits for care. Our data collection may have missed 30-day death or reinfarction events where the patient did not have a repeat visit somewhere in the health system.

5. Conclusion

Emergency department nurse triage is challenging and requires optimized tools to prioritize patients with time-sensitive conditions, allocate resources, and positively impact morbidity and mortality. Our study demonstrates that the ESI tool is inadequate in triaging patients with suspected ACS, and that there is room for substantial improvement in how nurses triage this vulnerable patient population. Most chest pain patients assigned ESI scores 1 and 2 are event free from MACE suggesting over triage. When the modified HEAR/T score was used to supplement ESI, more than 50% of patients improperly triaged could be reclassified correctly. By incorporating risk factors from the modified HEAR/T score into nurse triage, there is potential to increase identification of patients at greater risk for developing MACE. This early recognition of high-risk patients could lead to initiating treatment that has potential to improve patient outcomes.

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Figure Legend:

Figure 1: Distribution of Primary Study Outcome in each Mechanism of Triage: Emergency Severity Index Score and Modified HEAR/T Score

This figure compares the distribution of MACE events to each ESI triage score (A) and to each modified HEAR/T score (B).

Figure 2: Comparison between the classification performance of ESI score and modified HEAR/T scores in predicting major adverse cardiac events

This figure compares the area under the ROC curve for predicting MACE using the ESI score (A) versus using the modified HEAR/T score (B).

Figure 3: Association between the initial patient classification by ESI score versus modified HEAR/T score at the emergency department

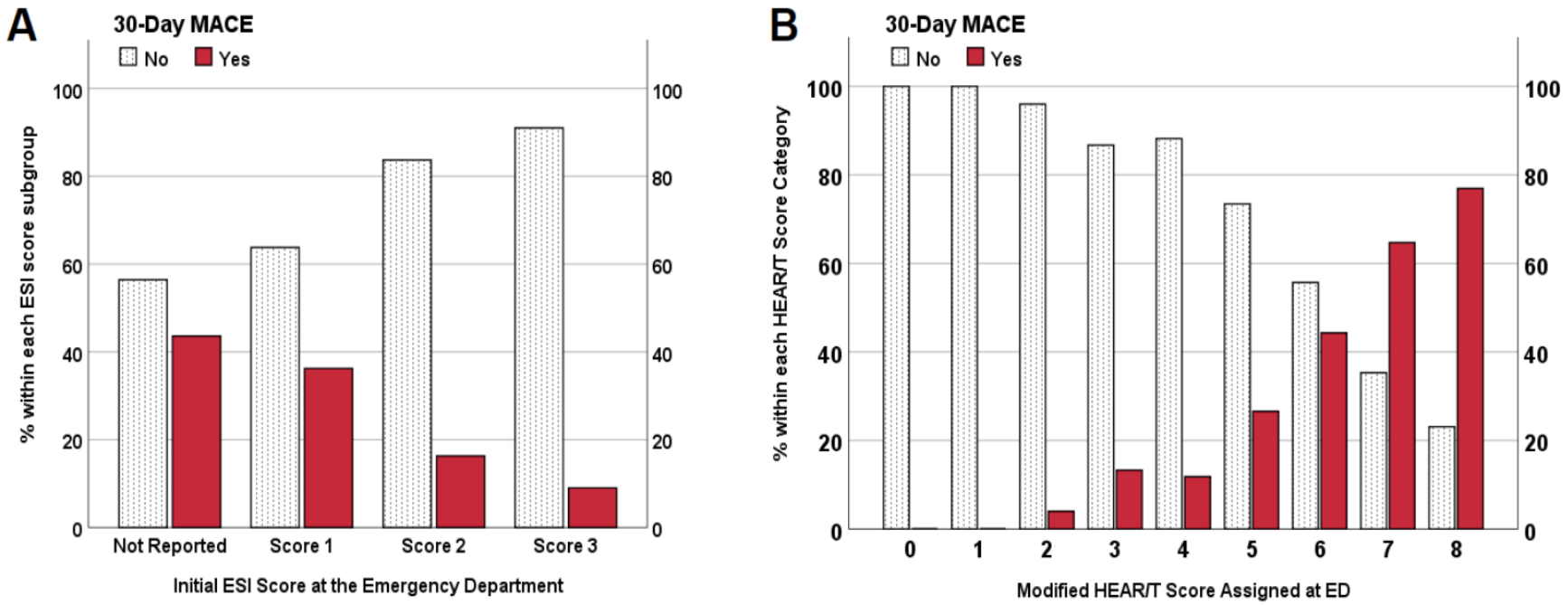
This figure compares the association between the patient acuity levels assigned by ESI score versus the reclassification performance using the modified HEAR/T score

Table 1: Patient Demographics and Clinical Characteristics of the Study Sample

Variables	All Patients (n=750)	Major Adverse Cardiac Events (MACE)	
		MACE (n=145, 19%)	No MACE (n=605, 81%)
Demographics			
Age (years; mean, SD)	59±17	**64 ± 15**	58 ± 17
Sex (Male)	427 (57%)	86 (59%)	347 (57%)
Race (Black)	300 (40%)	**33 (23%)**	268 (44%)
Major Adverse Cardiac Event Risk Factors			
Ever Smoked	434 (58%)	85 (59%)	350 (59%)
Hypertension	519 (70%)	100 (69%)	419 (70%)
Diabetes Mellitus	196 (26%)	**48 (33%)**	148 (25%)
Hyperlipidemia	259 (35%)	53 (37%)	206 (34%)
Coronary Artery Disease	248 (33%)	**57 (39%)**	191 (32%)
Old Myocardial Infarction	205 (28%)	**53 (37%)**	152 (25%)
Known Heart failure	130 (18%)	**32 (22%)**	98 (16%)
Prior PCI or CABG	207 (28%)	**59 (41%)**	148 (25%)
Chief Complaint			
Chest Pressure	645 (87%)	127 (88%)	518 (87%)
Shortness of Breathing	215 (29%)	44 (30%)	171 (29%)
Heart Rhythm Abnormalities	126 (17%)	26 (18%)	100 (17%)
Atypical Symptoms	94 (13%)	21 (15%)	73 (12%)

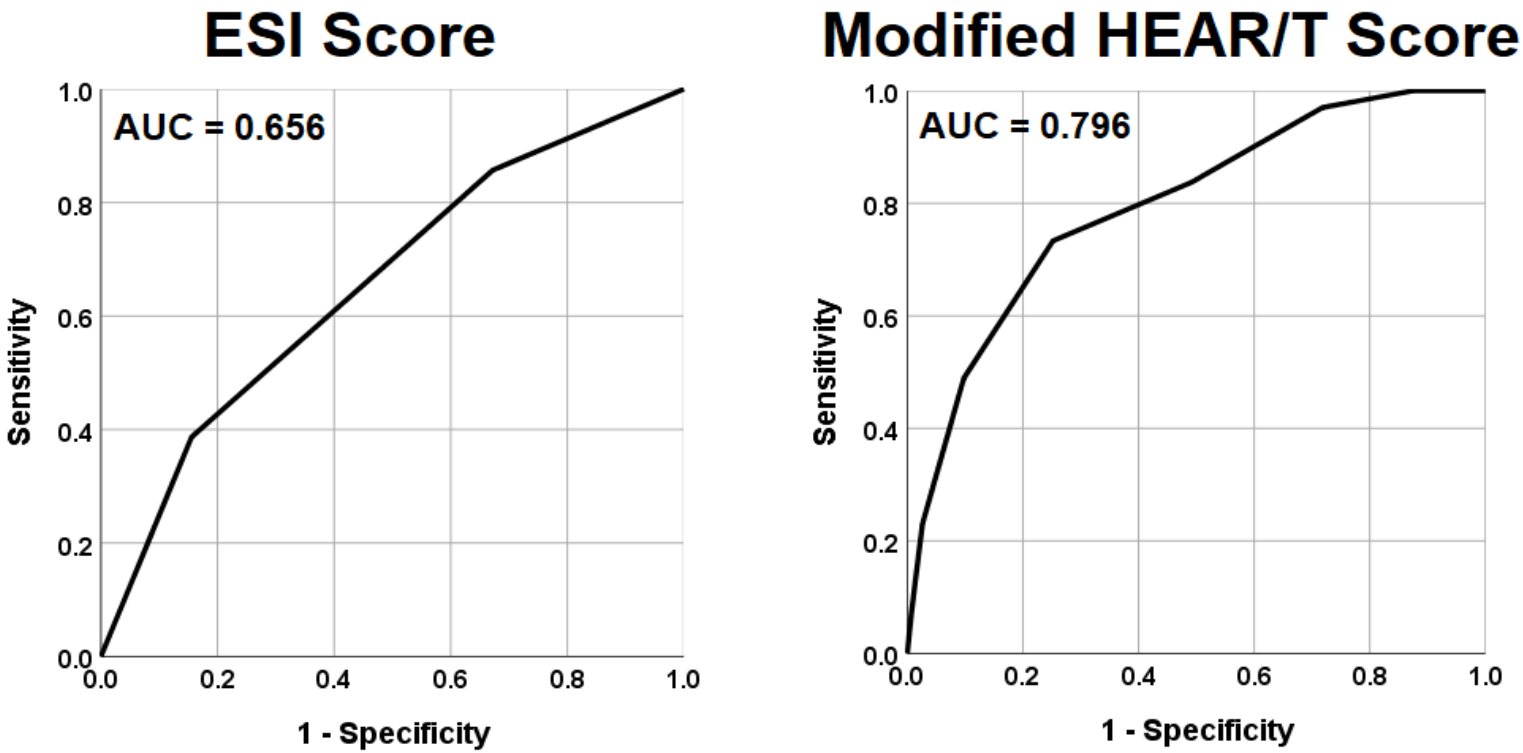
Abbreviations: PCI: percutaneous coronary intervention; CABG: coronary artery by-pass grafting surgery.

Figure 1: Distribution of Primary Study Outcome in each Mechanism of Triage: Emergency Severity Index Score and Modified HEAR/T Score



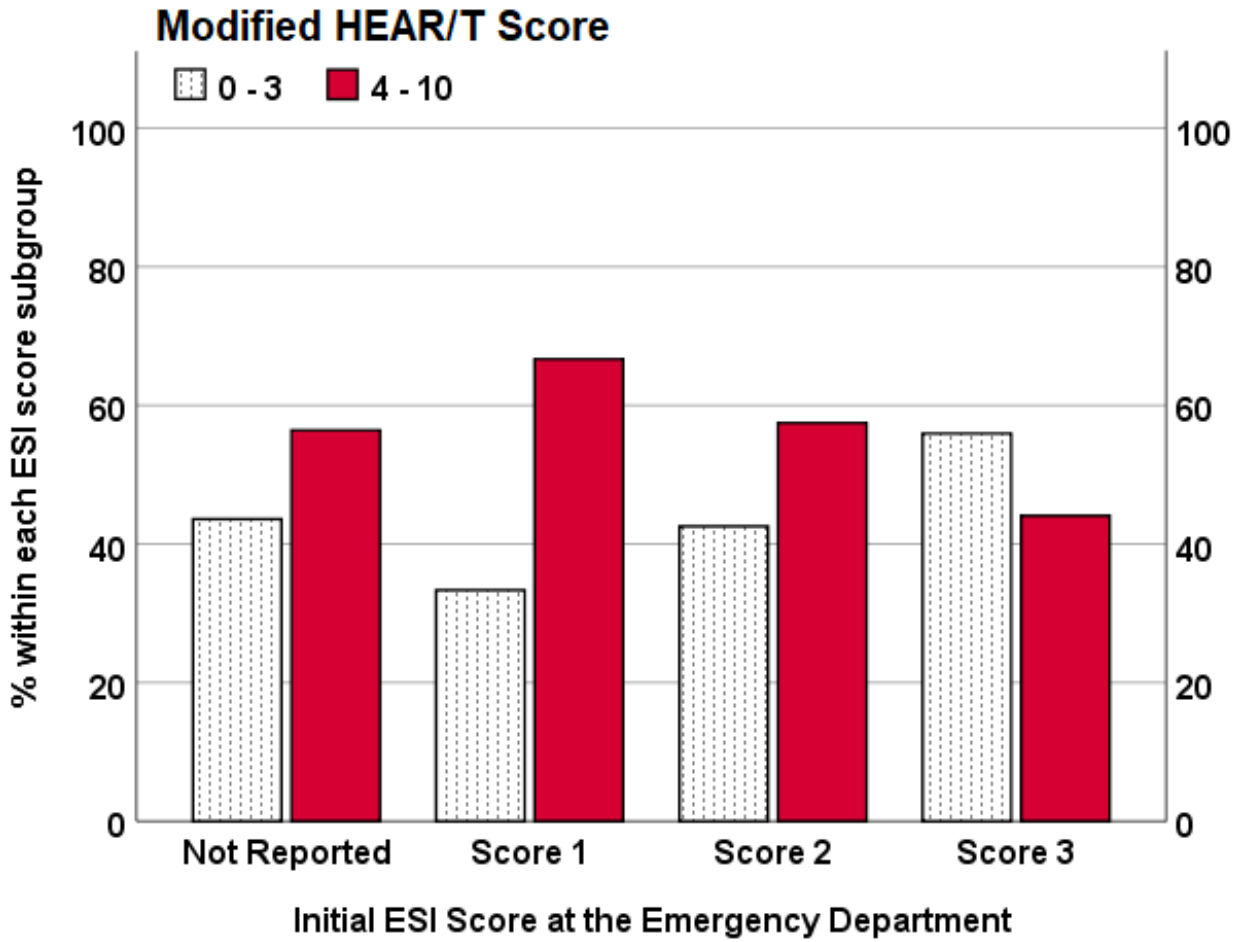
Abbreviations: ESI: Emergency Severity Index; MACE: Major adverse cardiac event; ED: Emergency Department

Figure 2: Comparison between the classification performance of ESI score and modified HEAR/T scores in predicting major adverse cardiac events



Abbreviation: ESI: Emergency Severity Index

Figure 3: Association between the initial patient classification by ESI score versus modified HEAR/T score at the emergency department



Abbreviation: ESI: Emergency Severity Index.