Prognostic and Diagnostic Assessment Systems for Acute Coronary Syndrome: A Scoping Review

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Abstract

Clinical scoring systems are widely used to support early risk stratification and clinical decision-making in patients with acute coronary syndrome (ACS). However, the characteristics, development processes, and clinical applications of these scoring systems remain dispersed across the literature. This scoping review aims to map and synthesize the available evidence on scoring systems used to assess or predict ACS events in hospital settings. A scoping review methodology was conducted using electronic databases, including PubMed, Scopus, and Emerald. The search terms included "acute coronary syndrome," "scoring system," OR "score predictor," and "in hospital." Of 1,961 identified records, 18 studies met the inclusion criteria after screening. Data were extracted using a charting approach to summarize study characteristics, scoring system variables, and reported outcomes. The review identified eleven ACS scoring systems, including widely used models such as GRACE, TIMI, and HEART. These scoring tools primarily incorporate clinical indicators such as age, systolic blood pressure, electrocardiogram findings, cardiac biomarkers, and cardiovascular risk factors. The results indicate that ACS scoring systems can be broadly categorized according to their clinical objectives, including diagnostic risk assessment, prognostic prediction, and early risk stratification in emergency settings. This review highlights the variability of predictive models across different clinical contexts and emphasizes the importance of selecting practical scoring systems that rely on readily available clinical indicators. The findings provide a comprehensive overview of existing ACS scoring systems and offer a conceptual framework that may help clinicians select appropriate risk assessment tools and guide future research on the development of simplified prediction models.

Keywords: Acute Coronary Syndrome, Risk Score, Clinical Prediction Model, Risk Stratification

INTRODUCTION

Acute Coronary Syndrome (ACS) encompasses a range of clinical manifestations resulting from acute myocardial ischemia, including chest pain, electrical instability, hemodynamic compromise such as cardiogenic shock, and mechanical complications. It is primarily classified into ST-segment elevation myocardial infarction (STEMI), non-ST-segment elevation myocardial infarction (NSTEMI), and unstable angina pectoris (UAP). (Lewis et al., 2020; Singh et al., 2024). Coronary heart disease (CHD) remains a major global health concern. According to the World Health Organization (WHO), cardiovascular diseases (CVDs) caused approximately 17.9 million deaths in 2019, representing the leading cause of mortality worldwide (WHO, 2021). More recent estimates indicate that CVD-related mortality increased to 19.05 million deaths in 2020, representing a substantial rise over the past decade (Tsao et al., 2023). The global prevalence of cardiovascular disease has also increased significantly, exceeding 607 million cases worldwide. In the Asia-Pacific region, ACS contributes considerably to cardiovascular mortality and disease burden (Nabovati et al., 2023). These trends highlight the urgent need for effective strategies to improve early detection, risk stratification, and management of ACS.

Patients presenting with suspected ACS account for approximately 10% of all emergency department visits, although only a minority are ultimately diagnosed with acute myocardial infarction (Khand et al., 2023). Given the time-sensitive nature of ACS, early diagnosis and prompt management are critical to reducing morbidity and mortality. Current clinical guidelines emphasize minimizing delays between symptom onset and treatment initiation, ideally within the first hour of presentation (Khaled et al., 2022). In this context, risk stratification tools play a crucial role in supporting clinical decision-making, facilitating early diagnosis, and optimizing patient management in emergency settings.

Risk scoring systems have been extensively developed to assist clinicians in evaluating patients with suspected ACS by integrating clinical presentation, electrocardiographic findings, cardiovascular risk factors, and cardiac biomarkers (Piccioni et al., 2024). Among these, the Thrombolysis in Myocardial Infarction (TIMI) score is one of the most widely utilized tools for risk stratification. However, recent evidence indicates that, despite its clinical utility, the TIMI score has notable limitations in accurately identifying low-risk patients presenting with chest pain in emergency settings. Comparative studies have demonstrated that TIMI exhibits lower sensitivity compared to more contemporary risk stratification tools, such as the HEART score, and lacks an optimal cutoff value capable of simultaneously achieving high sensitivity and specificity (Nasr Isfahani et al., 2025; Sarıbaş et al., 2024; Yukselen et al., 2024). Consequently, alternative scoring systems, including the HEART score, have been developed and widely adopted due to their simplicity and improved predictive performance, particularly in identifying low-risk patients suitable for early discharge (Six et al., 2013b).

In Southeast Asia, the burden of cardiovascular disease has increased rapidly over the past two decades, driven by epidemiological transitions and the rising prevalence of non-communicable diseases. Countries such as Indonesia are experiencing substantial increases in cardiovascular morbidity and mortality, with coronary artery disease emerging as a leading cause of death (Harmadha et al., 2023; Muharram et al., 2024; Roth et al., 2020). This growing burden places significant pressure on emergency healthcare systems, particularly in managing large numbers of patients presenting with chest pain. In such settings, reliable and efficient risk stratification tools are essential to support rapid clinical decision-making, optimize resource utilization, and ensure that high-risk patients receive timely intervention.

Scoring systems enable clinicians to categorize patients into high-, moderate-, or low-risk groups, thereby optimizing clinical decision-making and improving outcomes. However, despite the widespread use of various scoring models, differences remain in their intended purpose (diagnostic vs. prognostic), predictive variables, validation populations, and clinical settings. Existing literature shows considerable heterogeneity and overlap among scoring systems, with fragmented evidence regarding their comparative performance across diverse healthcare contexts. This overlap between multiple assessment tools, combined with variations in methodological design and validation settings, creates uncertainty for clinicians regarding which scoring system is most appropriate for specific clinical objectives. Furthermore, there is limited synthesis that systematically maps these tools based on their diagnostic, prognostic, or cardiac arrest predictive purposes.

Despite the availability of numerous ACS scoring systems, several challenges remain in their clinical application. Existing scoring models differ in their intended purposes (diagnostic versus prognostic), predictive variables, and validation populations. Furthermore, there is considerable heterogeneity in their methodological development and implementation across different healthcare settings. This variability contributes to clinicians' uncertainty about the most appropriate scoring system to use in specific clinical contexts. Additionally, many widely used scoring systems have been developed and validated predominantly in high-income countries, raising concerns about their applicability in low- and middle-income countries (LMICs), including those in Southeast Asia (Ismail et al., 2022; Kaur et al., 2022; Lim et al., 2022). Differences in healthcare infrastructure, diagnostic facility availability, and patient characteristics may influence the feasibility and performance of these scoring systems in resource-limited settings. Therefore, identifying practical, evidence-based scoring tools that can be implemented across diverse healthcare environments is essential (Yukselen et al., 2024).

Although prior systematic reviews have evaluated individual ACS scoring models, few have comprehensively mapped the full spectrum of scoring systems used in ACS assessment. Given the heterogeneity in clinical objectives, predictive variables, and validation settings, a scoping review is appropriate to examine existing evidence and identify gaps in its development and implementation, following PRISMA-ScR guidelines (Arksey & O'Malley, 2005; Peters et al., 2020; Tricco et al., 2018).

Despite the availability of numerous scoring systems, existing evidence remains fragmented, with limited synthesis regarding their development, implementation, and outcome measures across diverse settings. The underrepresentation of low- and middle-income countries further raises concerns about generalizability. This lack of integrated evidence represents a significant research gap.

Based on these considerations, this scoping review aims to map scoring systems used to assess acute coronary syndrome. The review addresses the following research questions: (1) How are ACS scoring systems developed? (2) What scoring systems are currently available? (3) How are they implemented in clinical practice? (4) What validation results have been reported? (5) What outcome measures are used? This review seeks to synthesize existing evidence to support clinical decision-making and guide the development of more practical, context-appropriate prediction models.

METHODS

Design

This study employed a scoping review design to map and synthesize existing evidence on scoring systems used to assess ACS. Scoping reviews are suitable for addressing broad research questions, identifying research gaps, and mapping evidence across diverse study designs, in contrast to systematic reviews that focus on narrowly defined questions and intervention effectiveness (Moher et al., 2015). Accordingly, this review included all relevant literature regardless of methodological approach.

This review followed the methodological framework proposed by Arksey and O'Malley and further refined by Pham et al. (Arksey & O'Malley, 2005; Pham et al., 2014). It also adhered to the PRISMA-ScR guidelines to ensure transparency and methodological rigor in study identification, screening, and reporting (Tricco et al., 2018).

This review was not registered in PROSPERO, as scoping reviews are not required to be registered. PROSPERO primarily prioritizes systematic reviews evaluating health interventions. Given that this study aimed to map existing evidence rather than assess intervention effects, registration was not deemed essential. However, established scoping review methodology and PRISMA-ScR standards were followed to ensure transparency and reproducibility.

Search Methods

The scoping review followed the five-stage framework proposed by Arksey and O'Malley, including identifying the research question, identifying relevant studies, study selection, data charting, and collating, summarizing, and reporting the results (Arksey & O'Malley, 2005).

The literature search was conducted from January 2000 to December 2024, covering the period during which most ACS risk scoring systems were developed and validated. Studies were included if they: (1) were quantitative or qualitative research articles; (2) reported the development, validation, or evaluation of ACS scoring systems; (3) involved adult patients (≥18 years) with suspected or confirmed ACS; (4) were published in English; (5) were available in full text; and (6) provided sufficient information on the design, development, or evaluation of scoring systems.

Studies were excluded if they: (1) discussed scoring systems without specific evaluation; (2) focused on conditions unrelated to ACS; or (3) were editorials, commentaries, or conference abstracts without full text.

Stage 1: Identifying the Research Question

In scoping reviews, defining clear objectives and research questions is essential to guide the review process. The research questions were developed using the Population–Concept–Context (PCC) framework.

Table 1. PCC Framework

Component	Description
Population	Adult patients with suspected or confirmed Acute Coronary Syndrome
Concept	Development, validation, and implementation of ACS scoring systems
Context	Hospital or emergency department settings

Based on this framework, five research questions were formulated:

1) How is the development process of the ACS scoring system described in the literature?
2) What scoring systems currently exist to assess ACS events?
3) How are ACS scoring systems implemented in clinical practice?
4) What correction or validation results have been reported for ACS scoring systems?
5) What measurement outcomes are reported in studies evaluating ACS scoring systems?

Stage 2: Identifying Relevant Studies

Keywords were identified based on the study topic and relevant Medical Subject Headings (MeSH), including "Acute Coronary Syndrome," "Scoring System," "Risk Score," "Predictive Score," and "In Hospital," and were combined using Boolean operators. Literature searches were conducted across multiple electronic databases, including PubMed, ScienceDirect, and Emerald. Additional studies were identified through manual screening of reference lists. The full search strategies for each database are presented in Table 2 to ensure transparency and reproducibility.

Table 2. Search Strategy Used in Electronic Databases

Databae	Search String	Filters
PubMed	("Acute Coronary Syndrome"[Mesh] OR "acute coronary syndrome" OR ACS OR "myocardial infarction" OR STEMI OR NSTEMI OR "unstable angina") AND ("risk score" OR "scoring system" OR "prediction score" OR "predictive model" OR "clinical score" OR "risk stratification") AND ("hospital" OR "emergency department" OR "emergency care" OR "in-hospital")	Language: English; Population: Adults; Year: 2000–2024
Scopus	TITLE-ABS-KEY ("acute coronary syndrome" OR ACS OR "myocardial infarction" OR STEMI OR NSTEMI OR "unstable angina") AND TITLE-ABS-KEY ("risk score" OR "scoring system" OR "prediction score" OR "predictive model" OR "clinical score") AND TITLE-ABS-KEY ("hospital" OR "emergency department")	Language: English; Population: Adults; Year: 2000–2024
ScienceDirect	TITLE-ABS-KEY ("acute coronary syndrome" OR ACS OR "myocardial infarction" OR STEMI OR NSTEMI OR "unstable angina") AND TITLE-ABS-KEY ("risk score" OR "scoring system" OR "prediction score" OR "predictive model" OR "clinical score") AND TITLE-ABS-KEY ("hospital" OR "emergency department")	Language: English; Population: Adults; Year: 2000–2024
Emerald	("acute coronary syndrome") AND ("scoring system" OR "risk score" OR "prediction model")	Articles; English

Stage 3: Selection of Studies

The search identified 1,961 articles from the selected databases. All records were imported into Rayyan AI for duplicate removal and screening, performed by the first author (IA). After removing 114 duplicates, 1,904 articles underwent title screening, of which 586 were considered potentially relevant and proceeded to abstract screening. Following this stage, 21 articles were selected for full-text assessment. During the eligibility assessment, two articles could not be retrieved, and one was excluded for not meeting the inclusion criteria. Full-text screening was conducted independently by two reviewers (IA and AK), with disagreements resolved through discussion and consensus. A total of 18 articles were ultimately included based on their relevance to the study objectives and their contribution to understanding the development, implementation, or evaluation of ACS scoring systems. Study selection was guided by research objectives rather than formal critical appraisal, although minimum methodological standards were considered. This approach aligns with the scoping review framework by Arksey and O'Malley (2005), which emphasizes mapping the breadth of evidence. The selection process is illustrated in Figure 1 using a PRISMA flow diagram. The study selection process is illustrated in Figure 1 using a PRISMA flow diagram, which summarizes the identification, screening, eligibility, and inclusion stages.

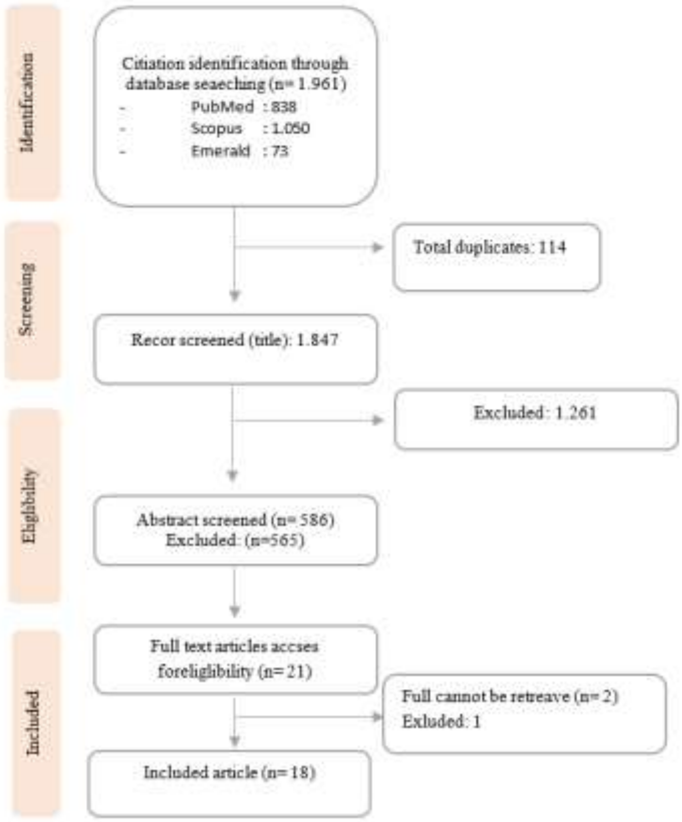

FIGURE 1
PRISMA and the phases of Arksey & O'Malley's framework

Stage 4: Data Charting

The data charting process followed the framework proposed by Arksey and O'Malley (2005), emphasizing an iterative approach to data extraction and synthesis. Both authors independently reviewed the 18 included full-text articles to extract relevant information. A data charting form was developed based on the study objectives and research questions and pilot-tested on several articles to ensure clarity and relevance, with minor refinements made accordingly. The extracted data included study characteristics such as author, publication year, study aims, design, population, type of scoring system, variables, and reported outcomes. The data were organized into a structured dataset (Table 1). Discrepancies between reviewers were resolved through discussion and consensus to ensure consistency and reliability. The charted data were continuously reviewed to maintain alignment with the study objectives.

Stage 5: Collating, summarizing, and reporting the results

Data can be organized and summarized thematically by detecting, analyzing, and elucidating patterns within the dataset to address the research topic (Arskey & O'Malley, 2005).

RESULTS

A total of 18 articles were included in this scoping review. The studies were conducted across 21 countries, with the highest contributions from the United States (n = 4), followed by the United Kingdom (n = 3), China (n = 3), Italy (n = 2), Canada (n = 2), Sweden (n = 2), and Australia (n = 2), while Turkey and South Korea each contributed one study. Several studies were multi-country collaborations, enhancing the generalizability of findings. Most studies focused on the development and evaluation of ACS scoring systems. Four main themes were identified: (1) scoring system development, (2) existing scoring systems, (3) scoring techniques, and (4) measurement outcomes.

Development of the ACS scoring system

Most studies employed cohort designs, either prospective or retrospective, to identify predictors of ACS and construct risk models. The development of scoring systems generally followed a structured process, beginning with problem identification, particularly the diagnostic challenges in patients with non-specific ECG findings. This was followed by systematic data collection from patients presenting with chest pain, including clinical history, ECG findings, cardiac biomarkers, and other relevant variables. Subsequently, predictive variables were incorporated into scoring models, with weighted values assigned to each parameter based on their contribution to ACS risk. The models were then evaluated through pilot testing and validation processes, using performance measures such as sensitivity, specificity, positive predictive value, and negative predictive value. External validation across different populations was also conducted to ensure consistency and generalizability of the scoring systems.

There exists a scoring system to assess the ACS event.

This review identified eleven scoring systems used to assess and predict ACS, including GRACE, HEART, TIMI, CACS, SAFER, Chest Pain Score, BETTER, ACEF, Pro-ACS, Novel score, MACS, and CSS-TN. These tools support risk stratification and clinical decision-making in patients with suspected ACS.

Ihsan Angga Anjarwadi et al., / Scientific Periodical of Public Health and Coastal 8(1), 2026, page 492-510

Table 3. Data Extraction

No	Authors/ Country	Design	Sample Size	Phase	Name of Scoring System	Item Evaluated	AUC / ROC	Findings
1	Akyuz et al., 2016 (Turkey)	Prospective Cohort	396 consecutive patients diagnosed with ACS: NSTEMI	Validation	GRACE (version 2.0)	GRACE score 2.0 for the mortality of NSTE-ACS patients	. In hospital outcomes: 0.53 – 0.58 . 1-year mortality: 0.51 – 0.75	GRACE 2.0 poorly predicts in-hospital outcomes but performs well for 1-year mortality; higher scores indicate increased mortality.
2	Pieper et al., 2009 Multicountry (14 countries)	Retrospective Cohort	48.023 Patients with ACS	Modified	GRACE	Variables: Killip class, SBP, heart rate, age, creatinine, and baseline risk factors.	0.858	Risk levels: low (0–108), moderate (109–140), high (>140).
3	Six et al., 2013 Multicountry (10 countries)	Retrospective Cohort Study	2.906 patients presenting with chest discomfort.	Modified	HEART	Components: history, ECG, age, risk factors, and troponin.	0.83 (0.82-0.85)	HEART score: low (0–3), moderate (4–6), high (7–10).
4	Melki & Jernberg, 2013 Sweden	Retrospective observational study	410 ED patients with chest discomfort without ST-segment abnormalities.	Modified	HEART	Components: history, ECG, age, risk factors, and troponin.	. Modified HEART > original HEART (AUC 0.93 vs 0.89).	The HEART score effectively predicted adverse outcomes, with key predictors including history, ECG, and troponin, and a simplified model showing comparable performance.
5	Georgiopoulos et al., 2023 Greece	Retrospectively designed longitudinal cohort study	A total of 9803 patients with ACS from March to June 2023.	Modified	GRACE Risk Score Modification	Variables: Killip class, SBP, heart rate, age, creatinine, and baseline risk factors.	0.878 for in-hospital mortality	Incorporating continuous high-sensitivity troponin T into the GRACE score improved discrimination and risk reclassification for predicting in-hospital, 30-day, and 1-year mortality in patients with ACS.
6	Pollack et al., 2006 USA	Prospective observational cohort study	3.929 adults with chest pain undergoing ECG.	Development	TIMI	Age, CAD risk factors, prior CAD, ASA use, angina, ECG, and biomarkers.	Not reported	7-item binary score; low (0–2), moderate (3–4), high (≥5).
7	Jaffery et al., 2007 USA	Retrospective Cohort	947 consecutive ED patients.	Modified	Modified TIMI	Age CAD History. Troponin ECG.	Modified TIMI (0.748) and original (0.696)	Simplified TIMI is comparable to the original; low (0–1), moderate (2), high (≥3).
8	Hess, Perry, et al., 2010 United Kingdom	Prospective cohort study	1017 individuals presenting with chest pain and potential	Validation	Validation TIMI	Age, CAD risk factors, prior CAD, aspirin use, angina, ECG changes, and biomarkers.	0.83 (modified TIMI) vs 0.79 (original TIMI)	The modified TIMI score demonstrated greater diagnostic accuracy than the original TIMI score for predicting 30-day adverse cardiac events in ED patients with chest pain.
9	Huynh et al., 2013 Canada	Retrospective Cohort	3670 patients with ACS	Develop-ment	C-ACS	Age, Killip, SBP, and HR.	0.73–0.79	Low (0–1), moderate (2), high (≥3).

Ihsan Angga Anjarwadi et al., / Scientific Periodical of Public Health and Coastal 8(1), 2026, page 492-510

No	Authors/ Country	Design	Sample Size	Phase	Name of Scoring System	Item Evaluated	AUC / ROC	Findings
10	Faxén et al., 2017 Sweden	Derivation cohort	Cardiac arrest: OHCA 240.226; IHCA 2,077 (total 242.303).	Develop-ment	SAFER Score	SBP, age, heart rate, ECG findings, and Killip class.	AUC: 0.72, 0.74, 0.65 (derivation, temporal, external).	Risk categories: low (0–2), intermediate (3–4), high (5–6), very high (≥7); higher scores correlate with increased cardiac arrest risk.
11	Conti et al., 2010 Italy	Prospective Cohort Study	2233 patients with Chest Pain.	Develop-ment	Chest Pain Score	Location Radiation Character Associated symptoms	0.81–0.83	Pain-based scoring: location (+3 typical, +1 atypical), radiation (+1), character (+3 typical, +1 atypical), associated symptoms (+2), prior chest pain (+3).
12	Xia et al., 2015 Jiangsu, China	Prospective Cohort Study	The study group consisted of 201 patients with confirmed UA.	Development	Better Score	MPO, hs-TnT, hs-CRP, coronary stenosis, plaque, and EFV.	0.937	BETTER score combines biomarkers and CT parameters to predict 1-year MACE: (MPO×0.1) + (hs-cTnT×50) + (hs-CRP×0.4) + (stenosis×9) + (plaque×13) + (EFV×0.2).
13	Stähli et al., 2018 Swiss	Prospective Cohort Study	1,901 patients from the Swiss ACS Cohort (prospective).	Development	ACEF Score	Age, creatinine, Ejection Fraction	Not reported	ACEF = age/LVEF +1 (if creatinine >176 μmol/L); risk: low (≤1.45), intermediate (>1.45–≤2.0), high (>2.0); predicts MACCE, with higher scores indicating worse outcomes.
14	Timóteo et al., 2017 Portuguese	Retrospective Cohort Study	8,586 patients (Portuguese multicenter registry).	Development	PRO ACS	Age, SBP, Killip class, ST Segment Elevation	AUC: 0.796, 0.785, 0.815 (dev, internal, external).	ProACS predicts in-hospital mortality using age ≥72 (2), SBP ≤116 (1), ST elevation (1), and Killip (2–3=1; 4=3); total score 0–7.
15	Crim et al., 2016 US	Retrospective Cohort Study	285 CAD patients presenting to the ED with chest pain.	Development	Novel Score	Revascularization, CKD, rest pain, ECG changes, troponin, comorbidity.	0.767	Novel ED score showed good discrimination for ACS and slightly outperformed modified TIMI; variables: prior revascularization (+1), CKD (−1), rest pain (+1), ECG changes (+1), troponin (+3), comorbidity (−2); total −2 to 6..
16	Ma et al., 2016 China	Retrospective cohort study	1,300 ED patients with suspected NSTE-ACS.	Development	Modified Heart	History, ECG, Age. Risk Factors. Hs-cTnl	0.84	Modified HEART predicts 3-month MACE; components: history, ECG, age, risk factors, hs-cTnI (0–2 each; total 0–10); risk: low (0–2), intermediate (3–4), high (5–10).
17	Body et al., 2014 Manchester, UK	Two sequential prospective observational cohort studies	790 participants	Development	MACS	Variables: hs-TnT, ECG ischemia, diaphoresis, vomiting, SBP <100 mmHg, worsening angina, and right arm/shoulder radiation.	0.95 (derivation); 0.92 (validation)	MACS uses 8 variables (hs-TnT, H-FABP, ECG ischemia, diaphoresis, vomiting, SBP <100, worsening angina, right arm/shoulder radiation) to predict MACE via logistic regression (very low–high risk).
18	Jang & Choe, 2024 South Korea	Empirical Quantitative Study: Retrospective cohort	3.131 patient	Development	Chest Pain Screening Scale for Triage Nurses (CSS-TN)	sex, age, typical ACS symptoms, NRS pain, pain duration, prior CAD, hypertension, and hyperlipidemia.	0.87	CSS-TN uses 8 predictors (sex, age, typical symptoms, NRS ≥6, pain ≥10 min, CAD, hypertension, dyslipidemia); score 0–10, with ≥6 indicating high ACS risk.

Technique for implementing the ACS event scoring system

Scoring techniques for ACS vary across models, reflecting differences in clinical focus and the predictive variables used. The GRACE score incorporates hemodynamic and clinical parameters such as Killip class, systolic blood pressure, heart rate, age, and creatinine (Akyuz et al., 2016; Georgiopoulos et al., 2023; Pieper et al., 2009), while the HEART score evaluates history, ECG, age, risk factors, and troponin. The TIMI score includes age, cardiovascular risk factors, prior coronary artery disease, aspirin use, angina severity, ECG changes, and biomarkers (Jaffery et al., 2007; Pollack et al., 2006; Six et al., 2013a).

Other models emphasize specific clinical or physiological parameters. The CACS and SAFER scores focus on age, systolic blood pressure, heart rate, and Killip class, with SAFER also including ST abnormalities. The Chest Pain Score assesses symptom characteristics such as location, radiation, and associated symptoms (Conti et al., 2010). Biomarker-based models, such as the BETTER score, integrate laboratory and imaging findings, including MPO, hs-TnT, hs-CRP, stenosis, plaque, and ectopic fat volume (Xia et al., 2015). Simpler models such as ACEF and Pro-ACS use fewer variables, including age, creatinine, ejection fraction, systolic blood pressure, Killip class, and ST-segment changes (Timóteo et al., 2017).

More complex models, such as Novel score and MACS, combine clinical, ECG, biomarker, and hemodynamic data. The MACS rule includes hs-TnT, ECG ischemia, diaphoresis, vomiting, systolic blood pressure, worsening angina, and pain radiation (Body et al., 2014). More recently, the CSS-TN was developed to support early triage, incorporating sex, age, symptoms, pain characteristics, prior CAD, hypertension, and hyperlipidemia (Jang & Choe, 2025).

Measurement Outcomes of Scoring Systems in Patients with ACS

Based on the 18 included studies, ACS scoring systems can be broadly categorized into three groups according to their primary clinical purpose: (1) initial diagnosis and emergency department triage, (2) prognosis and prediction of mortality or major adverse cardiac events (MACE), and (3) models incorporating novel biomarkers or advanced diagnostic parameters. This classification reflects the continuum of ACS management, from early detection to outcome prediction and diagnostic enhancement.

Category 1: Scores for Initial Diagnosis and Emergency Department Triage

This category includes scoring systems designed to support early identification and triage of patients presenting with chest pain. The HEART score is widely used for short-term MACE prediction based on clinical history, ECG findings, age, risk factors, and troponin levels. Similarly, the TIMI score is applied in patients with unstable angina or NSTEMI using clinical and biomarker-based variables. Other tools, such as the MACS rule and the Novel score, integrate symptoms, ECG findings, and biomarkers to improve diagnostic accuracy in emergency settings. The Chest Pain Score focuses on symptom characteristics, while the more recent CSS-TN model enables triage nurses to identify high-risk patients using simple clinical predictors. Overall, these tools facilitate early decision-making, triage prioritization, and safe disposition of patients.

Category 2: Scores for Prognosis and Risk Prediction of Mortality or Major Adverse Cardiac Events

This category includes scoring systems used to predict clinical outcomes after ACS diagnosis. The GRACE score is one of the most widely validated models, incorporating multiple clinical and laboratory variables to estimate mortality risk. Simplified models, such as C-ACS and Pro-ACS, rely on readily available parameters for mortality prediction. The ACEF score, based on age, creatinine, and ejection fraction, is also commonly used to predict mortality and adverse cardiovascular events. These tools are primarily applied to guide treatment strategies, risk stratification, and long-term management.

Category 3: Scores Incorporating Novel Biomarkers or Advanced Diagnostic Parameters

The third category includes models integrating novel biomarkers and advanced diagnostic techniques to enhance accuracy. The BETTER score combines inflammatory and cardiac biomarkers with imaging findings. At the same time, the MACS rule incorporates high-sensitivity troponin and heart-type fatty acid-binding protein, alongside clinical and ECG variables. These approaches reflect recent advancements in ACS risk stratification, emphasizing the growing role of biomarker and imaging integration in clinical decision-making.

DISCUSSION

This review identified eleven scoring systems used to assess the incidence and prognosis of ACS in hospital settings, reflecting the diverse approaches to risk stratification in clinical practice. Consistent with the findings on scoring system development, most models were developed in high-income countries such as the United States, the United Kingdom, China, Canada, and Portugal, where the burden of cardiovascular disease is substantial and has driven the need for reliable predictive tools (Singh et al., 2023).

Across the included studies, several key variables consistently emerged in scoring system development and implementation, including age, systolic blood pressure (SBP), cardiovascular risk factors, heart rate, cardiac biomarkers, and ECG findings. These variables align with established pathophysiological mechanisms and clinical guidelines. Age remains a strong predictor due to its association with endothelial dysfunction and atherosclerosis progression (Ferrucci & Fabbri, 2018). Similarly, low SBP is associated with increased mortality and adverse cardiovascular outcomes (Park et al., 2015), while traditional risk factors such as hypertension, diabetes, and dyslipidemia are widely incorporated into risk models (Kimura et al., 2019). Cardiac biomarkers, particularly high-sensitivity troponin, play a central role in detecting myocardial injury (Baro et al., 2019; Khan et al., 2021), and the 12-lead ECG remains essential for early diagnosis and clinical decision-making (Bouzid et al., 2021).

In line with the identified scoring techniques, this review found that different models apply varying combinations of clinical, laboratory, and hemodynamic parameters. Comprehensive models such as GRACE and TIMI integrate multiple variables to estimate risk. In contrast, simplified tools such as HEART and MACS prioritize ease of use and rapid application in emergency settings. These differences reflect a trade-off between model complexity and clinical feasibility, particularly in time-sensitive environments such as emergency departments. Regarding measurement outcomes, the scoring systems identified in this review can be broadly categorized into three groups: (1) tools for early diagnosis and triage, (2) models for prognosis and prediction of mortality or major adverse cardiac events (MACE), and (3) models incorporating novel biomarkers or advanced diagnostic parameters. While models such as HEART and TIMI are commonly used for early risk stratification, prognostic tools such as GRACE and ACEF are applied to predict mortality and long-term outcomes. More recent models integrating biomarkers and imaging parameters reflect advances in diagnostic technology and precision medicine.

However, consistent with this review's findings, the predictive performance of ACS scoring systems varies across populations and clinical settings. Models such as GRACE and TIMI demonstrate good discrimination but may show reduced accuracy or calibration issues in contemporary or non-Western populations. Heterogeneity in study populations, healthcare systems, and outcome definitions contributes to variability in performance and limits generalizability (Asrial et al., 2022; Ismail et al., 2022; Van Der Sangen et al., 2022).

These findings highlight important challenges in implementing ACS scoring systems. Many models require multiple laboratory parameters or advanced diagnostics, which may limit their applicability in LMICs, including Southeast Asia. Limited access to high-sensitivity biomarkers and imaging modalities may restrict the use of more complex models (Corcoran et al., 2015; Kasim et al., 2023; Lim et al., 2022; Shariff et al., 2022; Yukselen et al., 2024). In this context, simplified scoring systems such as HEART, TIMI, and MACS appear more feasible, as they rely on readily available clinical data. The HEART score, in particular, has been widely recommended for emergency department triage due to its simplicity and strong predictive performance (Mahler et al., 2015; Poldervaart et al., 2017).

From a practical perspective, the findings of this review have important implications for healthcare systems in Indonesia and similar settings. The use of standardized and simplified scoring tools may improve diagnostic accuracy, accelerate clinical decision-making, and optimize resource utilization. In addition, these tools can facilitate the safe discharge of low-risk patients, thereby reducing unnecessary hospital admissions (Laureano-Phillips et al., 2019; Mahler et al., 2015; Yukselen et al., 2024). However, implementation barriers remain, including variability in clinical training, limited diagnostic resources, and the lack of integrated digital decision-support systems.

This review has several limitations. The literature search was restricted to English-language articles, and some relevant studies or grey literature may not have been captured. Additionally, heterogeneity in study design, population characteristics, and clinical settings may limit comparability across studies. In conclusion, ACS scoring systems play a crucial role in improving early diagnosis, risk stratification, and clinical decision-making. However, their performance varies across contexts, highlighting the need for simplified, context-appropriate models and broader external validation, particularly in LMICs. Future research should focus on developing practical scoring tools for early, resource-limited settings and on integrating these models into digital health systems to enhance clinical outcomes.

CONCLUSIONS

This scoping review classifies ACS scoring systems into diagnostic, prognostic, and cardiac arrest prediction categories. Clinically, immediate adoption of practical tools such as HEART, TIMI, and MACS is essential to improve triage accuracy and patient outcomes. At the policy level, mandatory integration into standardized protocols and digital decision-support systems is warranted. Future research must prioritize robust external validation and the development of simplified, context-adapted models for resource-limited settings.

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