Original Article

Comparative Performance of TIMI and GRACE Scores for Predicting Mortality and MACE in Acute Coronary Syndrome

Fajar Prasetyo Winoto[1], Titin Andri Wihastuti[2], Laily Yuliatun[2]

[1] Master of Nursing Study Program Faculty of Health Science, Universitas Brawijaya, East Java, Indonesia.
[2] Department of Nursing, Faculty of Health Science, Universitas Brawijaya, East Java, Indonesia.

ARTICLE INFO

Article History
Submit : March 16, 2026
Accepted : July 2, 2026
Published : July 12, 2026

Correspondence
Fajar Prasetyo Winoto; Department of Nursing, Faculty of Health Science, Universitas Brawijaya, Malang, East Java, Indonesia.

Email:
fajarprasetyo794@gmail.com

Citation:
Winoto, F. P. ., Wihastuti, T. A. ., & Yuliatun, L. . (2026). Comparative Performance of TIMI and GRACE Scores for Predicting Mortality and MACE in Acute Coronary Syndrome. Journal of Applied Nursing and Health, 8(2), 1623–1637. https://doi.org/10.55018/janh.v8i2.695

ABSTRACT

Background: TIMI and GRACE scores are widely used for prognostic risk stratification in acute coronary syndrome (ACS), yet comparative evidence across ACS subtypes, settings, follow-up periods, and outcomes remains heterogeneous. This scoping review mapped evidence comparing TIMI and GRACE scores for predicting mortality and MACE in patients with ACS or suspected ACS.

Methods: This scooping review followed the PRISMA-ScR guidelines, the PCC framework, and the Arksey and O'Malley approach. Searches were conducted in ProQuest, Scopus, and CINAHL using Boolean search terms related to TIMI, GRACE, ACS, mortality, and MACE. Eligible studies were empirical quantitative studies comparing TIMI and GRACE for predicting mortality and MACE in adults with ACS. Records were screened, full texts were assessed, data were recorded using a standardized form, and findings were synthesized narratively based on outcomes and clinical settings.

Results: A total of 187 records were identified, 45 duplicates were removed, 142 records were screened, 44 full-text reports were assessed, and 12 studies were included. Studies were published between 2022 and 2025 and included at least 12,039 participants from China, Lithuania, India, Turkey, Spain, Pakistan, and Iran. For mortality, GRACE more consistently demonstrated stronger discrimination than TIMI, particularly in NSTEMI, broader AMI cohorts, and STEMI patients undergoing reperfusion or PCI. For MACE, findings were more heterogeneous; GRACE generally performed better in confirmed NSTE-ACS and STEMI PCI cohorts, whereas TIMI showed comparable or sometimes higher discrimination than GRACE in undifferentiated emergency chest pain populations.

Conclusion: The comparative performance of TIMI and GRACE depends on ACS phenotype, clinical context, and outcome definition. GRACE appears more robust for mortality prediction, while TIMI retains practical value as a simple bedside tool, especially in rapid triage contexts. Future studies should standardize MACE definitions, reporting metrics, and subgroup analyses across ACS populations.

Keywords: acute coronary syndrome; GRACE; TIMI; mortality; MACE; scoping review.

Implications for Practice:

- Clinicians should prioritize the GRACE score for mortality risk stratification in patients with confirmed acute coronary syndrome while using the TIMI score as a practical tool for rapid bedside assessment when immediate clinical decisions are required.
- Health policy should support the integration of context-appropriate risk stratification

Implications for Practice:

protocols and interprofessional training to promote consistent implementation of evidence-based cardiovascular care across emergency, inpatient, and post-discharge services.

- Midwifery and other health professional education programs should strengthen competency in cardiovascular risk assessment and clinical decision-making by incorporating the application of prognostic risk scores that are adaptable to Low- and Middle-Income Countries and other resource-constrained healthcare settings

Introduction

Acute coronary syndrome (ACS) remains a major global health burden and continues to account for substantial cardiovascular morbidity, mortality, emergency department presentations, and hospital admissions. Contemporary ACS management requires rapid diagnosis, early risk stratification, timely reperfusion or invasive evaluation, and coordinated post-discharge care. Recent international guidelines emphasize that ACS should be approached across the full disease spectrum, including ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina, because prognosis varies according to hemodynamic instability, electrocardiographic findings, biomarker elevation, renal function, age, comorbidity burden, frailty, and treatment pathway (Task et al., 2023; Taub, 2025). Recent evidence also highlights the clinical heterogeneity of NSTEMI, particularly in patients with multivessel disease, older age, and multiple comorbidities, where individualized risk assessment is essential for determining the timing and extent of invasive management (Muste et al., 2026).

Risk stratification scores are intended to translate complex clinical information into reproducible estimates of adverse outcomes and to support decision-making in emergency, inpatient, reperfusion, and post-discharge settings. Among these tools, the Thrombolysis in Myocardial Infarction (TIMI) score remains clinically attractive because it is relatively simple, can be applied rapidly at the bedside, and may be useful where immediate triage decisions are required. However, contemporary studies suggest that TIMI may underestimate mortality risk in some modern ACS populations, especially in non-ST-elevation ACS cohorts where age, Killip class, heart rate, renal dysfunction, and treatment-related factors strongly influence outcomes (Kasim et al., 2024; Varughese et al., 2025). In contrast, the Global Registry of Acute Coronary Events (GRACE) score incorporates broader clinical and physiological parameters and remains a widely used benchmark for mortality prediction in ACS. Recent studies have shown that GRACE retains prognostic value for in-hospital and follow-up mortality in NSTE-ACS and NSTEMI, although its performance may be enhanced by adding variables such as biomarkers, frailty measures, corrected QT interval, lactate, or inflammatory markers (Wontor et al., 2024; Yildirim et al., 2025).

Despite the established clinical use of TIMI and GRACE, the comparative value of these two scores remains uncertain across ACS phenotypes and prognostic outcomes. Recent studies indicate that GRACE may be more robust for mortality prediction, particularly in confirmed ACS, NSTEMI, and higher-risk populations. However, the prediction of major adverse cardiovascular or cardiac events (MACE) remains more variable because MACE definitions differ substantially across studies and may include death, recurrent myocardial infarction, heart failure, stroke, revascularization, stent thrombosis, or rehospitalization. Emerging evidence also shows that additional predictors, including systemic inflammation, non-invasive hemodynamic measures, lactate, frailty, and

machine-learning-derived variables, may improve risk prediction beyond traditional scoring systems (Szabo et al., 2022; Wita et al., 2024; Xin et al., 2025; Zheng et al., 2025). This variability creates uncertainty regarding when TIMI or GRACE should be preferred, whether the two scores should be used sequentially or selectively, and how their use should be adapted to emergency triage, invasive management, nursing surveillance, and post-discharge risk monitoring.

Therefore, an important evidence gap remains. Existing studies have evaluated TIMI and GRACE scores across different populations, clinical settings, follow-up periods, and outcome definitions, but the available evidence has not been clearly mapped to determine where their comparative performance is consistent, where findings diverge, and which ACS subgroups remain underrepresented. This gap is clinically relevant because the choice between TIMI and GRACE may differ between emergency triage, inpatient risk stratification, reperfusion or PCI pathways, and post-discharge monitoring.

A scoping review is appropriate for this purpose because it allows broad and systematic mapping of available evidence, clarification of key concepts, identification of knowledge gaps, and description of the range of study designs, populations, outcomes, and settings represented in the literature. Recent methodological literature emphasizes that scoping reviews and related evidence-mapping approaches are particularly useful when the evidence base is heterogeneous and when the aim is to describe the extent and nature of evidence rather than produce a pooled effect estimate (Campbell et al., 2023; Nurma & Hadie, 2024; Pollock et al., 2024). Accordingly, this scoping review systematically maps comparative studies of TIMI and GRACE scores for predicting mortality and MACE in patients with ACS or suspected ACS, with particular attention to clinical setting, ACS phenotype, outcome definition, and implications for acute care, nursing surveillance, and post-discharge cardiovascular risk management.

Methods

Design

This study was conducted as a scoping review using the Joanna Briggs Institute methodological guidance and reported in accordance with the PRISMA extension for scoping reviews (PRISMA-ScR)(Alexander et al., 2020; Tricco et al., 2018). A scoping approach was selected because the review question concerned mapping comparative evidence across heterogeneous populations, outcomes, and clinical settings rather than estimating a pooled measure of diagnostic or prognostic accuracy. The review question was: What evidence is available on the comparative performance of TIMI and GRACE scores for predicting mortality and MACE in adults with ACS or suspected ACS?

Eligibility Criteria

The PCC framework was used to define eligibility. The population comprised adults with confirmed ACS, AMI, STEMI, NSTEMI, NSTE-ACS, unstable angina, or suspected ACS/chest pain populations undergoing ACS risk stratification. The concept was the comparative prognostic performance of TIMI and GRACE risk scores, either as the two main scores or as part of a broader comparison with other tools. The context included emergency departments, inpatient cardiology settings, reperfusion or percutaneous coronary intervention (PCI) pathways, and post-discharge follow-up. Eligible outcomes were mortality and/or MACE.

Empirical quantitative studies were included when they evaluated both TIMI and GRACE and reported comparative prognostic findings for mortality or MACE.

Review articles, editorials, conference abstracts, duplicate reports, studies without a TIMI-GRACE comparison, studies in an irrelevant population, and studies with outcomes unrelated to mortality or MACE were excluded.

Information Sources

Records were identified from three databases: ProQuest, Scopus, and CINAHL. The search was finalized on 27 June 2026.

Search Strategy

The database search was conducted using a Boolean strategy that combined terms for the prognostic scores, ACS populations, and target outcomes. The core search string was: ("TIMI score" OR "Thrombolysis in Myocardial Infarction score" OR "GRACE score" OR "Global Registry of Acute Coronary Events") AND ("acute coronary syndrome" OR ACS OR STEMI OR NSTEMI OR "unstable angina") AND (mortality OR MACE OR "major adverse cardiovascular events" OR "major adverse cardiac events"). The same search concept was adapted only where required by database-specific syntax while preserving the meaning of the Boolean terms.

Selection Process

Search results were exported, duplicate records were removed, and records were screened in two stages. First, titles and abstracts were screened for relevance to ACS, TIMI, GRACE, mortality, and/or MACE. Because the search strategy was intentionally broad and used OR operators to maximize sensitivity, full-text eligibility required that studies evaluate both TIMI and GRACE scores and report comparative prognostic findings for mortality and/or MACE. The final selection process yielded 12 included studies after exclusion of reports with wrong population, absence of direct TIMI-GRACE comparison, wrong outcomes, non-eligible publication type, or duplicate/overlapping publication.

Data Collection Process

Data were collected using a standardized extraction form developed in accordance with the review objectives and the Population–Concept–Context (PCC) framework. Two reviewers independently extracted data from each included study. Any discrepancies were resolved through discussion until consensus was reached. No contact was made with the original study authors to obtain or verify additional information because all required data were available from the published reports. No automation tools or artificial intelligence-assisted software were used during the data collection process.

Data Charting Process

Data charting was conducted using a pilot-tested standardized charting form that was refined before full data extraction to ensure consistency across reviewers. The charting process was performed independently by two reviewers and included study characteristics, population and setting, study design, risk scores evaluated, follow-up period, outcome measures, and key comparative findings. Disagreements were resolved through consensus. No additional data were requested from study investigators, as the review relied exclusively on published evidence.

Data Items

The data extracted from each included study comprised the first author and publication year, country, study design, clinical setting, participant characteristics, sample size, age, acute coronary syndrome phenotype, risk scores evaluated, follow-up period, primary outcomes, and key comparative findings related to mortality and/or major adverse cardiovascular

events (MACE). Data extraction was aligned with the Population–Concept–Context (PCC) framework to ensure consistent capture of population characteristics, comparative prognostic performance of TIMI and GRACE scores, and clinical context. No assumptions or data imputation were applied, and only information explicitly reported in the included studies was extracted.

Critical Appraisal of Individual Sources of Evidence

Formal critical appraisal or risk-of-bias assessment was not undertaken because the primary objective of this scoping review was to map the breadth and characteristics of the available evidence rather than evaluate methodological quality or estimate pooled effects. Consistent with the Joanna Briggs Institute guidance for scoping reviews, no studies were excluded based on methodological quality, and the findings were synthesized descriptively. Methodological limitations identified across the included studies were considered narratively in the Discussion to support interpretation of the evidence.

Consultation to Expert

A formal expert consultation was not conducted as part of this scoping review. To avoid methodological overstatement, no external experts were involved in validating the findings or interpreting the evidence. Instead, the review relied exclusively on published empirical studies and established methodological guidance for evidence mapping.

Synthesis of Results

The extracted data were synthesized narratively because substantial heterogeneity was observed across study populations, clinical settings, outcome definitions, follow-up periods, and reported performance measures. The findings were organized into three thematic domains: mortality prediction, MACE prediction, and context-dependent comparative performance across acute coronary syndrome phenotypes and clinical settings. This approach enabled identification of consistent evidence, areas of disagreement, and knowledge gaps while avoiding inappropriate quantitative pooling.

Results

Selection of Sources of Evidence

The database search identified 187 records: ProQuest (n = 104), Scopus (n = 31), and CINAHL (n = 52). After removing 45 duplicate records, 142 records were screened. Ninety-eight records were excluded at title/abstract screening, leaving 44 reports sought and retrieved for full-text eligibility assessment. Thirty-two full-text reports were excluded: wrong population (n = 10), no direct TIMI-GRACE comparison (n = 12), wrong outcomes not related to mortality or MACE (n = 6), review/editorial/conference abstract (n = 2), and duplicate or overlapping report (n = 2). The final review included 12 studies (**Figure 1 and Table 1**).

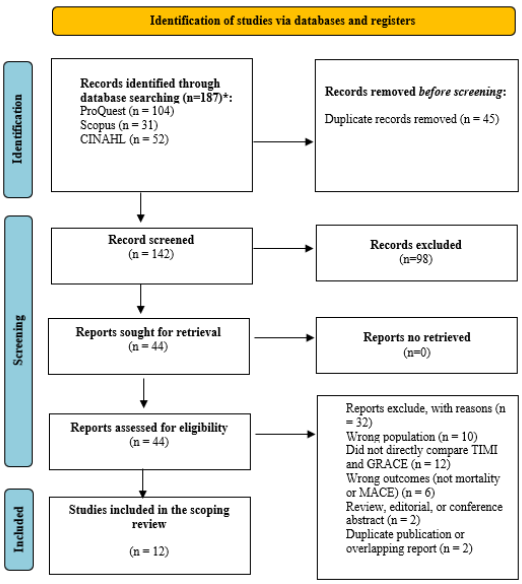

Figure 1. PRISMA-ScR flow diagram for study selection

Table 1. PRISMA-ScR Study Selection Summary

Selection stage / reason	Total Records (n)
Records identified through database searching	187
ProQuest	104
Scopus	31
CINAHL	52
Duplicate records removed before screening	45
Records screened	142
Records excluded during title/abstract screening	98
Reports sought for retrieval	44
Reports not retrieved	0
Reports assessed for eligibility	44
Reports excluded, with reasons	32
Wrong population	10
Did not directly compare TIMI and GRACE	12
Wrong outcomes: not mortality or MACE	6
Review, editorial, or conference abstract	2
Duplicate publication or overlapping report	2
Studies included in the scoping review	12

Note. MACE = major adverse cardiovascular/cardiac events.

Characteristics of Sources of Evidence

The 12 included studies were published between 2022 and 2025 and involved at least 12,039 participants. Studies were conducted in China, Lithuania, India, Turkey, Spain, Pakistan, and Iran. Study designs included retrospective cohort studies, prospective observational studies, registry analyses, and cross-sectional validation studies. Clinical contexts included confirmed NSTEMI, STEMI, AMI, NSTE-ACS, PCI/reperfusion cohorts, emergency department chest pain cohorts, and post-discharge follow-up populations (**Table 2**).

Table 2. Characteristics of Included Studies

Study	Country	Design / setting	n / age	Scores	Follow-up	Outcome and comparative finding
(Yanqiao et al., 2022)	China	Retrospective observational study; NSTEMI patients admitted to a large academic hospital	232; Median 67 years	TIMI vs GRACE	Median 3.7 years; 4-year follow-up	In-hospital composite event; long-term all-cause mortality; cardiac mortality. GRACE outperformed TIMI: in-hospital AUC 0.82 vs 0.62; all-cause mortality 0.89 vs 0.68; cardiac mortality 0.91 vs 0.67.
(Yang et al., 2022)	China	Retrospective cohort study; Hospitalized acute myocardial infarction (STEMI and NSTEMI)	2,220; Median 66 (IQR 56-74) years	GRACE, TIMI, HEART	Median 8 years	Long-term all-cause death. GRACE showed higher predictive accuracy than TIMI for long-term death in both STEMI and NSTEMI.

Study	Country	Design / setting	n / age	Scores	Follow-up	Outcome and comparative finding
(Aldujeli et al., 2022)	Lithuania	Single-center retrospective cohort study; STEMI patients undergoing early PCI	768; NR overall	GRACE, TIMI, SYNTAX I, SYNTAX II	5 years or until death	5-year MACE: ischemic/hemorrhagic stroke, target-vessel revascularization, nonfatal MI, cardiovascular death. SYNTAX I performed best; GRACE and TIMI had weak discrimination for 5-year MACE.
(Dinesh et al., 2022)	India	Prospective observational study; Emergency department chest pain patients; suspected ACS	199; Mean 51.61 +/- 16.47; range 19-87 years	HEART, GRACE, TIMI	6 weeks	MACE within 6 weeks. HEART had highest AUC (0.96), followed by TIMI (0.815) and GRACE (0.814).
(Tufan & Faysal, 2023)	Turkey	Retrospective cross-sectional study; Consecutive STEMI patients	1,057; Survivor median 59; non-survivor median 64 years	IMRS vs TIMI and GRACE	Short- and long-term follow-up	Short- and long-term mortality. IMRS showed non-inferior predictive capability compared with TIMI and GRACE for mortality.
(Yalcin Ocak et al., 2023)	Turkey	Prospective single-center observational study; Emergency department patients hospitalized for pre-diagnosed NSTE-ACS (NSTEMI + UAP)	357; Median 60 (IQR 18); range 25-90 years	TIMI, HEART, GRACE	30 days	30-day MACE and angiographic severity of CAD (Gensini). HEART and GRACE better predicted MACE than TIMI; MACE AUC: TIMI 0.575, HEART 0.648, GRACE 0.621.
(San et al., 2023)	Spain	Prospective cohort study; Acute non-traumatic chest pain with probable NSTE-ACS in ED or primary care emergency center	317; Mean 58 years; MACE 63.6 vs no MACE 57.6 years	HEART, GRACE, TIMI	6 weeks	MACE at 6 weeks. AUC: HEART 0.743, TIMI 0.717, GRACE 0.649; HEART performed best for low-risk stratification.
(Bakhsh et al., 2023)	Pakistan	Cross-sectional validation study; Undifferentiated atraumatic cardiac-like chest pain with non-diagnostic ECG in ED	237 enrolled; 226 analyzed; Mean 64.0 +/- 13.6 years	HEART, GRACE, TIMI	6 weeks	MACE at 6 weeks. At >=95% sensitivity, HEART identified more low-risk patients than GRACE or TIMI; GRACE missed 4.08% MACE and TIMI missed 3.03% MACE in low-risk groups.

Study	Country	Design / setting	n / age	Scores	Follow-up	Outcome and comparative finding
(Wang et al., 2024)	China	Multicenter prospective registry analysis; STEMI survivors after hospitalization	3,389 for <=30-day analysis; 3,247 for 30-day to 1-year analysis; Survivor median 62.0 vs non-survivor 71.4 years for <=30-day outcome	Age SI, Age MSI vs TIMI and GRACE	<=30 days post-discharge and 30 days to 1 year	Postdischarge mortality. Age SI and Age MSI showed comparable predictive ability to TIMI and GRACE, especially for mortality within 30 days after hospitalization.
(Kumar et al., 2025)	Pakistan	Prospective observational study; STEMI patients undergoing primary PCI/emergent percutaneous revascularization	2,839; Mean 55.6 +/- 11.2 years	TIMI, PAMI, CADILLAC, GRACE	Median 244 days; visits every 3 months up to 12 months	Short-term MACE: all-cause mortality, reinfarction requiring revascularization, HF rehospitalization, stent thrombosis, CVA. GRACE slightly outperformed TIMI for MACE AUC: 0.695 vs 0.682.
(SR et al., 2025)	India	Prospective observational study; STEMI patients undergoing reperfusion therapy (thrombolysis or primary PCI)	150; <50: 28%; 50-65: 45.3%; >65: 26.7%	TIMI, GRACE, SI/MSI/Age SI, MBG	In-hospital and 30 days	In-hospital mortality, ICU stay, 30-day MACE. GRACE had higher AUC than TIMI for mortality (0.88 vs 0.74) and MACE (0.82 vs 0.69).
(Isfahani et al., 2025)	Iran	Retrospective cohort study; Non-traumatic chest pain patients presenting to two tertiary EDs	274; Mean 53.33 years	HEART, TIMI, GRACE, EDACS-ADP, HET	6 weeks	6-week MACE. AUC: HEART 0.925, TIMI 0.868, GRACE 0.815, EDACS-ADP 0.803; GRACE calculated in 163 patients with creatinine data.

Note. ACS = acute coronary syndrome; AMI = acute myocardial infarction; CAD = coronary artery disease; ED = emergency department; GRACE = Global Registry of Acute Coronary Events; HEART = History, Electrocardiogram, Age, Risk factors, Troponin; MACE = major adverse cardiovascular/cardiac events; MBG = myocardial blush grade; NR = not reported; NSTE-ACS = non-ST-elevation acute coronary syndrome; NSTEMI = non-ST-elevation myocardial infarction; PCI = percutaneous coronary intervention; SI = shock index; STEMI = ST-elevation myocardial infarction; TIMI = Thrombolysis in Myocardial Infarction; UAP = unstable angina pectoris.

Thematic Synthesis of Findings

Mortality Prediction

Mortality-focused evidence generally favored GRACE over TIMI. In East Asian NSTEMI patients, GRACE showed stronger discrimination than TIMI for in-hospital events, 4-year all-cause mortality, and 4-year cardiac mortality (Yanqiao et al., 2022). In a broader AMI cohort with median 8-year follow-up, GRACE also outperformed TIMI for long-term all-cause death in both STEMI and NSTEMI subgroups (Yang et al.,

2022). Among STEMI reperfusion patients, GRACE produced a higher AUC than TIMI for in-hospital mortality (SR et al., 2025).

Two studies did not primarily test TIMI versus GRACE as the central comparison but used both scores as conventional comparators. In STEMI patients, the Intermountain Risk Score was non-inferior to TIMI and GRACE for short- and long-term mortality (Çınar et al., 2023). In a large STEMI registry, age-adjusted shock indices demonstrated comparable predictive ability to TIMI and GRACE for post-discharge mortality, particularly within 30 days after hospitalization (Wang et al., 2024). These findings suggest that GRACE remains a strong benchmark for mortality risk, but simpler bedside tools may approximate performance in selected STEMI settings.

MACE Prediction

Evidence for MACE prediction was more heterogeneous than evidence for mortality. In STEMI patients undergoing emergent percutaneous revascularization, GRACE slightly outperformed TIMI for MACE prediction, although overall discrimination was modest (Kumar et al., 2025). In STEMI patients undergoing reperfusion, GRACE also showed stronger discrimination than TIMI for 30-day MACE (SR et al., 2025). In confirmed NSTE-ACS patients in the emergency department, GRACE and HEART performed better than TIMI for 30-day MACE, although all scores demonstrated limited-to-moderate discrimination (Yalcin Ocak et al., 2023).

In contrast, emergency department studies involving undifferentiated chest pain or probable NSTE-ACS frequently showed TIMI performing similarly to or better than GRACE for short-term MACE. Dinesh et al. (2022) reported near-identical discrimination for TIMI and GRACE, while HEART performed best. San Roman Arispe et al. (2023) found TIMI had higher AUC than GRACE for 6-week MACE. Bakhsh et al. (2023) reported that, at a fixed sensitivity threshold, TIMI missed fewer MACE than GRACE among low-risk patients, although HEART classified more patients as low risk. Nasr Isfahani et al. (2025) found TIMI had higher AUC than GRACE for 6-week MACE, while HEART had the highest overall performance.

Context-Dependent Comparative Performance

The evidence map indicates that performance is strongly context dependent. GRACE tended to perform better in confirmed ACS populations and mortality-focused analyses, likely because it incorporates variables reflecting hemodynamic compromise, renal function, cardiac arrest, Killip class, and biomarker status. TIMI, however, remained clinically relevant in rapid triage contexts where simplicity, speed, and ease of bedside use are priorities. In chest pain cohorts where the probability of confirmed ACS was lower, TIMI sometimes performed as well as or better than GRACE for MACE, although HEART often outperformed both.

Discussion

This scoping review mapped the contemporary evidence comparing the prognostic performance of TIMI and GRACE scores for predicting mortality and major adverse cardiovascular events (MACE) across diverse acute coronary syndrome (ACS) populations. The overall evidence consistently indicates that the GRACE score provides superior discrimination for mortality prediction, whereas comparative performance for MACE remains more heterogeneous and highly dependent on clinical context, ACS phenotype, and outcome definitions. These findings are consistent with current international ACS guidelines, which continue to recommend GRACE as the preferred tool for

comprehensive risk assessment because of its robust prognostic accuracy across the spectrum of ACS and its ability to guide invasive management and follow-up strategies (Task et al., 2023; Taub, 2025).

The more consistent performance of GRACE for mortality prediction is biologically and clinically plausible. Unlike TIMI, GRACE incorporates multiple physiological indicators reflecting both ischemic burden and systemic illness severity, including age, heart rate, systolic blood pressure, Killip class, serum creatinine, cardiac arrest at presentation, ST-segment deviation, and cardiac biomarker elevation. These variables capture several pathophysiological pathways associated with adverse outcomes, including hemodynamic instability, renal dysfunction, ventricular failure, and extensive myocardial injury, thereby improving discrimination across heterogeneous ACS populations (Task et al., 2023; Wontor et al., 2024). Recent investigations further suggest that the prognostic performance of GRACE can be enhanced by incorporating frailty assessment, inflammatory biomarkers, lactate concentration, or novel biochemical markers, reflecting the evolving concept that mortality risk in ACS extends beyond traditional cardiovascular variables alone (Szabo et al., 2022; Wontor et al., 2024; Xin et al., 2025; Yildirim et al., 2025).

In contrast, the evidence regarding MACE prediction was considerably less consistent. This variability likely reflects substantial methodological heterogeneity rather than true differences in score performance. Across the included studies, MACE encompassed diverse combinations of all-cause mortality, recurrent myocardial infarction, repeat revascularization, stroke, heart failure hospitalization, stent thrombosis, and coronary artery bypass grafting. Such variability inevitably influences predictive performance because several MACE components are affected by treatment decisions, institutional protocols, operator experience, and healthcare accessibility rather than baseline patient risk alone. Consequently, comparisons across studies should be interpreted cautiously, highlighting the need for standardized MACE definitions and reporting frameworks to facilitate meaningful comparisons and future evidence synthesis (Task et al., 2023; Zheng et al., 2025).

An important finding of this review is that the relative performance of TIMI and GRACE differs according to the stage of the patient pathway. GRACE demonstrated greater prognostic utility in patients with confirmed ACS, particularly NSTEMI and STEMI populations, where comprehensive mortality estimation informs decisions regarding invasive management, intensive monitoring, and post-discharge follow-up. Conversely, TIMI frequently showed comparable performance in emergency department cohorts presenting with undifferentiated chest pain or suspected ACS. Because TIMI relies on fewer clinical variables and can be calculated rapidly without extensive laboratory data, it remains valuable during the earliest stages of assessment when immediate triage decisions are required. However, simplified bedside scores should complement rather than replace comprehensive clinical evaluation, serial biomarker testing, electrocardiographic assessment, and clinician judgment (Task et al., 2023; Taub, 2025).

These findings also illustrate the distinction between statistical discrimination and clinical effectiveness. Although GRACE generally demonstrated higher area under the receiver operating characteristic curve (AUC) values, superior predictive performance alone does not necessarily translate into improved patient outcomes. Risk prediction tools improve

care only when integrated into structured clinical workflows that support timely escalation of care, adherence to guideline-directed therapy, multidisciplinary communication, and discharge planning. Recent cardiovascular quality improvement initiatives increasingly emphasize embedding validated risk scores into electronic clinical decision-support systems to facilitate standardized risk assessment and reduce unwarranted variation in clinical practice (Task et al., 2023; Taub, 2025).

The practical implications of score selection may be particularly important in Low- and Middle-Income Countries and other resource-constrained healthcare settings. Hospitals with limited laboratory capacity, shortages of specialist personnel, or limited access to electronic decision-support systems may encounter practical barriers to routine GRACE implementation despite its superior prognostic performance. Under these circumstances, TIMI may provide a pragmatic alternative for rapid bedside risk stratification because of its simplicity and minimal data requirements. Nevertheless, healthcare systems should progressively strengthen infrastructure, improve laboratory availability, and expand digital decision-support capabilities to facilitate broader implementation of comprehensive risk assessment tools such as GRACE where feasible. Such context-sensitive implementation strategies are likely to maximize both feasibility and clinical effectiveness across diverse healthcare environments (Task et al., 2023; Taub, 2025; Campbell et al., 2023).

Implications and limitations

For nursing and multidisciplinary cardiovascular care, accurate risk stratification supports early recognition of deterioration, prioritization of monitoring, triage to invasive pathways, and structured discharge planning. Nurses in emergency, coronary care, and catheterization settings frequently coordinate repeated vital signs, electrocardiography, biomarker sampling, medication administration, and patient education. These tasks generate the clinical information needed for TIMI and GRACE calculation and create opportunities to identify high-risk patients early.

The findings suggest that health services should use risk scores according to the clinical question. When the goal is mortality risk estimation in confirmed ACS, GRACE should generally be prioritized. When the goal is rapid triage in suspected ACS or chest pain pathways, TIMI may be used as a practical adjunct, but it should not replace clinical judgment or more comprehensive assessment. For post-discharge care, patients classified as high risk by GRACE, TIMI, or comparable bedside indices should receive structured follow-up, medication adherence counseling, cardiac rehabilitation referral, and early return precautions.

Relevance to Practice

The findings of this review support the context-specific implementation of prognostic risk stratification in routine acute coronary syndrome care. In clinical practice, nurses and other frontline healthcare professionals can use the GRACE score to identify patients at high risk of mortality who require closer monitoring, timely referral for invasive management, and structured discharge planning, while the TIMI score may serve as a practical alternative for rapid bedside triage when comprehensive laboratory data or electronic decision-support systems are unavailable. Healthcare institutions should integrate standardized risk assessment protocols into emergency and inpatient cardiovascular pathways and provide regular staff training to ensure consistent application of evidence-based risk

stratification. For health policymakers, prioritizing the adoption of feasible risk assessment strategies that align with local infrastructure and workforce capacity may improve the allocation of limited resources and the quality of ACS care, particularly in Low- and Middle-Income Countries, where constraints in laboratory services, digital health infrastructure, and specialist availability necessitate simple, scalable, and cost-effective clinical decision-making tools.

Conclusion

The available evidence indicates that GRACE generally provides stronger prognostic performance than TIMI for mortality prediction in ACS, particularly in confirmed NSTEMI, AMI, and STEMI reperfusion populations. For MACE, comparative performance is more variable and depends on ACS phenotype, clinical setting, follow-up period, and outcome definition. TIMI remains useful as a simple bedside tool, especially in rapid triage contexts, but GRACE appears more appropriate when comprehensive mortality risk stratification is needed. Standardized outcome reporting and context-specific implementation studies are needed to guide score selection in emergency, inpatient, and post-discharge cardiovascular care.

Funding

This research received no external funding.

CrediT Authorship Contributions Statement

Fajar Prasetyo Winoto: Conceptualization, Methodology, Supervision, Writing – Original Draft.

Titin Andri Wihastuti: Validation, Formal Analysis, Writing – Review & Editing, Project Administration.

Laily Yuliatun: Investigation, Resources, Data Curation, Writing – Review & Editing.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This study was conducted independently without any external financial sponsorship or institutional funding.

Acknowledgments

The authors would like to express their sincere gratitude to all individuals and institutions who contributed to the completion of this study. Special appreciation is extended to the academic supervisors and colleagues at the Faculty of Health Sciences, Universitas Brawijaya, for their valuable suggestions and constructive feedback throughout the research process. The authors also acknowledge the support from the affiliated institution for providing access to scientific databases and resources that facilitated this review. This study was conducted with the authors' personal funding, without any external grants or sponsorships.

References

Aldujeli, A., Haq, A., Hamadeh, A., Stalmokaite, A., & Maciulevicius, L. (2022). *A comparison of crisk scores ' long-term predictive abilities for patients diagnosed with ST elevation myocardial infarction who underwent early percutaneous coronary intervention*. *56*(1), 56–64.

Alexander, L., Mcinerney, P., Godfrey, C. M., & Khalil, H. (2020). *scoping reviews*. https://doi.org/10.11124/JBIES-20-00167

Bakhsh, K., Pervez, T., Ashraf, M. N., Rizwan, M. H., & Chaudhary, N. (2023). *Comparison of Various Clinical Risk Assessment Tools in Predicting Major Adverse Cardiac Events in Patients Presenting in Emergency Department*

with Undifferentiated Cardiac Chest Pain. *73*(1), 195–199.

Campbell, F., Tricco, A. C., Munn, Z., Pollock, D., Saran, A., Sutton, A., White, H., & Khalil, H. (2023). *Mapping reviews , scoping reviews , and evidence and gap maps (EGMs): the same but different — the " Big Picture " review family*. 1–8. https://doi.org/10.1186/s13643-023-02178-5

Dinesh, M. V., Ramesh, A. C., & Rangaswamy, K. M. M. (2022). *A prospective risk stratification and validation of HEART , GRACE and TIMI scores for chest pain patients presenting to the emergency department*. *8*(2), 134–140. https://doi.org/10.34172/jept.2022.16

Isfahani, M. N., Mohseni, H., & Nasrabadi, E. N. (2025). *Improving chest pain risk assessment : validation of HEART , TIMI , GRACE , EDACS- ADP , and HET for MACE prediction in the emergency department*. *4*.

Kasim, S., Nur, P., Amir, F., Id, S. M., Aziz, F., Ahmad, A. W., Ibrahim, K. S., Hanis, M., Hamidi, M., Ezman, R., Shariff, R., Yean, A., Fong, Y., & Song, C. (2024). *Data analytics approach for short- and long-term mortality prediction following acute non- ST-elevation myocardial infarction (NSTEMI) and Unstable Angina (UA) in Asians*. 1–28. https://doi.org/10.1371/journal.pone.0298036

Kumar, R., Safdar, U., Yaqoob, N., Khan, S. F., Matani, K., Khan, N., Jalil, B., Yousufzai, E., Shahid, M. O., Khan, S., Naeem, S., Bhagia, K., Ahmed, M., Tunio, A. F., Mughal, K. A., Hyder, A., Farooq, F., Sial, J. A., Saghir, T., & Karim, M. (2025). Assessment of the prognostic performance of TIMI, PAMI, CADILLAC and GRACE scores for short-Term major adverse cardiovascular events in patients undergoing emergent percutaneous revascularisation: A prospective observational study. *BMJ Open*, *15*(3), 1–14. https://doi.org/10.1136/bmjopen-2024-091028

Muste, S. R., Babes, E. E., Bustea, C., Dobjanschi, L., Muste, F. A., & Zaha, D. C. (2026). *Non-ST-Elevation Myocardial Infarction : A Heterogeneous Syndrome with Evolving Management — A Narrative Review*. 1–34.

Nurma, S., & Hadie, H. (2024). *ABC of a Scoping Review : A Simplified JBI Scoping Review Guideline*. *16*(2), 185–197. https://doi.org/10.21315/eimj2024.16.2.14

Pollock, D., Evans, C., Menghao, R., Alexander, L., Pieper, D., Moraes, D., Peters, M. D. J., Tricco, A. C., Khalil, H., Godfrey, C. M., Saran, A., Campbell, F., & Munn, Z. (2024). *" How-to ": scoping review ?* *176*. https://doi.org/10.1016/j.jclinepi.2024.111572

San, I. N., Arispe, R., Sol, J., Gil, A. C., & Trujillano, J. (2023). Comparison of heart , grace and TIMI scores to predict major adverse cardiac events from chest pain in a Spanish health care region European Society of Cardiology. *Scientific Reports*, 1–12. https://doi.org/10.1038/s41598-023-44214-3

SR, A., Lakshmaiah, Y., DGSR, K. M., NT, M. M., KJ, D. P., K, R., & Y, N. R. (2025). A Comparison of TIMI (Thrombolysis in Myocardial Infarction) and GRACE (Global Registry of Acute Coronary Events) Scores, Myocardial Blush Grade, and Shock Index-Based Indices for Predicting Outcomes in STEMI Patients Undergoing Reperfusion. *Cureus*, *17*(5). https://doi.org/10.7759/cureus.84938

Szabo, D., Szabo, A., Magyar, L., Banhegyi, G., Kugler, S., Pinter, A., Juhasz, V., Ruppert, M., Olah, A., Ruzsa, Z., Edes, I. F., Szekely, A., Becker, D., Merkely, B., & Hizoh, I. (2022). *Admission lactate level and the GRACE 2 . 0 score are independent and additive predictors of 30-day mortality of STEMI patients treated with primary PCI — Results of a real-world registry*. *Idi*, 1–15. https://doi.org/10.1371/journal.pone.0277785

Task, A., Members, F., Byrne, R. A., Ireland, C., Rossello, X., Coughlan, J. J., Ireland, T. F. C., Barbato, E., Berry, C., Kingdom, U., Chieffo, A., Claeys, M. J., Dan, G., Dweck, M. R., Galbraith, M., Kingdom, U., France, M. G., Jüni, P., Lorusso, R., … United, J. (2023). *2023 ESC Guidelines for the management of acute coronary syndromes Developed by the task force on the management of acute coronary syndromes of the European Society of Cardiology (ESC) (United Kingdom), (United Kingdom),*. 3720–3826. https://doi.org/10.1093/eurheartj/ehad191

Taub, P. R. (2025). *2025 ACC / AHA / ACEP / NAEMSP / SCAI Guideline for the Management of Patients With Acute Coronary Syndromes*. *85*(22), 2135–2237. https://doi.org/10.1016/j.jacc.2024.11.009

Tricco, A. C., Lillie, E., Zarin, W., Brien, K. K. O., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Ma, Q., Horsley, T., Weeks, L., Hartling, L., Aldcroft, A., Hons, B. A., Wilson, M. G., & Garritty, C. (2018). *R ESEARCH AND R EPORTING M ETHODS PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation*. *August 2016*. https://doi.org/10.7326/M18-0850

Tufan, Ç., & Faysal, S. (2023). *Evaluation of Intermountain Risk Score for Short- and Long-Term Mortality in ST Elevation Myocardial Infarction Patients*. *74*(4), 357–364. https://doi.org/10.1177/00033197221105753

Varughese, V. J., Pollock, J., Patel, P., Richardson, C., Joseph, C., & Vacca, D. (2025). *Outcomes of NSTEMI Admissions and Significance of TIMI Scores : A Nationwide Analysis Using the National Inpatient Sample*.

Wang, S., Zhang, Y., Qi, D., Wang, X., Zhu, Z., & Yang, W. (2024). *Age shock index and age-modified shock index are valuable bedside prognostic tools for postdischarge mortality in ST-elevation myocardial infarction patients*. *56*(1), 1–15.

Wita, W., Shariefuddin, A., Pramudyo, M., & Martha, J. W. (2024). *Shock index creatinine : a new predictor of mortality in acute coronary syndrome patients*. *4*, 1–8.

Wontor, R., Ołpińska, B., Rudnicka, M. Ł., Wyderka, R., Dudek, K., Grudzień, K. Ł., & Jaroch, J. (2024). *Addition of the Tilburg Frailty Indicator to the classic Global Registry of Acute Coronary Events risk score improves its prognostic value in elderly patients with acute coronary syndrome*. 1–7. https://doi.org/10.20452/pamw.16862

Xin, J., Liu, Y., Zhang, C., & Wang, Q. (2025). *Predictive value of novel inflammatory markers combined with GRACE score hospital outcome in patients with for in- - segment elevation myocardial infarction : a retrospective observational study*. 1–9. https://doi.org/10.1136/bmjopen-2024-096621

Yalcin Ocak, N., Yesilaras, M., Kilicaslan, B., Eyler, Y., Mutlu, İ., & Kutlu, M. (2023). Comparing TIMI, HEART, and GRACE Risk Scores to Predict Angiographic Severity of Coronary Artery Disease

and 30-Day Major Adverse Cardiac Events in Emergency Department Patients with NSTEACS. *Prehospital and Disaster Medicine*, *38*(6), 740–748. https://doi.org/10.1017/S1049023X23006490

Yang, B., Bai, L., Zhang, Y., Cheng, Y., Zhao, C., Huang, B., & Chen, M. (2022). *The Value of Different Short-Term Risk Scoring Models in Predicting Long-Term Death of Acute Myocardial Infarction*.

Yanqiao, L., Shen, L., Yutong, M., Linghong, S., & Ben, H. (2022). *Comparison of GRACE and TIMI risk scores in the prediction of in - hospital and long - term outcomes among East Asian non - ST - elevation myocardial infarction patients*. 1–10.

Yildirim, M., Reich, C., Salbach, C., Biener, M., Mueller, M., Sörensen, N. A., Haller, P. M., Blankenberg, S., Neumann, J. T., Twerenbold, R., Frey, N., & Giannitsis, E. (2025). Identification of patients with suspected NSTE - ACS in the observe zone : evaluating GRACE 1 . 0 score and a biomarker panel for risk stratification and management optimization European Society of Cardiology Global Registry of Acute Coronary Events. *Clinical Research in Cardiology*, *114*(6), 783–795. https://doi.org/10.1007/s00392-025-02642-3

Zheng, J., Li, J., Li, T., Hu, F., & Cheng, D. (2025). *Development and validation of an in-hospital major adverse cardiovascular events risk model for young patients with acute coronary syndrome : a retrospective cohort study*. https://doi.org/10.7717/peerj.19513