Research Square

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Iron Homeostasis Markers and 1-Year Mortality in Critically Ill Patients with Acute Myocardial Infarction

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Research Article

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Abstract

Background

The prognostic value of iron homeostasis markers (ferritin, transferrin, and transferrin saturation [TSAT]) in critically ill patients with acute myocardial infarction (AMI) remains unclear.

Methods

We included AMI patients from the MIMIC-IV database who had iron markers measured within 24 hours of ICU admission. The primary outcome was 1-year all-cause mortality. Cox regression, Kaplan-Meier, restricted cubic splines, and ROC analyses were used to assess associations and predictive performance.

Results

Among 416 patients, the highest tertiles of ferritin (HR = 1.88) and TSAT (HR = 1.60) were independently associated with increased mortality, while the middle tertile of transferrin showed reduced risk (HR = 0.64). Nonlinear relationships were observed. Individual marker predictive accuracy was modest (AUC 0.57–0.63), with no significant improvement over baseline risk models.

Conclusion

Early-measured ferritin, TSAT, and decreased transferrin are independently associated with 1-year mortality in ICU-admitted AMI patients, but their modest predictive value limits their use as standalone risk tools, and their incremental value beyond traditional models is limited. Subgroup interaction findings were not significant after multiple-testing correction and require validation.

I. Introduction

Acute myocardial infarction (AMI) remains a leading cause of death and disability worldwide. Despite advances in reperfusion and secondary prevention, mortality remains high [1, 2]. and the global burden is projected to increase through 2050 [3]. Identifying reliable prognostic markers is therefore essential for developing novel therapeutic strategies.

Iron is an essential trace element involved in oxygen transport and energy metabolism [4, 5]. In the heart, iron is critical for cellular respiration, yet pathological accumulation can induce cardiomyocyte death via oxidative stress [6]. Iron homeostasis imbalance has emerged as a driver of myocardial injury through oxidative stress and inflammation, affecting cardiovascular prognosis [7]. The discovery of ferroptosis, an iron-dependent cell death pathway, has further sparked interest in iron homeostasis in cardiovascular disease, though its role in acute settings remains unclear.

Although numerous studies have linked iron homeostasis markers to cardiovascular disease [8-11], most have focused on heart failure. Mechanistic evidence suggests a relationship with coronary artery disease, but their association with AMI—particularly ferritin, transferrin, and TSAT—and their prognostic value remain unclear.

Ferritin is the main intracellular iron-storage protein and a biomarker of iron reserves, playing a key role in diagnosing iron deficiency. It also acts as an acute-phase reactant, with levels rising during inflammatory states [12, 13].

Transferrin is the main iron-transport protein in plasma, regulated by iron status, inflammation, and nutrition. Its levels rise in iron deficiency but fall during inflammation. Notably, serum iron, transferrin, and TSAT are superior to ferritin for diagnosing inflammatory anemia in critically ill patients [14].

Transferrin saturation (TSAT) reflects the percentage of transferrin bound by iron, calculated as serum iron divided by total iron-binding capacity. Some studies report that low TSAT and ferritin indicate myocardial iron deficiency and adverse outcomes, while high ferritin and transferrin may increase coronary risk via metabolic and inflammatory pathways [15-18]. However, other studies have failed to confirm these associations [19-22].

Elevated ferritin and other iron markers have been linked to increased mortality in various critical illnesses, including ARDS and severe COVID-19, particularly when measured at admission[23-25].

Therefore, this study aimed to evaluate the association of acute-phase ferritin, transferrin, and TSAT with 1-year mortality in ICU-admitted AMI patients, and to compare their prognostic value.

II. Research Methods

2.1 Database

This study utilized the Medical Information Mart for Intensive Care IV (MIMIC-IV v3.0) database, comprising over 50,000 intensive care unit (ICU) admissions collected at the Beth Israel Deaconess Medical Center in Boston, Massachusetts, spanning from 2008 to 2022. The MIMIC-IV database provides extensive datasets, including patient demographics, vital signs, laboratory data, as well as diagnoses encoded in accordance with the International Classification of Diseases Ninth Revision (ICD-9) and Tenth Revision (ICD-10) systems.

2.2 Research Population

Patients were identified from the MIMIC-IV database using the following criteria: diagnosis of Acute Myocardial Infarction (ICD-9 codes beginning with 410 or ICD-10 codes beginning with I21). Only the first ICU admission for each patient during the study period was considered. Inclusion required the presence of complete iron-homeostasis data (serum iron, Ferritin, Transferrin, TIBC) obtained within the first 24 hours of ICU admission. For patients with multiple records, the earliest was selected. Exclusion criteria comprised ICU stay duration less than 24 hours, age younger than 18 years, and incomplete dataset entries. Ultimately, 416 cases were identified. Based on clinical experience and prior research, given that both elevated and reduced levels of iron homeostasis markers may influence patient prognosis, patients were stratified into low, medium, and high groups according to tertiles of the exposure variable, following established study protocols [12].

2.3 Data Extraction and Variables

Data were extracted using Structured Query Language (SQL) with PostgreSQL. Baseline characteristics included demographics (age, sex, height, weight), vital signs (heart rate, systolic blood pressure, diastolic blood pressure), and severity scores at admission (Simplified Acute Physiology Score II (SAPSII), Systemic Inflammatory Response Syndrome (SIRS) score, Acute Physiology Score III (APSIII), and Sequential Organ Failure Assessment (SOFA) score). Medication histories (beta-blockers, loop diuretics (including furosemide and torsemide), angiotensin-converting enzyme inhibitors (ACEI), and angiotensin receptor blockers (ARB)) and laboratory parameters were collected within the initial 24 hours after ICU admission. Laboratory parameters included red blood cells (RBC), white blood cells (WBC), neutrophils, hemoglobin, lymphocytes, platelets, urinary creatinine, serum creatinine (Scr), blood urea nitrogen (BUN), creatine kinase-MB (CKMB), partial pressure of carbon dioxide (PCO2), C-reactive protein (CRP), total cholesterol (TC), total triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), N-terminal pro-B-type natriuretic peptide (NT-proBNP),

low-density lipoprotein cholesterol (LDL-C), potassium, sodium, pH, partial pressure of oxygen (PO2), glucose, glycated hemoglobin (HbA1c), and troponin T (TnT). Iron metabolism markers (serum iron, ferritin, transferrin, and total iron-binding capacity (TIBC)) were also collected. For repeated laboratory measures, the earliest value within 24 hours was selected. Comorbid conditions, including chronic obstructive pulmonary disease (COPD), atrial fibrillation (AF), diabetes, and chronic kidney disease (CKD), were identified using ICD-9 and ICD-10 codes. The observation period extended from ICU admission until the occurrence of the primary endpoint, death, or the end of the 1-year follow-up period.

The Transferrin Saturation (TSAT) was calculated using the formula: TSAT (%) = serum iron (μg/dL) / total iron-binding capacity (μg/dL) × 100.

III. Statistical Methods

Handling of Missing Data

Variables with >50% missing values were excluded. For covariates with <50% missingness, we assumed missing at random. Iron-homeostasis markers (ferritin, transferrin, and TSAT) were fully observed and not imputed; only covariates with partial missing data were imputed.

Multiple imputation was implemented using the mice package (version 3.16.0) in R (version 4.5.0). Continuous variables were imputed using predictive mean matching, and binary categorical variables were imputed using logistic regression. We generated 20 imputed datasets, and convergence of the imputation algorithm was monitored visually using trace plots. Parameter estimates from the 20 imputed datasets were pooled according to Rubin's rules. All primary analyses were performed on the multiply imputed datasets.

Statistical Analysis

Continuous variables are presented as mean (standard deviation [SD]) or median (interquartile range [IQR]), as appropriate, and were compared between groups using either the Mann-Whitney U test or the Student’s t-test, based on variable distribution. Categorical variables are described by frequency and proportion (%) and were compared using either Fisher’s exact test or Pearson’s chi-square test, depending on the sample characteristics.

Following stratification into tertile groups, Kaplan-Meier survival analysis was employed to compare mortality among categories. Associations between Ferritin, Transferrin, TSAT, and 1-year mortality were estimated using the Cox proportional-hazards model, yielding adjusted hazard ratios (HRs) and 95% confidence intervals (CIs). Model 1 assessed unadjusted associations; Model 2 was adjusted for sex, age, and Body Mass Index (BMI); and Model 3 incorporated all covariates in Model 2, plus a prespecified set of additional covariates selected a priori based on clinical relevance and their univariate association with 1-year mortality in baseline comparisons (SBP, SAPSII, SOFA, APSIII, RBC, WBC, hemoglobin, Scr, BUN, ACEI, AF). Ferritin, Transferrin, and TSAT were each included as continuous and categorical predictors. HRs with 95% CIs were reported. Model fit and multicollinearity were assessed by likelihood-ratio testing and variance inflation factor, respectively. For all indicators, the lowest tertile served as the reference group.

The predictive performance of each marker was further assessed using Receiver Operating Characteristic (ROC) curve and Area Under Curve (AUC) analyses. Optimal cut-off values were determined. A basic risk model was constructed using variables with $P < 0.05$ in baseline characteristics, and each marker was added to this model to evaluate its incremental predictive value.

Sensitivity Analysis and Exploratory Analysis

To evaluate the robustness of the findings, Ferritin, Transferrin, and TSAT were categorized into high and low groups based on the optimal cut-off values derived from ROC analysis, and Cox regression analyses were subsequently repeated.

Restricted cubic spline (RCS) models with 3 knots were employed to flexibly model the association between each iron-homeostasis marker and 1-year mortality. Knots were placed at the 10th, 50th, and 90th percentiles of each marker's distribution. The reference point was set at the median value of each marker. Nonlinearity was tested using the Wald test against a linear term.

Furthermore, based on the aforementioned cut-off values, exploratory subgroup analyses were performed according to age (dichotomized by median), sex, COPD, AF, diabetes, and CKD status. Cox proportional hazards models were used to calculate HRs and 95% CIs for mortality risk within each subgroup, and interactions were tested using the likelihood-ratio test. Given the number of tests performed (6 subgroups × 3 markers = 18 interaction tests), Benjamini–Hochberg false discovery rate (FDR) adjusted P-values were additionally reported alongside nominal P-values. These subgroup analyses were predefined as exploratory, and all interaction findings should be interpreted as hypothesis-generating.

We repeated the fully adjusted Cox regression model (Model 3) using a complete-case analysis on the subset of patients with no missing values in any Model 3 covariate. Results were compared with those from the multiply imputed primary analysis.

To evaluate whether the prespecified covariate set in Model 3 adequately captured confounding, we performed a full-model sensitivity analysis. This model simultaneously adjusted for all baseline characteristics listed in Table 1, excluding the iron-homeostasis markers (as exposures) and variables with prohibitively high collinearity (serum iron and TIBC, which are components of TSAT).

All statistical analyses were conducted using R software (version 4.5.0) and SPSS. A two-sided P value < 0.05 was considered statistically significant.

IV. Results

4.1 Baseline Characteristics

After screening eligible AMI cases from the MIMIC-IV database, a total of 416 patients who met all inclusion criteria were ultimately included in this study. The flow of patient selection is outlined in Figure 1. Patients were grouped according to 1-year survival status, resulting in a survival group (n = 222) and a non-survival group (n = 194).

Among the 416 patients included, the iron-homeostasis markers of primary interest (ferritin, transferrin, TSAT, TIBC, and serum iron) were completely observed. Several covariates had missing values: height had the highest missing proportion (41.3%, n = 172), followed by PCO_2 and PO_2 (both 28.4%, n = 118), CK-MB (21.9%, n = 91), troponin T (17.3%, n = 72), pH (17.1%, n = 71), weight (1.4%, n = 6), and a small number of missing observations for SBP, DBP, RBC, WBC, hemoglobin, and platelets (each <1%). No covariate exceeded the 50% missingness threshold, and all variables with any missing values were included in the multiple imputation procedure.

Compared to survivors, non-survivors were older, had higher severity scores, lower RBC, SBP, and hemoglobin, and higher WBC, Scr, and BUN; AF was more prevalent and ACEI use less common. Non-survivors had significantly higher ferritin and TSAT, and lower transferrin and TIBC, with no significant difference in serum iron. Baseline characteristics are summarized in Table 1. The distribution of baseline covariates across tertiles of each iron-homeostasis marker is shown in Supplementary Tables S1–S3.

Table 1

4.2 Association between Ferritin and 1-Year Death Risk

Kaplan–Meier analysis revealed significant differences in mortality across ferritin tertiles (log-rank P < 0.001, Figure 2). In Cox regression, ferritin as a continuous variable showed no significant association with mortality in any model (all P > 0.05). However, as a categorical variable (tertiles), higher ferritin was associated with increased mortality risk. Compared with the lowest tertile (T1), the highest tertile (T3) was independently associated with increased mortality in fully adjusted Model 3 (HR 1.88, 95% CI 1.23–2.87, P = 0.004), as was T2 (HR 1.54, 95% CI 1.03–2.30, P = 0.036). Unadjusted and partially adjusted estimates are shown in Table 2.

The restricted cubic spline (RCS) model depicted a non-linear association between Ferritin and 1-year mortality, with a significant overall association (P for overall = 0.005) and non-linearity (P for nonlinear = 0.019). As Ferritin levels increased, the risk of mortality began to rise at lower concentrations, with the Hazard Ratio (HR) showing a progressive increase. Excess risk was observed even at moderate Ferritin levels, and this elevated risk persisted at higher concentrations (Figure 3).

4.3 Association between Transferrin and 1-Year Death Risk

Kaplan–Meier analysis showed significant mortality differences across transferrin tertiles (log-rank P < 0.001, Figure 2). In Cox regression, transferrin as a continuous variable was significantly inversely associated with mortality in fully adjusted Model 3 (HR 0.99, 95% CI 0.99–0.99, P = 0.007). As a categorical variable, the middle tertile (T2) was independently associated with lower mortality in Model 3 (HR 0.64, 95% CI 0.45–0.91, P = 0.013); the highest tertile (T3) showed a similar but non-significant trend (HR 0.68, 95% CI 0.46–1.02, P = 0.062). Unadjusted and partially adjusted estimates are shown in Table 2.

The RCS analysis identified a non-linear relationship (nonlinear P = 0.003); HRs exceeded 1 for Transferrin <150, then rapidly decreased to below 1 as Transferrin increased above 200, indicating reduced risk (Figure 3).

4.4 Association between Transferrin Saturation and 1-year Mortality Risk

When Transferrin Saturation (TSAT) was entered as a continuous variable, Cox proportional-hazards Model 1 (HR 1.01; 95% CI 1.01–1.01; P < 0.001) and Model 2 (HR 1.01; 95% CI 1.01–1.01; P < 0.001) showed significant associations with 1-year mortality; however, no statistically significant association was found in the fully adjusted Model 3 (HR 1.00; 95% CI 1.00–1.01; P = 0.191).

Kaplan–Meier analysis showed significant mortality differences across TSAT tertiles (log-rank P = 0.034, Figure 2). As a categorical variable, the highest tertile (T3) was independently associated with increased mortality in Model 3 (HR 1.60, 95% CI 1.10–2.34, P = 0.014); the middle tertile (T2) became significant only after full adjustment (HR 1.61, 95% CI 1.11–2.34, P = 0.012). Unadjusted and partially adjusted estimates are shown in Table 2.

The RCS model showed a linear trend between TSAT and mortality (non-linearity P = 0.395). Mortality risk consistently increased as TSAT rose, particularly at values >50% (Figure 3).

Figure 2

Table 2

Figure 3

4.5 ROC Curve Analysis of Ferritin, Transferrin, and Transferrin Saturation

ROC curves assessed the predictive accuracy of ferritin, transferrin, and TSAT for 1-year mortality (Figure 4). The AUCs were 0.63, 0.62, and 0.57, respectively, with no significant pairwise differences. The optimal cut-offs were 196.5 for ferritin, 131.5 for transferrin, and 40.0 for TSAT Adding these markers to a baseline model (age, SBP, SAPSII, SOFA, APSIII, RBC, WBC, hemoglobin, SCr, BUN, ACEI, AF) did not significantly improve prediction (baseline AUC: 0.738; +ferritin: 0.742, p=0.394; +transferrin: 0.741, p=0.727; +TSAT: 0.740, p=0.527), indicating limited incremental value (Figure 4).

Figure 4

4.6 Sensitivity and Exploratory Analysis

To assess the robustness and reliability of the findings, variance inflation factor (VIF) analysis was performed on the fully adjusted Model 3, and all VIF values for iron homeostasis markers were < 2.5, indicating no significant collinearity. Grouping analyses based on ROC-derived cut-offs yielded results consistent with the main findings (Supplementary Table 4, Supplementary Figure 1).

Subgroup analyses showed nominally significant interactions for ferritin with COPD (P=0.042) and AF (P=0.010), for transferrin with diabetes (P=0.012), and for TSAT with CKD (P=0.027). However, none remained significant after FDR correction (all adjusted P > 0.05; Table 3). These subgroup findings should therefore be interpreted as hypothesis-generating and do not constitute evidence of definitive effect modification.

Complete-case analysis (n=243) showed HR directions consistent with the primary analysis for all three markers (Supplementary Table 5). Although CIs were wider, no material discrepancy in association direction was observed, supporting the robustness of the findings to the missing-data handling strategy.

Full-model sensitivity analysis adjusting for all baseline characteristics in Table 1 confirmed the robustness of all three associations, All three markers retained statistical significance, with HRs comparable to or slightly stronger than those in Model 3 (Supplementary Table 6).

V. Discussion

In this MIMIC-IV-based cohort of ICU-admitted AMI patients, elevated ferritin, elevated TSAT, and reduced transferrin were independently associated with 1-year mortality.

5.1 Relationship between Ferritin and Prognosis in AMI Patients

Elevated serum ferritin was independently associated with increased 1-year mortality. In fully adjusted analyses, the highest tertile (>577.10 ng/mL) showed a 1.88-fold higher risk versus the lowest tertile (<172.95 ng/mL; 95% CI 1.23–2.87). RCS analysis confirmed a non-linear relationship (P for nonlinearity < 0.05), with risk rising progressively at higher ferritin levels.

Ferritin is an established biomarker of body iron stores, yet its interpretation in acute settings is complicated by its dual role as an iron-storage protein and an acute-phase reactant[13].While elevated ferritin has been linked to coronary artery disease risk, its prognostic value in AMI remains controversial [15, 26-28]. In line with prior studies in ischemic heart disease [12]. we found that high ferritin levels independently predicted 1-year mortality in ICU-admitted AMI patients. Mechanistically, excess labile iron can exacerbate oxidative stress and mitochondrial dysfunction [29-31]. Under conditions of sustained oxidative injury, these processes may create a cellular environment permissive for ferroptosis; however, our observational data cannot establish a direct ferroptotic contribution to the observed mortality risk. These oxidative and inflammatory pathways are likely amplified in the ICU setting, where patients experience both acute ischemic insult and systemic inflammation. Importantly, while previous studies have emphasized the adverse effects of

low ferritin [21, 22],our findings underscore the prognostic significance of high ferritin. This divergence may reflect differences in study populations and timing of measurement: our cohort consisted exclusively of critically ill AMI patients with ferritin assessed within 24 hours of ICU admission, a period marked by maximal inflammatory and stress responses.

5.2 Relationship between Transferrin and Prognosis in AMI Patients

Serum transferrin was significantly inversely associated with 1-year mortality in ICU-admitted AMI patients. In fully adjusted analyses, the middle tertile (T2) showed significantly lower mortality (HR 0.64, 95% CI 0.45–0.91); the highest tertile (T3) showed a similar but non-significant trend (HR 0.68, 95% CI 0.46–1.02, P=0.062). RCS analysis confirmed a non-linear relationship (P=0.003), with risk increasing below 150 mg/dL and decreasing above 200 mg/dL, reaching a plateau thereafter.

Notably, the protective effect of T3 became statistically significant in the full-model sensitivity analysis (HR 0.57, 95% CI 0.37–0.88, P=0.012), comparable to T2 (HR 0.59), suggesting that its non-significance in Model 3 was due to residual confounding rather than a true absence of effect.

As the principal iron transport protein, transferrin deficiency impairs the delivery of iron required for erythropoiesis and tissue oxygenation, thereby exacerbating myocardial hypoxia. Transferrin is also a negative acute-phase reactant [14, 32], its synthesis is suppressed under inflammatory conditions, leading to decreased circulating levels. In critically ill patients, several additional factors further contribute to reduced transferrin concentrations. Malnutrition, which is highly prevalent in the ICU and frequently develops or worsens during prolonged critical illness, directly limits the hepatic synthesis of transferrin and other visceral proteins[33, 34]. Furthermore, capillary leak syndrome—a hallmark of systemic inflammation—promotes the extravasation of transferrin from the intravascular to the interstitial space, further lowering plasma concentrations[35]. These mechanisms operate in concert with inflammation-driven synthetic suppression, and the resulting hypotransferrinemia disrupts cellular iron uptake and compromises both cardiomyocyte and endothelial cell function[36]. Accordingly, the reduced transferrin levels observed in our study likely reflect a confluence of inflammation, malnutrition, capillary leak, and functional iron deficiency—a multifactorial profile that collectively signals impaired myocardial metabolism and compromised repair capacity[37]. This broader interpretation underscores the value of transferrin as an integrative biomarker that captures multiple dimensions of illness severity, rather than merely reflecting iron status alone. Although these pathophysiological mechanisms are biologically plausible, clinical evidence regarding the independent prognostic value of transferrin in AMI patients has remained limited. Our study addresses this gap and provides novel evidence supporting transferrin as a potential risk stratification tool in ICU-admitted AMI patients.

5.3 Relationship between Transferrin Saturation and Prognosis in AMI Patients

The association between TSAT and 1-year mortality was complex. As a continuous variable, TSAT was not significant after full adjustment (HR 1.00, 95% CI 1.00–1.01, P=0.191). However, the highest tertile (T3) remained significantly associated with increased mortality (HR 1.60, 95% CI 1.10–2.34, P=0.014). RCS analysis showed a linear trend (P for nonlinearity=0.395), with risk increasing notably above 50%.

TSAT reflects transferrin-bound iron and is a marker of iron metabolism. High TSAT may indicate iron overload and oxidative stress [29-31]. but in acute inflammation, it can also be driven by declining transferrin levels rather than true iron excess. Its attenuation as a continuous variable after full adjustment suggests confounding by inflammatory, nutritional, or renal factors. Notably, prior studies in elderly and heart failure populations identified low TSAT as a mortality predictor [38, 39]. The contrast between those findings and ours likely stems from fundamental differences in clinical settings and patient profiles. Our cohort consisted of critically ill AMI patients in the ICU, where dysregulated iron metabolism is predominantly driven by inflammation and acute stress, rather than by chronic iron deficiency. In this

specific population, high TSAT may more directly reflect relative iron excess, heightened oxidative stress, and increased susceptibility to reperfusion injury—rather than serving as a reassuring indicator of sufficient iron stores. These findings underscore that the clinical interpretation of TSAT and other iron metabolism markers is highly population-dependent. In ICU-admitted AMI patients, elevated TSAT during the early phase of admission—particularly exceeding 50%—should be regarded as a high-risk warning signal rather than a benign indicator of adequate iron status. Applying iron metabolism assessment frameworks derived from heart failure or community-based populations to this setting may underestimate the prognostic risk.

5.4 Comparison of Predictive Values and Subgroup Analysis

ROC analysis showed modest predictive performance for all three markers (AUCs: ferritin 0.63, transferrin 0.62, TSAT 0.57), below the threshold for clinical utility (AUC ≥0.70). The optimal cut-offs (ferritin 196.5 μg/L, transferrin 131.5 mg/dL, TSAT 40.0%) should be considered preliminary and not ready for clinical use.

Adding these markers to a baseline model did not significantly improve AUC (baseline: 0.738; +ferritin: 0.742, P=0.394; +transferrin: 0.741, P=0.727; +TSAT: 0.740, P=0.527), indicating limited incremental value. This likely reflects information overlap with established severity scores and laboratory parameters (e.g., SAPSII, SOFA, Scr), as well as the inherent limitation of single-time-point measurements for predicting long-term outcomes.

Nevertheless, exploratory subgroup analyses suggested possible effect modification by selected comorbidities, with nominally significant interactions for ferritin by COPD and AF status, for transferrin by diabetes, and for TSAT by CKD. However, none of these interactions remained significant after Benjamini–Hochberg correction for multiple testing (Table 3), and they should be viewed as hypothesis-generating. If validated in independent cohorts, these patterns may suggest a context-dependent role of iron metabolism. For instance, in COPD, AF, and diabetes, chronic systemic inflammation and oxidative stress could potentiate the acute-phase reactivity of ferritin and transferrin, whereas in CKD, impaired renal iron handling may specifically affect the relationship between TSAT and survival. These hypothesized mechanisms require dedicated prospective investigation.

Together, these observations suggest that although iron markers have limited incremental value in the overall AMI population, they may provide modest prognostic information in specific subgroups (COPD, AF, diabetes, CKD). This heterogeneity supports population-specific interpretation and warrants further validation.

Our findings challenge the traditional "iron deficiency versus overload" dichotomy. In critically ill AMI patients, the prognostic value of iron markers is best understood within a multidimensional framework that integrates inflammatory load and acute stress.

In this critical illness context, hyperferritinemia and hypotransferrinemia are primarily a phenotypic expression of the acute-phase response. The robust inflammatory storm, driven by cytokines such as IL-6, directly modulates the synthesis of these proteins, making them composite markers of systemic inflammation, oxidative stress, and nutritional status. Consequently, the so-called "iron overload" profile (e.g., high ferritin, elevated TSAT) may, in many cases, represent a "pseudo-iron overload" state driven by inflammation rather than a true increase in total body iron.

The resulting dysregulation of iron handling may still contribute to myocardial injury. Under conditions of intense inflammation and oxidative stress, the increased availability of labile iron can exacerbate reactive oxygen species production via the Fenton reaction, leading to lipid peroxidation and mitochondrial dysfunction[29-31]. This cascade of oxidative damage is a known upstream trigger for ferroptosis, an iron-dependent form of regulated cell death [40-42]. It is, therefore, theoretically plausible that sustained disruption of iron homeostasis in these patients creates a myocardial environment susceptible to ferroptotic injury, adding a speculative, yet biologically coherent, layer to the observed association between elevated iron markers and mortality. However, the specific contribution of ferroptosis to ongoing

myocardial damage in this setting requires dedicated investigation, and our data do not permit confirmation of this mechanism.

the prognostic interpretation of iron homeostasis markers in ICU-admitted AMI patients must move beyond the traditional "iron deficiency vs. overload" dichotomy and adopt a multidimensional framework that integrates inflammatory load, acute stress, and organ dysfunction. This conceptual advance also provides a theoretical foundation for future interventional studies targeting the crosstalk between iron metabolism and inflammatory pathways.

Our findings contrast with studies in heart failure populations, where low ferritin and low TSAT predict adverse outcomes[38, 39, 43, 44]. This discrepancy reflects fundamentally different pathophysiology: chronic iron deficiency in stable HF versus acute, inflammation-driven iron dysregulation in critically ill AMI. In our patients, ferritin and TSAT behave primarily as inflammatory markers rather than indicators of iron stores.

In summary, the prognostic interpretation of iron markers in ICU-admitted AMI patients requires a multidimensional framework integrating inflammatory load, acute stress, and organ dysfunction. This framework also provides a theoretical foundation for future interventional studies targeting the crosstalk between iron metabolism and inflammation. Importantly, diagnostic and therapeutic frameworks developed for chronic HF—such as iron repletion based on TSAT thresholds—may not apply to ICU-admitted AMI patients and warrant re-evaluation.

5.5 Significance and limitations of the study

This study addresses a gap in prior research by evaluating iron homeostasis markers (ferritin, transferrin, TSAT) measured within 24 hours of ICU admission in AMI patients. We found that elevated ferritin, elevated TSAT, and reduced transferrin were independently associated with adverse prognosis, though with modest effect sizes and limited incremental value beyond established risk factors. These readily available parameters may provide modest adjunctive prognostic information and warrant further investigation as complements to—not replacements for—existing risk assessment tools.

Several limitations should be acknowledged. First, the retrospective design precludes causal inference, and residual confounding cannot be excluded despite extensive adjustment—as illustrated by the full-model sensitivity analysis showing statistical significance for transferrin T3 that was not observed in Model 3. Second, requiring complete iron panel data within 24 hours introduced selection bias, excluding patients too ill for testing or with incomplete data. Moreover, iron panels are not routinely ordered for all AMI patients, potentially enriching our cohort with patients with suspected iron abnormalities or comorbidities (e.g., anemia, CKD), limiting generalizability. Third, single-time-point measurements preclude insight into temporal dynamics. Most importantly, our findings are derived exclusively from ICU patients and are not generalizable to all AMI patients. Future multicenter prospective studies are needed to validate these findings in broader populations and to explore whether dynamic monitoring or targeted interventions can improve outcomes.

5.6 Conclusion

In this cohort of ICU-admitted AMI patients, elevated ferritin, elevated TSAT, and reduced transferrin, measured within 24 hours of ICU admission, were independently associated with 1-year all-cause mortality. However, the modest individual predictive accuracy of these markers (AUC range 0.57–0.63) indicates that they should not be used as standalone tools for early risk stratification in critically ill AMI patients. Instead, these readily available laboratory parameters may serve as adjunctive indicators that modestly complement established risk factors; however, their incremental discriminatory value is limited, and they should not replace existing risk assessment tools. The prognostic cut-off values identified in this study—196.5 μg/L for ferritin, 131.5 mg/dL for transferrin, and 40.0% for TSAT—may serve as preliminary references for future research; however, their clinical utility as screening thresholds requires validation in prospective studies. In

exploratory subgroup analyses, nominally significant interactions were observed for selected comorbidities (COPD, AF, diabetes, and CKD); however, none remained significant after correction for multiple testing. These hypothesis-generating findings suggest possible population-dependent heterogeneity that requires independent validation. Mechanistically, the interplay between inflammation-driven iron dysregulation and the acute-phase response provides a plausible explanation for the risk associations observed in this unique ICU-AMI population, although the relative contribution of direct iron toxicity versus inflammatory pathway activation remains to be determined. Nevertheless, as a retrospective, single-center study, our findings are subject to inherent limitations including selection bias, residual confounding, and the inability to capture dynamic changes in iron metabolism from single admission measurements. Future multicenter prospective studies are warranted to validate these findings, investigate the prognostic value of longitudinal iron parameter monitoring, and examine whether iron-modulating interventions, carefully designed to distinguish inflammation-driven dysregulation from true iron overload, may improve outcomes in patients with AMI.

Abbreviations

ICU
Intensive Care Unit
AMI
Acute Myocardial Infarction
MIMIC-IV
Medical Information Mart for Intensive Care IV
ROC
Receiver Operating Characteristic
TSAT
Transferrin Saturation
TIBC
Total Iron-Binding Capacity
ICD-9
International Classification of Diseases Ninth Revision
ICD-10
International Classification of Diseases Tenth Revision
SQL
Structured Query Language
HR
Heart Rate
SBP
Systolic Blood Pressure
DBP
Diastolic Blood Pressure
SAPSII
Simplified Acute Physiology Score II
SIRS
Systemic Inflammatory Response Syndrome
APSIII
Acute Physiology Score III
SOFA

Sequential Organ Failure Assessment
ACEI
Angiotensin-Converting Enzyme Inhibitors
ARB
Angiotensin Receptor Blockers
RBC
Red Blood Cells
WBC
White Blood Cells
Ucr
Urinary Creatinine
Scr
Serum Creatinine
BUN
Blood Urea Nitrogen
CKMB
Creatine Kinase-MB
PCO2
Partial Pressure of Carbon Dioxide
CRP
C-Reactive Protein
TC
Total Cholesterol
TG
Total Triglycerides
HDL-C
High-Density Lipoprotein Cholesterol
NT-proBNP
N-terminal pro-B-type Natriuretic Peptide
LDL-C
Low-Density Lipoprotein Cholesterol
PO2
Partial Pressure of Oxygen
HbA1c
Glycated Hemoglobin
TnT
Troponin T
COPD
Chronic Obstructive Pulmonary Disease
AF
Atrial Fibrillation
CKD
Chronic Kidney Disease
SD
Standard Deviation
IQR

Interquartile Range
HR
Hazard Ratio(Note:The abbreviation is the same as "Heart Rate," but it has different meanings in different contexts)
CI
Confidence Interval
BMI
Body Mass Index
AUC
Area Under Curve
VIF
Variance Inflation Factor
RCS
Restricted Cubic Spline

Declarations

Ethics approval and consent to participate

Patient consent was not required for this study as the use of this de-identified database has been approved by the Institutional Review Boards of both the Massachusetts Institute of Technology and Beth Israel Deaconess Medical Center. Upon successful completion of the necessary evaluation (Certificate No. 32173796), the individuals involved in this study were granted authorization to access the MIMIC-IV database after completing a series of courses provided by the National Institutes of Health (NIH).

Consent for publication

Not Applicable.

Availability of data and materials

The data underlying this article were derived from the Medical Information Mart for Intensive Care IV (MIMIC-IV) database (version 3.0), which is available in the PhysioNet repository at https://physionet.org/content/mimiciv/3.0/. Researchers can access the database after completing the required training course (CITI Data or Specimens Only Research) and signing a data use agreement, following the protocol detailed on the PhysioNet website.

Competing Interests

None declared.

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Authors' contributions

Yubin Shen: Study concept and design. Yubin Shen, Chenyang Wu, Yuqin Zhan, Tingshan Yu: Acquisition, analysis, or interpretation of data. Yubin Shen: Drafting of the manuscript. All authors: Critical revision of the manuscript for important intellectual content. Yubin Shen, Yuqin Zhan: Statistical analysis. Chenyang Wu, Tingshan Yu: Administrative, technical, or material support.Yahui Ding: Study supervision.

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Clinical trial number

Not Applicable.

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Tables

Table 1

Variables	Total (n = 416)	0 (n = 222)	1 (n = 194)	P
Age, M (Q_1, Q_3)	69.50 (59.00, 78.00)	67.00 (57.00, 75.00)	73.00 (64.00, 80.00)	<.001
Bmi, M (Q_1, Q_3)	27.38 (24.69, 31.24)	27.52 (24.80, 31.34)	27.24 (24.37, 31.01)	0.571
Heart Rate, M (Q_1, Q_3)	103.00 (90.00, 117.25)	102.00 (89.25, 115.00)	105.00 (92.00, 119.75)	0.253
Sbp, M (Q_1, Q_3)	143.00 (128.00, 159.00)	147.00 (130.00, 162.00)	139.00 (125.00, 155.75)	0.003
Dbp, M (Q_1, Q_3)	89.00 (78.00, 102.00)	89.00 (80.00, 102.00)	90.00 (78.00, 101.75)	0.613
Sapsii, M (Q_1, Q_3)	39.50 (32.00, 49.00)	36.00 (29.00, 43.00)	45.50 (38.00, 54.00)	<.001
Sofa, M (Q_1, Q_3)	6.00 (3.00, 8.00)	5.00 (2.25, 8.00)	6.00 (4.00, 9.00)	<.001
Apsiii, M (Q_1, Q_3)	48.00 (39.00, 64.00)	44.50 (34.00, 57.00)	54.00 (43.00, 70.50)	<.001
Rbc, M (Q_1, Q_3)	3.23 (2.82, 3.74)	3.35 (2.90, 3.79)	3.10 (2.74, 3.66)	0.004
Wbc, M (Q_1, Q_3)	12.20 (8.70, 16.15)	11.70 (8.45, 15.47)	12.60 (8.95, 17.98)	0.042
Hemoglobin, M (Q_1, Q_3)	9.40 (8.30, 11.00)	9.70 (8.50, 11.10)	9.20 (8.20, 10.78)	0.016
Platelets, M (Q_1, Q_3)	214.00 (152.75, 280.00)	217.00 (163.25, 276.75)	207.00 (143.00, 284.75)	0.292
Scr, M (Q_1, Q_3)	1.80 (1.08, 3.30)	1.50 (0.93, 2.90)	2.10 (1.20, 3.60)	<.001
Bun, M (Q_1, Q_3)	38.00 (23.00, 64.25)	33.00 (20.00, 59.00)	44.00 (29.00, 67.00)	<.001
Ckmb, M (Q_1, Q_3)	14.00 (5.00, 35.25)	15.00 (6.00, 44.00)	12.50 (5.00, 29.75)	0.221
Pco2, M (Q_1, Q_3)	44.90 (39.00, 51.00)	44.90 (39.25, 51.45)	44.90 (39.00, 51.00)	0.883
Potassium, M (Q_1, Q_3)	4.50 (4.10, 5.10)	4.50 (4.10, 5.00)	4.50 (4.10, 5.20)	0.531
Sodium, M (Q_1, Q_3)	139.00 (136.00, 142.00)	140.00 (137.00, 142.00)	139.00 (136.00, 142.00)	0.061
Ph, M (Q_1, Q_3)	7.38 (7.32, 7.43)	7.38 (7.31, 7.42)	7.38 (7.32, 7.43)	0.990
Po2, M (Q_1, Q_3)	91.50 (53.00, 153.45)	93.50 (55.00, 147.90)	86.60 (52.00, 157.75)	0.910
Glucose, M (Q_1, Q_3)	165.50 (128.00, 226.00)	164.50 (123.00, 212.75)	167.50 (134.00, 240.75)	0.120
Tnt, M (Q_1, Q_3)	0.66 (0.18, 1.56)	0.65 (0.17, 1.64)	0.68 (0.19, 1.52)	0.809
Ferritin, M (Q_1, Q_3)	322.00 (136.50, 858.00)	241.50 (108.25, 597.50)	426.00 (198.75, 1138.50)	<.001
Iron, M (Q_1, Q_3)	37.00 (20.00, 70.25)	36.00 (19.00, 68.50)	37.00 (22.25, 75.50)	0.521
Transferrin, M (Q_1, Q_3)	174.50 (132.75, 219.25)	183.00 (150.25, 227.50)	166.50 (116.50, 212.75)	<.001
Tibc, M (Q_1, Q_3)	227.00 (172.75, 285.25)	238.00 (195.25, 295.50)	216.50 (151.50, 276.75)	<.001
Tsat, M (Q_1, Q_3)	15.94 (9.35, 33.73)	15.09 (8.28, 26.92)	17.47 (9.72, 42.64)	0.017
Gender, n(%)				0.820
F	152 (36.54)	80 (36.04)	72 (37.11)	
M	264 (63.46)	142 (63.96)	122 (62.89)	
Hospital Mortality, n(%)				<.001
0	336 (80.77)	222 (100.00)	114 (58.76)	

1	80 (19.23)	0 (0.00)	80 (41.24)	
Mortality 28d, n(%)				<.001
0	335 (80.53)	222 (100.00)	113 (58.25)	
1	81 (19.47)	0 (0.00)	81 (41.75)	
Sirs, n(%)				0.150
1	3 (0.72)	1 (0.45)	2 (1.03)	
2	69 (16.59)	42 (18.92)	27 (13.92)	
3	168 (40.38)	95 (42.79)	73 (37.63)	
4	176 (42.31)	84 (37.84)	92 (47.42)	
Beta Blocker, n(%)				0.218
0	279 (67.07)	143 (64.41)	136 (70.10)	
1	137 (32.93)	79 (35.59)	58 (29.90)	
Loop Diuretic, n(%)				0.885
0	246 (59.13)	132 (59.46)	114 (58.76)	
1	170 (40.87)	90 (40.54)	80 (41.24)	
Acei, n(%)				0.013
0	390 (93.75)	202 (90.99)	188 (96.91)	
1	26 (6.25)	20 (9.01)	6 (3.09)	
Arb, n(%)				0.806
0	410 (98.56)	218 (98.20)	192 (98.97)	
1	6 (1.44)	4 (1.80)	2 (1.03)	
Copd, n(%)				0.134
0	274 (65.87)	139 (62.61)	135 (69.59)	
1	142 (34.13)	83 (37.39)	59 (30.41)	
Af, n(%)				0.048
0	261 (62.74)	149 (67.12)	112 (57.73)	
1	155 (37.26)	73 (32.88)	82 (42.27)	
Diabetes, n(%)				0.173
0	210 (50.48)	119 (53.60)	91 (46.91)	
1	206 (49.52)	103 (46.40)	103 (53.09)	
Ckd, n(%)				0.213
0	213 (51.20)	120 (54.05)	93 (47.94)	
1	203 (48.80)	102 (45.95)	101 (52.06)	

Table 2

ferritin						
Variables	Model1		Model2		Model3	
	HR (95% CI)	P-value	HR (95% CI)	P-value	HR (95% CI)	P-value
Continuous	1.00(1.00 ~ 1.00)	0.656	1.00(1.00 ~ 1.00)	0.439	1.00(1.00 ~ 1.00)	0.208
Quartile						
T1	Ref.		Ref.		Ref.	
T2	1.72(1.18 ~ 2.52)	0.005	1.80(1.23 ~ 2.64)	0.003	1.54(1.03 ~ 2.30)	0.036
T3	2.48(1.72 ~ 3.59)	<.001	2.76(1.90 ~ 4.00)	<.001	1.88(1.23 ~ 2.87)	0.004
transferrin						
Variables	Model1		Model2		Model3	
	HR (95% CI)	P-value	HR (95% CI)	P-value	HR (95% CI)	P-value
Continuous	0.99(0.99 ~ 0.99)	<.001	0.99(0.99 ~ 0.99)	<.001	0.99(0.99 ~ 0.99)	0.007
Quartile						
T1	Ref.		Ref.		Ref.	
T2	0.54(0.38 ~ 0.75)	<.001	0.52(0.37 ~ 0.73)	<.001	0.64(0.45 ~ 0.91)	0.013
T3	0.48(0.34 ~ 0.68)	<.001	0.47(0.33 ~ 0.67)	<.001	0.68(0.46 ~ 1.02)	0.062
tsat						
Variables	Model1		Model2		Model3	
	HR (95% CI)	P-value	HR (95% CI)	P-value	HR (95% CI)	P-value
Continuous	1.01(1.01 ~ 1.01)	<.001	1.01(1.01 ~ 1.01)	<.001	1.00(1.00 ~ 1.01)	0.191
Quartile						
T1	Ref.		Ref.		Ref.	
T2	1.24(0.87 ~ 1.78)	0.234	1.30(0.90 ~ 1.86)	0.159	1.61(1.11 ~ 2.34)	0.012
T3	1.59(1.11 ~ 2.26)	0.011	1.69(1.19 ~ 2.42)	0.004	1.60(1.10 ~ 2.34)	0.014

Model 1: UnadjustedModel 2: Adjusted for sex, age, and BMI.Model 3: Further adjusted for a prespecified set of covariates selected based on clinical relevance and their significant between-group differences at baseline: SBP, SAPSII, SOFA, APSIII, RBC, WBC, hemoglobin, Scr, BUN, ACEI, and AF (in addition to age, sex, and BMI from Model 2)

Table3

Ferritin

Variable	Subgroup	Patients (n, %)	Group 1 (Events/Total)	Group 2 (Events/Total)	HR (95% CI)	P-value	P for interaction	adjusted_p
All patients		416 (100.00)	48 / 153	146 / 263	2.26 (1.63 - 3.13)	<.001	--	
Gender	Female (F)	152 (36.54)	22 / 70	50 / 82	2.58 (1.56 - 4.26)	<.001	0.58	0.803
	Male (M)	264 (63.46)	26 / 83	96 / 181	2.13 (1.38 - 3.28)	<.001		
COPD	No (0)	274 (65.87)	28 / 97	107 / 177	2.90 (1.91 - 4.40)	<.001	0.042	0.166
	Yes (1)	142 (34.13)	20 / 56	39 / 86	1.41 (0.82 - 2.43)	0.208		
Atrial Fibrillation (Af)	No (0)	261 (62.74)	22 / 94	90 / 167	3.02 (1.89 - 4.81)	<.001	0.010	0.108
	Yes (1)	155 (37.26)	26 / 59	56 / 96	1.61 (1.01 - 2.56)	0.046		
Diabetes	No (0)	210 (50.48)	19 / 80	72 / 130	3.00 (1.81 - 4.97)	<.001	0.046	0.166
	Yes (1)	206 (49.52)	29 / 73	74 / 133	1.77 (1.15 - 2.71)	0.010		
Chronic Kidney Disease (Ckd)	No (0)	213 (51.20)	22 / 84	71 / 129	2.75 (1.71 - 4.45)	<.001	0.098	0.221
	Yes (1)	203 (48.80)	26 / 69	75 / 134	1.82 (1.17 - 2.85)	0.008		
Age (Median Split)	Younger Group (1)	208 (50.00)	16 / 69	65 / 139	2.47 (1.43 - 4.28)	0.001	0.857	0.951
	Older Group (2)	208 (50.00)	32 / 84	81 / 124	2.34 (1.55	<.001		

					- 3.53)			
Transferrin								
Variable	**Subgroup**	**Patients (n, %)**	**Group 1 (Events/Total)**	**Group 2 (Events/Total)**	**HR (95% CI)**	**P-value**	**P for interaction**	**adjusted_p**
All patients		416 (100.00)	71 / 103	123 / 313	0.41 (0.30 - 0.55)	<.001	--	
Gender	Female (F)	152 (36.54)	22 / 30	50 / 122	0.40 (0.24 - 0.66)	<.001	0.964	0.964
	Male (M)	264 (63.46)	49 / 73	73 / 191	0.41 (0.28 - 0.59)	<.001		
COPD	No (0)	274 (65.87)	52 / 71	83 / 203	0.38 (0.27 - 0.54)	<.001	0.563	0.803
	Yes (1)	142 (34.13)	19 / 32	40 / 110	0.48 (0.28 - 0.83)	0.008		
Atrial Fibrillation (Af)	No (0)	261 (62.74)	44 / 65	68 / 196	0.37 (0.25 - 0.54)	<.001	0.325	0.585
	Yes (1)	155 (37.26)	27 / 38	55 / 117	0.47 (0.29 - 0.74)	0.001		
Diabetes	No (0)	210 (50.48)	37 / 50	54 / 160	0.28 (0.19 - 0.43)	<.001	0.012	0.108
	Yes (1)	206 (49.52)	34 / 53	69 / 153	0.58 (0.38 - 0.87)	0.009		
Chronic Kidney Disease (Ckd)	No (0)	213 (51.20)	33 / 47	60 / 166	0.32 (0.21 - 0.50)	<.001	0.084	0.216
	Yes (1)	203 (48.80)	38 / 56	63 / 147	0.51 (0.34 - 0.77)	0.001		
Age (Median Split)	Younger Group (1)	208 (50.00)	28 / 48	53 / 160	0.43 (0.27 - 0.68)	<.001	0.778	0.934

	Older Group (2)	208 (50.00)	43 / 55	70 / 153	0.39 (0.27 - 0.58)	<.001		
TSAT								
Variable	**Subgroup**	**Patients (n, %)**	**Group 1 (Events/Total)**	**Group 2 (Events/Total)**	**HR (95% CI)**	**P-value**	**P for interaction**	**adjusted_p**
All patients		416 (100.00)	141 / 333	53 / 83	1.96 (1.42 - 2.68)	<.001	--	
Gender	Female (F)	152 (36.54)	53 / 122	19 / 30	2.00 (1.18 - 3.37)	0.01	0.898	0.951
	Male (M)	264 (63.46)	88 / 211	34 / 53	1.93 (1.30 - 2.87)	0.001		
COPD	No (0)	274 (65.87)	97 / 220	38 / 54	2.25 (1.55 - 3.28)	<.001	0.249	0.498
	Yes (1)	142 (34.13)	44 / 113	15 / 29	1.49 (0.83 - 2.68)	0.181		
Atrial Fibrillation (Af)	No (0)	261 (62.74)	78 / 205	34 / 56	2.09 (1.40 - 3.13)	<.001	0.566	0.803
	Yes (1)	155 (37.26)	63 / 128	19 / 27	1.81 (1.08 - 3.02)	0.024		
Diabetes	No (0)	210 (50.48)	61 / 166	30 / 44	2.57 (1.66 - 3.99)	<.001	0.069	0.207
	Yes (1)	206 (49.52)	80 / 167	23 / 39	1.46 (0.92 - 2.32)	0.109		
Chronic Kidney Disease (Ckd)	No (0)	213 (51.20)	63 / 169	30 / 44	2.71 (1.75 - 4.20)	<.001	0.027	0.162
	Yes (1)	203 (48.80)	78 / 164	23 / 39	1.37 (0.86 - 2.18)	0.185		
Age (Median	Younger Group (1)	208 (50.00)	56 / 164	25 / 44	2.11 (1.32	0.002	0.741	0.934

Split)				- 3.39)	
	Older Group (2)	208 (50.00)	85 / 169	28 / 39	1.92 (1.25 - 2.95)	0.003

P-values for interaction are nominal and unadjusted. BH-adjusted P: Benjamini–Hochberg false discovery rate adjusted P-value for 18 tests (6 subgroups × 3 markers). After correction, none of the interaction P-values remained significant at an FDR threshold of <0.05. Subgroup findings should be interpreted as hypothesis-generating.

Figures

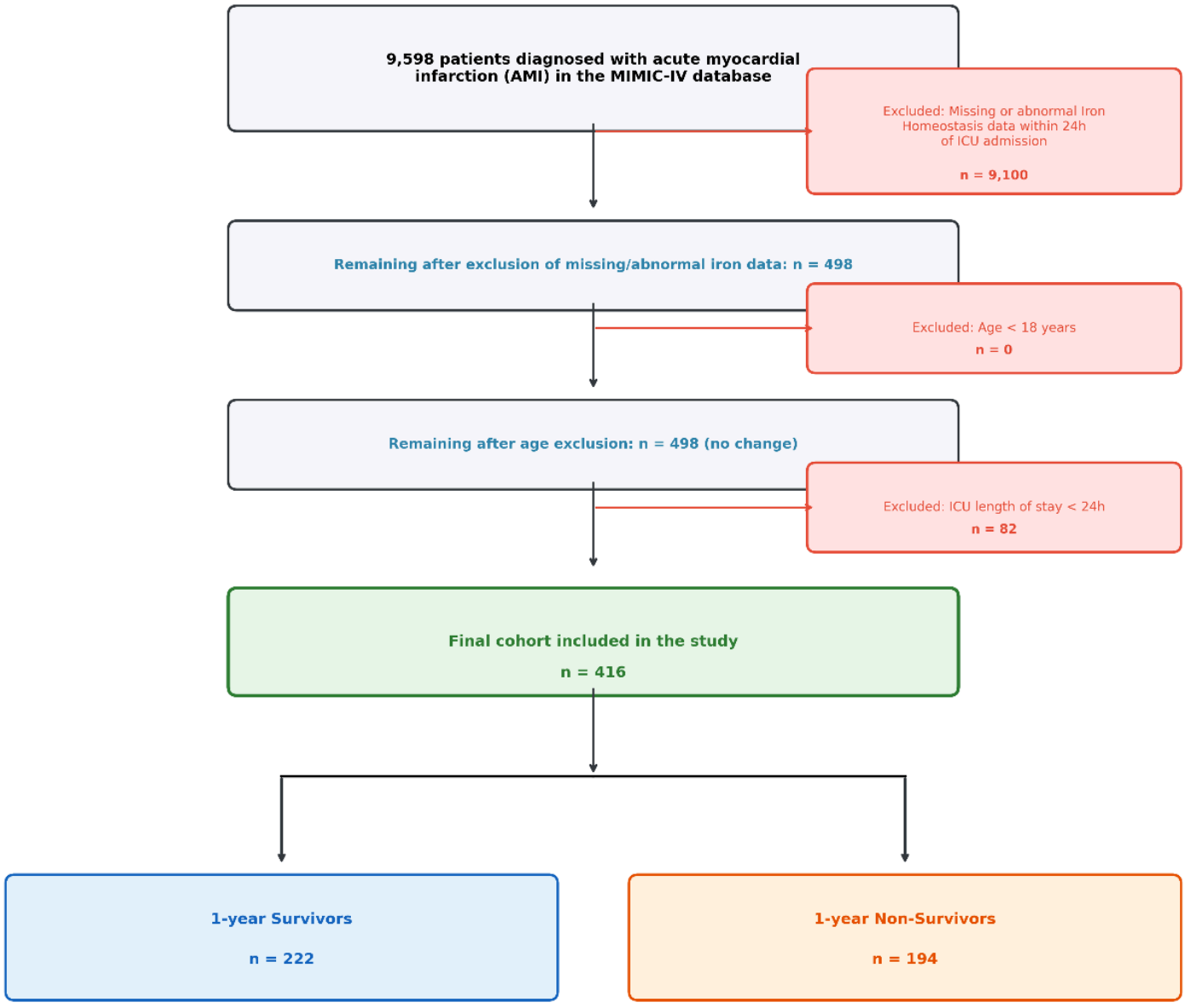


Figure 1

Legend not included with this version.

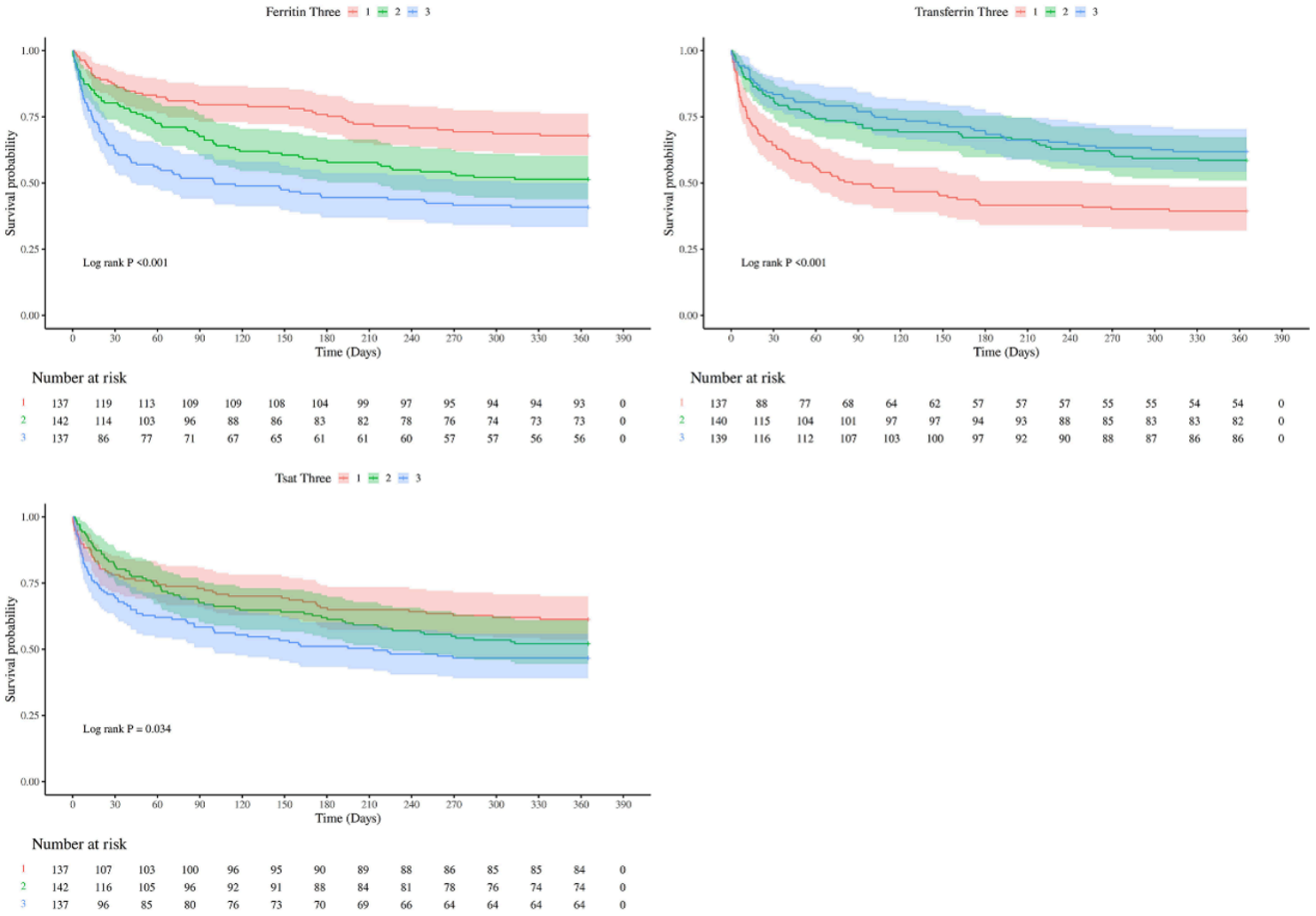


Figure 2

Survival analysis curves for 1-year mortality in patients with acute myocardial infarction: 1. Ferritin 2. Transferrin 3. Total Iron-Binding Capacity (TIBC)

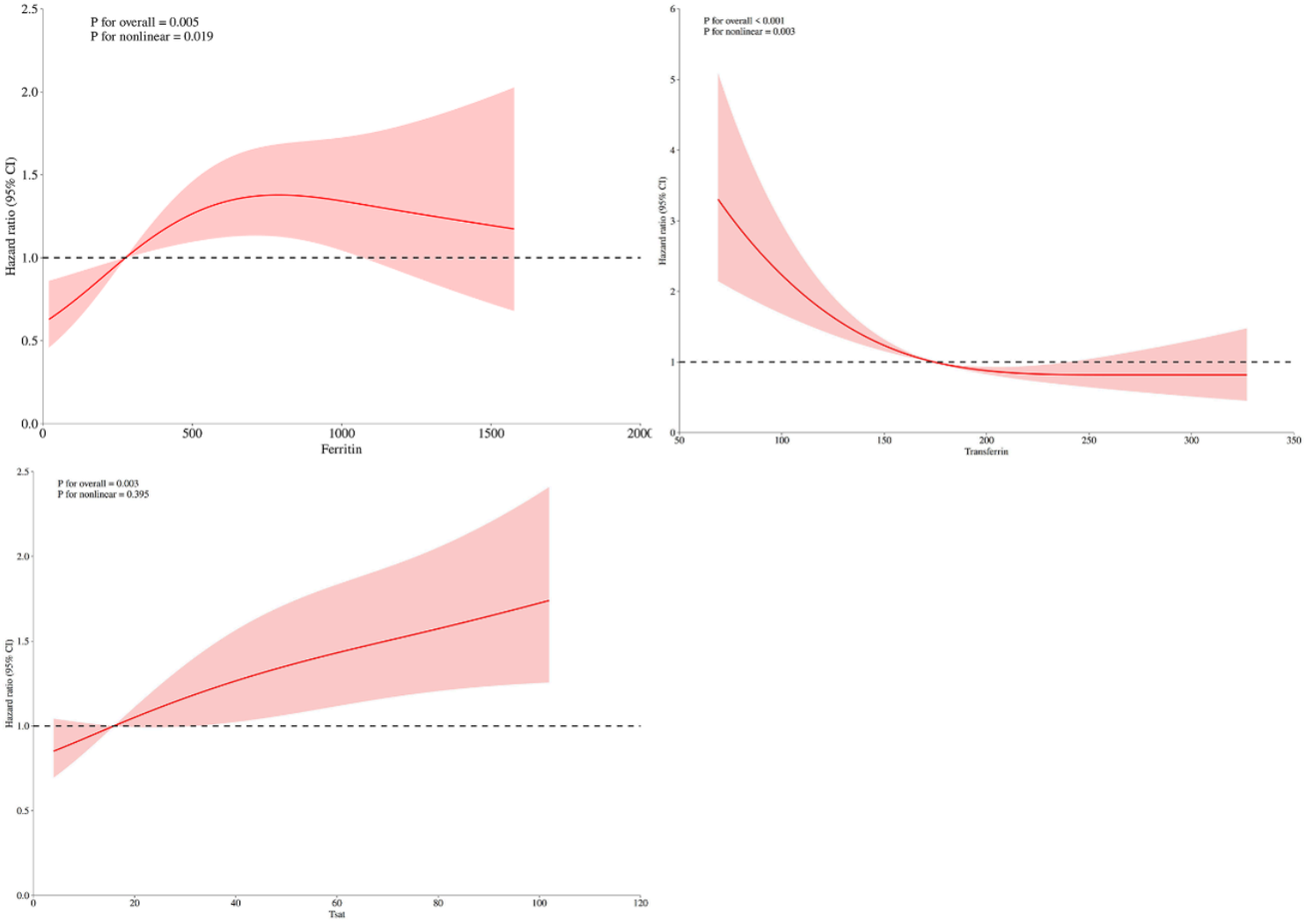
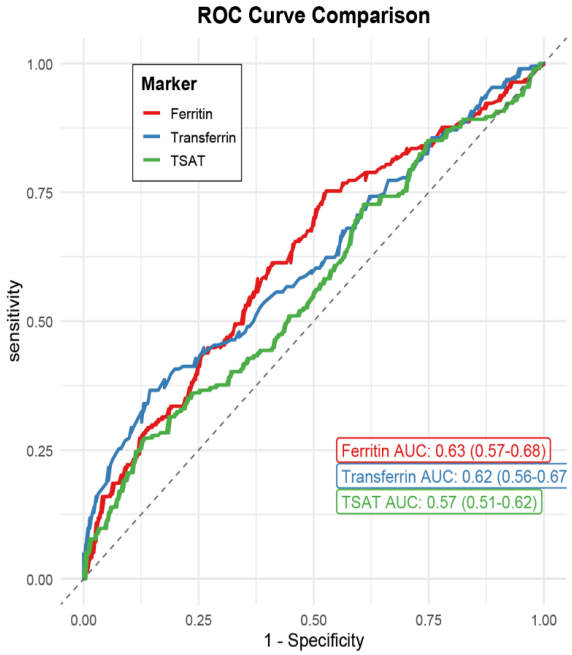


Figure 3

Restricted cubic spline regression analysis of: 1. Ferritin 2. Transferrin 3. Transferrin Saturation



Comparison	p_value
Ferritin vs Transferrin	p = 0.670
Ferritin vs TSAT	p = 0.068
Transferrin vs TSAT	p = 0.157

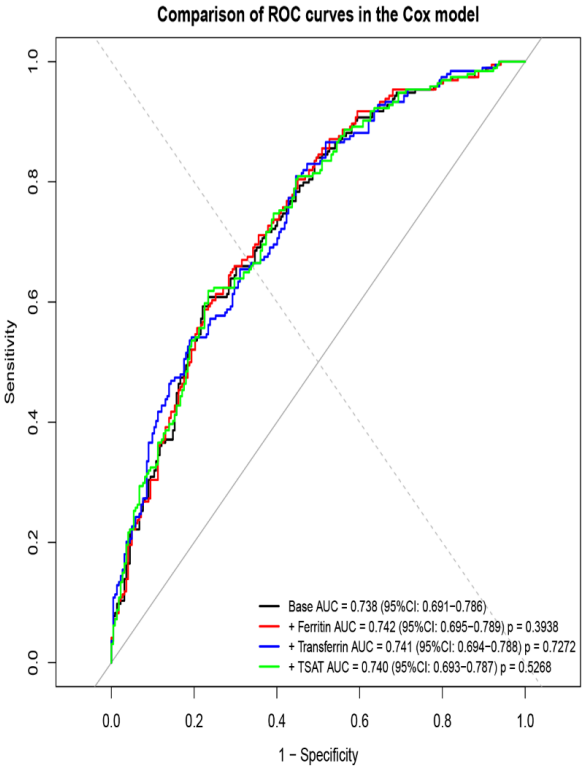


Figure 4

1: Comparison of ferritin, transferrin, and transferrin saturation in predicting 1-year mortality.

2: Comparison between the base risk model and the base risk model with the addition of ferritin/transferrin/transferrin saturation.

The base risk model includes: age, SBP, SAPSII, SOFA, APSIII, RBC, WBC, hemoglobin, SCr, BUN, ACEI, AF.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTable.docx
- SupplementaryFigure1.docx