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Original Article

Predictors of 90-day Readmission After Hospitalization in Heart Failure with Reduced Ejection Fraction Patients: A Single-Centre Analytical Cohort Retrospective Study

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Abstract

Background: Heart failure with Reduced Ejection Fraction (HFrEF) is a chronic condition frequently associated with recurrent hospitalizations. These readmissions compromise patient outcomes and impose significant burdens on healthcare systems. Identifying high-risk HFrEF patients enables treatment optimization. This single-center analytical study investigates predictors of 90-day readmission after hospitalization in HFrEF patients.

Methods: This retrospective cohort study enrolled patients with Left Ventricular Ejection Fraction (LVEF) ≤40% who were admitted to the Cardiology Department Emergency Room at Adam Malik General Hospital for Acute Decompensated Heart Failure (ADHF) from January 2023 to January 2025 using consecutive sampling, followed for 90 days post-discharge. Statistical analyses included Mann-Whitney U, independent t-tests, chi-square, and backward stepwise multivariate logistic regression.

Results: Of 180 patients (71 rehospitalized, 109 non-rehospitalized), multivariate analysis identified five independent predictors of 90-day readmission: Length of Stay (LOS) >7 days (p<0.001, OR 7.854, 95% CI 3.216-19.179), prior Chronic Kidney Disease (CKD) (p=0.008, OR 3.989, 95% CI 1.430-11.131), lower LVEF (p<0.001, OR 0.844, 95% CI 0.777-0.916), Sodium-Glucose Co-Transporter 2 (SGLT2) inhibitor non-use (p=0.006, OR 0.116, 95% CI 0.025-0.544), and lower admission Hemoglobin (Hb) (p=0.028, OR 0.803, 95% CI 0.661-0.976). Kaplan-Meier analysis revealed significant differences in 90-day rehospitalization-free survival across clinical subgroups. Rehospitalized patients had a median survival of 42 days versus 72 days for non-rehospitalized patients (log-rank p<0.001). SGLT2 inhibitor users during index hospitalization showed the strongest curve separation despite a small sample (n=4 vs n=15; log-rank p=0.002), while prolonged LOS >7 days, CKD, and anemia independently predicted worse outcomes (all log-rank p<0.001).

Conclusions: In HFrEF patients, longer LOS >7 days, prior CKD, lower LVEF, lower admission Hb, and lack of inpatient SGLT2 inhibitor use independently predicted 90-day readmission.

Keywords: Predictors, Readmission, Acute Decompensated Heart Failure, HFrEF, SGLT2 Inhibitors

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Introduction

Heart Failure (HF) is a clinical syndrome resulting from structural and/or functional cardiac abnormalities leading to elevated intracardiac pressures and/or inadequate cardiac output at rest and/or during exercise.[1] HF remains a growing global public health challenge. In 2019, approximately 56.19 million people worldwide had HF (Age-Standardized Rate [ASR]: 711.90 per 100,000 population), with Southeast Asia ASR rising from 729.15 to 755.95 per 100,000 and Indonesia from 835.45 to 900.90 per 100,000 between 1990-2019.[2-3]

HF represents the end-stage of various cardiovascular diseases and ranks among leading causes of hospitalization worldwide. Prognosis remains poor, with 5-10% in-hospital mortality, ~15% mortality within 3 months post-discharge, and >50% within 5 years. Readmissions affect 83% of patients (≥1 readmission) and 43% (≥4 readmissions), particularly within 30 days (~25%) extending to 90 days (~31%).[6-10]

Traditionally, HF phenotypes are classified by Left Ventricular Ejection Fraction (LVEF). Heart failure with Reduced Ejection Fraction (HFrEF) is defined as LVEF ≤40%.[1] Epidemiologically, patients with HFrEF experience substantially higher rates of early rehospitalization. The Atherosclerosis Risk in Communities (ARIC) study showed HFrEF survivors of Acute Decompensated Heart Failure (ADHF) had higher 90-day readmission rates vs. preserved EF, with ~28% experiencing HF readmission or death.[11] Other studies show that among 1224 patients with HFrEF, approximately 28% experience either readmission for HF or death within 90 days post discharge.[12]

HF readmissions impose substantial economic burdens on healthcare systems and patients. This single-center analytical study investigates predictors of 90-day readmission following ADHF hospitalization in HFrEF patients (LVEF ≤40%). Early identification of high-risk individuals with acute HF may facilitate timely optimization of therapy and help mitigate the associated financial burden.[13] This single-center analytical study investigates the predictors of 90-day readmission after hospitalization in HFrEF patients.

Methods

Study Design and Participants

This retrospective cohort study defined rehospitalization as worsening HF requiring inpatient treatment. It aimed to identify predictors of 90-day readmission in patients with ADHF and LVEF ≤40%. The study was conducted at the Integrated Heart Center, Haji Adam Malik General Hospital, Medan, Indonesia.

The data were obtained from the medical records of patients with ADHF (LVEF ≤40%) admitted to the Emergency Department between January 2023 and January 2025, with 90-day follow-up post-discharge. Consecutive sampling enrolled all eligible patients. Inclusion criteria were age ≥18 years, ADHF diagnosis with LVEF ≤40%, and complete hospitalization data. Exclusion criteria included: loss to follow-up, estimated Glomerular Filtration Rate (eGFR) <30 mL/min/1.73 m², elective readmissions, and discharge against medical advice. The final cohort comprised 180 patients.

Data Collection

All research samples in this study were patients with ADHF (LVEF ≤40%) who met the inclusion and exclusion criteria. The data were collected by Yuke Sarasti, MD, FIHA, and the Research Assistant Medical Doctor. Data were gathered from electronic medical records of each patient and compiled in Microsoft Excel. The collected data in Microsoft Excel were then analyzed using the SPSS application Data were collected from the medical records, including demographic data; age and gender, medical history; Diabetes Mellitus Type 2 (DMT2), Hypertension (HT), Chronic Kidney Disease (CKD), and Coronary Artery Disease (CAD) , clinical presentation; New York Heart Association (NYHA) class at admission, physical examination; Systolic Blood Pressure (SBP) at admission, Diastolic Blood Pressure (DBP) at admission, Heart Rate (HR) at admission, echocardiographic examination; LVEF, laboratory tests; Hemoglobin (Hb) at admission, serum urea at admission, serum creatinine at admission, e-GFR at admission, serum sodium at admission, serum potassium at admission, and therapy administration; Angiotensin Receptor Neprilysin Inhibitor (ARNI), Angiotensin Converting Enzyme-Inhibitor (ACE-I), Angiotensin Receptor Blocker (ARB), Beta Blocker (BB), Mineralocorticoid Receptor Antagonist (MRA), Sodium-Glucose co-Transporter 2 (SGLT2) Inhibitor . Patients were followed for 90 days follow-up after discharge.

Outcome

Patients who were enrolled in the study were monitored through the HF clinic. The outcome for this investigation was the status of all-cause rehospitalization (rehospitalization or non-

rehospitalization). Data on rehospitalizations were primarily collected via phone calls with the patients or their family members if patients were not admitted to our hospital or were missing outpatient department visits.

Statistical Analysis

The collected data will be analyzed using SPSS version 26. Univariate analysis will be used to describe the general characteristics of the study subjects. Categorical variables will be presented as frequency distributions and percentages. Numerical variables will be presented as mean ± standard deviation (SD). Bivariate analysis will be conducted to examine the relationship between the two main variables. Chi-square or Fisher's exact tests will be used to analyze the relationship between two categorical variables. Independent-samples t-test or Mann-Whitney test will be used to analyze the relationship between two numerical variables. Variables with a p-value < 0.25 in the bivariate analysis were included in the multivariate analysis using multiple logistic regression tests. An independent variable is considered significantly associated with the dependent variable if the p-value < 0.05 in the multivariate analysis.

Results

Study Population and Eligibility Pathway (first paragraph now describes total patients screened, inclusion/exclusion criteria application, final cohort of 180 patients, and flowchart reference to Figure 1). Baseline Characteristics (subsequently describes demographic, clinical, laboratory, and treatment differences between rehospitalized vs. non-rehospitalized groups as shown in Table 1).

In Table 1, a total of 180 patients were included, divided into two groups: those who were not re-hospitalized (n=109) and those who were re-hospitalized (n=71). A flowchart describing the eligibility pathway in our study was provided in Figure 1. In Table 1, there were no significant differences between the two groups in terms of age (58.10 ± 10.49 vs. 58.25 ± 10.34 years; p = 0.925) or sex distribution (male: 76.1% vs. 80.7%; female: 23.9% vs 19.3%; p = 0.452). Similarly, the New York Heart Association (NYHA) functional class at admission did not differ significantly between the groups (p = 0.576).

Regarding comorbidities, the prevalence of DMT2 was comparable between the re-hospitalized and non-re-hospitalized groups (56.3% vs. 52.3%; p = 0.595), indicating no significant association with rehospitalization. In contrast, CKD was significantly more common among re-hospitalized patients (40.8% vs. 9.2%; p < 0.001). The presence of HT and CAD showed no statistically significant difference between the two groups (p = 0.647 and p = 0.343, respectively). Patients with Length of Stay (LOS) more than seven days were more likely to be re-hospitalized (57.7% vs. 12.8%; p < 0.001).

In terms of vital signs at admission, there were no significant differences between the two groups in SBP (122.83 ± 26.45 vs. 124.41 ± 25.60 mmHg; p = 0.550), DBP (73.70 ± 14.26 vs. 77.87 ± 16.48

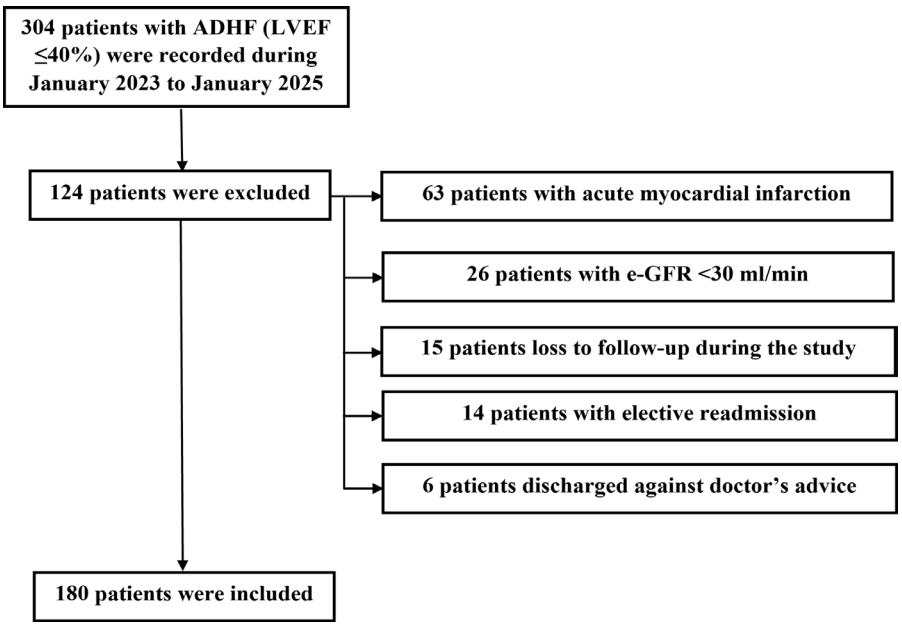


Figure 1. Flowchart of patient selection.

Table 1. Baseline characteristics and bivariate analysis.

Characteristics	Rehospitalization (n = 71)	Non-Rehospitalization (n = 109)	P-value
Age (mean±SD)	58.10±10.49	58.25±10.34	0.925
Gender, n (%)			
Male	54 (76.1)	88 (80.7)	0.452
Female	17 (23.9)	21 (19.3)	
NYHA class at admission, n (%)			
NYHA III	42 (59.2)	69 (63.3)	0.576
NYHA IV	29 (40.8)	40 (36.7)	
LOS >7 days, n (%)	41 (57.7)	14 (12.8)	0.000*
DMT2, n (%)	40 (56.3)	57 (52.3)	0.595
HT, n (%)	34 (47.9)	56 (51.4)	0.647
CKD, n (%)	29 (40.8)	10 (9.2)	0.000*
CAD, n (%)	56 (78.9)	92 (84.4)	0.343
SBP at admission (mean±SD)	122.83±26.45	124.41±25.60	0.550
DBP at admission (mean±SD)	73.70±14.26	77.87±16.48	0.126
HR at admission (mean±SD)	88.01±22.66	87.63±20.83	0.929
Hb at admission (mean±SD)	11.85±2.18	13.06±2.04	0.000*
Serum urea at admission (mean±SD)	73.13±48.02	52.52±31.42	0.013*
Serum creatinine at admission (mean±SD)	1.68±0.86	1.34±0.52	0.026*
e-GFR <60 ml/min/1.73 m2 at admission, n (%)	45 (63.4)	46 (42.2)	0.005*
Serum sodium at admission (mean±SD)	139.68±6.23	141.56±5.45	0.041*
Serum potassium at admission (mean±SD)	3.71±0.33	3.74±0.34	0.939
LVEF (mean±SD)	26.13±5.99	30.75±5.36	0.000*
ARNI, n (%)	16 (22.5)	22 (20.2)	0.706
ACE-I, n (%)	32 (45.1)	62 (56.9)	0.121
ARB, n (%)	21 (29.6)	23 (21.1)	0.196
BB, n (%)	57 (80.3)	92 (84.4)	0.474
MRA, n (%)	61 (85.9)	99 (90.8)	0.306
SGLT2-I, n (%)	4 (5.6)	15 (13.8)	0.006*

Note: NYHA, New York Heart Association; LOS, Length Of Stay; DMT2, Diabetes Mellitus Type 2; HT, Hypertension; CKD, Chronic Kidney Disease; CAD, Coronary Artery Disease; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; HR, Heart Rate; Hb, Hemoglobin; e-GFR, estimated-Glomerular Filtration Rate; LVEF, Left Ventricular Ejection Fraction, ARNI, Angiotensin Receptor–Neprilysin Inhibitors; ACE-I, Angiotensin Converting Enzyme Inhibitor; ARB, Angiotensin Receptor Blocker; BB, Beta Blocker; MRA, Mineralocorticoid Receptor Antagonist; SGLT2-I, Sodium-Glucose cotransporter 2 Inhibitor

mmHg; p = 0.126), or HR (88.01 ± 22.66 vs. 87.63 ± 20.83 bpm; p = 0.929).

Laboratory findings revealed that re-hospitalized patients had lower Hb concentrations (11.85 ± 2.18 mg/dL vs. 13.06 ± 2.04 mg/dL; p < 0.001), higher serum urea (73.13 ± 48.02 mg/dL vs. 52.52 ± 31.42 mg/dL; p = 0.013), and higher serum creatinine (1.68 ± 0.86 mg/dL vs. 1.34 ± 0.52 mg/dL; p = 0.026). Consistent with these renal findings, reduced eGFR (eGFR < 60 mL/min/1.73 m^2) was more prevalent among re-hospitalized patients (63.4% vs. 42.2%; p = 0.005). Serum sodium levels were also significantly lower in the re-hospitalized group (139.68 ± 6.23 mEq/L vs. 141.56 ± 5.45 mEq/L; p = 0.041), whereas serum potassium levels were similar (3.71±0.33 mEq/L vs. 3.74±0.34; p = 0.939).

The LVEF was markedly reduced in re-hospitalized patients (26.13 ± 5.99% vs. 30.75 ± 5.36%; p < 0.001), indicating more severe cardiac dysfunction.

Regarding pharmacological treatment, there were no significant differences between groups in the use of ARNIs, angiotensin-converting enzyme inhibitors (ACEIs), ARBs, beta-blockers, or MRAs.

However, the use of an SGLT2 inhibitor was significantly lower among re-hospitalized patients (5.6% vs. 13.8%; p = 0.006).

Multivariate analysis was used in this study to determine which independent variables influence the dependent variable and to identify the most dominant independent variable in predicting rehospitalization in patients with ADHF (LVEF ≤40%). The type of multivariate analysis used was multiple logistic regression because the dependent variable in this study is categorical. The multiple logistic regression analysis in this study used the backward (conditional) method. The backward (conditional) method is one approach in multiple logistic regression analysis, where all independent variables that meet the criteria (p-value < 0.25 in the bivariate analysis) are included in the multivariate model. Then, independent variables with the highest p-value > 0.05 are manually removed one by one through several selection stages.

In Table 2, the final multivariate analysis results identified five independent variables significantly associated with 90-day rehospitalization risk in ADHF patients (LVEF ≤40%). LOS >7 days (OR: 7.854; 95% CI: 3.216–19.179; p<0.001) and CKD (OR: 3.989; 95% CI: 1.430–11.131; p=0.008) independently increased the risk of rehospitalization. Conversely, higher Hb levels (OR: 0.803; 95% CI: 0.661–0.976; p=0.028), greater LVEF at index admission (OR: 0.844; 95% CI: 0.777–0.916; p<0.001), and SGLT2 inhibitor use during admission (OR: 0.116; 95% CI: 0.025–0.544; p=0.006) were independently associated with reduced risk of readmission at 90 days post-discharge.

Table 2. Multivariate analysis of factors influencing rehospitalization.

Variable	OR (95%CI)	P-value
LOS >7 days	7.854 (3.216 – 19.179)	0.000
CKD	3.989 (1.430 – 11.131)	0.008
Hb at admission	0.803 (0.661 – 0.976)	0.028
LVEF	0.844 (0.777 – 0.916)	0.000
SGLT2-I	0.116 (0.025 – 0.544)	0.006

Note: LOS, Length Of Stay; CKD, Chronic Kidney Disease; Hb, Hemoglobin; LVEF; Left Ventricular Ejection Fraction; SGLT2-I, Sodium-Glucose co-transporter 2 Inhibitor.

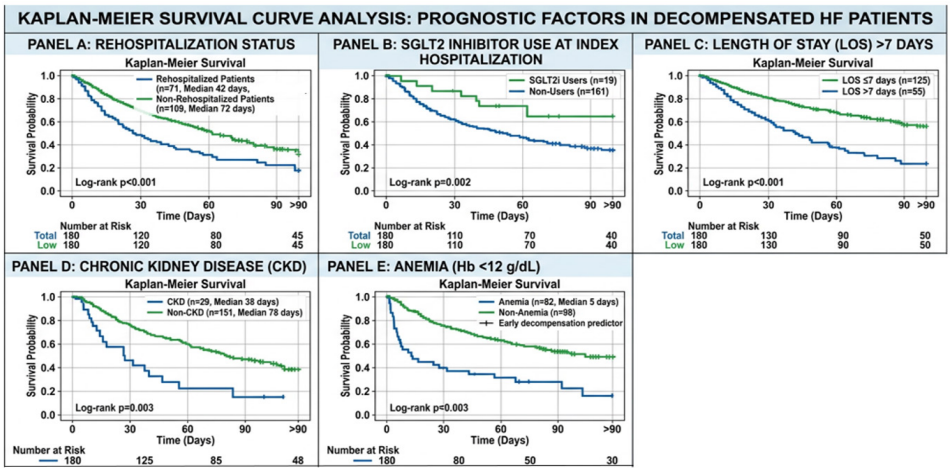


Figure 2. Kaplan–meier survival curve care analysis, prognostic factors in decompensated HF patients. Panel A showed rehospitalized patients (n=71) had a median survival of 42 days (95% CI: 35-55 days) versus 72 days for non-rehospitalized patients (n=109; log-rank p<0.001), with numbers at risk declining from 180 at baseline to 45 at day 90. Panel B revealed the strongest curve separation among SGLT2i users during index hospitalization (n=19) versus non-users (n=161; log-rank p=0.002), confirming the strong protective effect of inpatient SGLT2i initiation despite the small sample size. Panel C demonstrated significant divergence after day 30 between patients with length of stay (LOS) ≤7 days (n=125) versus >7 days (n=55; log-rank p<0.001). Panel D highlighted poor prognosis in CKD patients (n=29, median 38 days) compared to non-CKD (n=151, median 78 days; log-rank p=0.003), Panel E depicted anemia (Hb <12 mg/dL; n=82, median 5 days) versus non-anemia (n=98) as a strong predictor of early decompensation through tissue hypoxia.

Discussion

This study identified five independent predictors of 90-day readmission in patients hospitalized for ADHF with LVEF ≤40%: longer LOS (LOS >7 days), pre-existing CKD, anemia (low Hb), reduced LVEF, and non-use of SGLT2 inhibitors during hospitalization.

Longer LOS strongly predicted readmission, consistent with large studies by Samsky et al. (>3 million HF patients), Sud et al. (58,230 patients), and Omar et al. Prolonged hospitalization rarely occurs in isolation but serves as a proxy marker for complex clinical scenarios—severe initial decompensation, poor diuretic response, or undiagnosed comorbidities. These patients are often discharged with residual congestion, creating a high-risk window for early rehospitalization.[14-16]

Pre-existing CKD independently increased readmission risk, corroborated by Lawson et al. (ASIAN-HF registry), Swindle et al. (126,214 patients), and Saito's meta-analysis. This reflects cardiorenal syndrome pathophysiology: CKD impairs diuretic efficacy during admission (persistent congestion), and post-discharge fluid/electrolyte imbalances rapidly precipitate HF decompensation. Indonesian studies confirm this relationship in local HFrEF populations.[17-19]

Anemia predicted readmission, aligning with Ye et al. (3,335 AHF patients), Kajimoto et al. (4,842 ADHF patients), and Al-Tamimi et al. Beyond reduced oxygen delivery, anemia increases cardiac workload (tachycardia, higher myocardial O_2 demand) in low-LVEF hearts and signals iron deficiency, impairing myocardial energetics. A 2023 American Heart Association (AHA) study confirms Hb as an independent early readmission predictor.[20-22]

Lower admission LVEF predicted readmission, supported by Schjødt's systematic review, Lim et al. (4,566 patients), and Bhosale et al. Very low LVEF indicates limited cardiac reserve—even minor stressors (infection, salt excess, medication non-adherence) overwhelm the damaged myocardium, triggering recurrent acute HF.[23-25]

Despite guideline recommendations, only 9.3% (15/180) received an SGLT2 inhibitor inpatient, reflecting implementation gaps. Non-use strongly predicted readmission, corroborated by Cherbi's meta-analysis (27% HF rehospitalization reduction), SOLOIST-WHF, and EMPULSE trials. Mechanisms: rapid natriuresis, hemodynamic stabilization, cardioprotective effects, and adherence establishment under monitoring. Inpatient initiation yields superior outcomes vs. post-discharge start.[26-27] These predictors form an interconnected risk profile. Prolonged LOS and CKD reflect admission severity and decongestion failure; low LVEF/anemia indicate limited physiological reserve; SGLT2 inhibitor non-use represents modifiable treatment gaps. Routine inpatient risk stratification using these factors could optimize discharge planning and guideline-directed medical therapy implementation.[28]

Conclusion

Several parameters, including reduced Hb concentration, presence of CKD, extended length of hospital stay, markedly decreased ejection fraction, and not taking an SGLT2 inhibitor during hospitalization, have been identified as predictors of unfavorable outcomes following an initial hospitalization for ADHF with LVEF ≤40%. Recognition of these factors may facilitate the identification of high-risk patients who warrant more comprehensive, individualized therapeutic strategies and rigorous post-discharge monitoring.

List of Abbreviations

ACE-I	Angiotensin Converting Enzyme-Inhibitor
ADHF	Acute Decompensated Heart Failure
AHA	American Heart Association
ARB	Angiotensin Receptor Blocker
ARIC	Atherosclerosis Risk in Communities
ARNI	Angiotensin Receptor Neprilysin Inhibitor
ASR	Age-Standardized Rate
BB	Beta Blocker
CAD	Coronary Artery Disease
CKD	Chronic Kidney Disease
DBP	Diastolic Blood Pressure
DMT2	Diabetes Mellitus Type 2
eGFR	estimated Glomerular Filtration Rate
Hb	Hemoglobin
HF	Heart Failure
HFrEF	Heart failure with Reduced Ejection Fraction
HR	Heart Rate
HT	Hypertension
LOS	Length of Stay
LVEF	Left Ventricular Ejection Fraction
MRA	Mineralocorticoid Receptor Antagonist
NYHA	New York Heart Association
SBP	Systolic Blood Pressure
SGLT2	Sodium-Glucose Co-Transporter 2

Ethical Clearance

The study protocols were conducted in accordance with the Declaration of Helsinki and were approved by the Institutional Review Board, Universitas Prima Indonesia, Medan, Indonesia (No: 028/KEPK/UNPRI/XI/2025).

Publication Approval

We hereby consent to the publication of this manuscript titled "Predictors of 90-day Readmission After Hospitalization in Heart Failure with Reduced Ejection Fraction Patients: A Single-Centre Analytical Cohort Retrospective Study" in the Indonesian Journal of Cardiology.

Authors' Contributions

All authors read and approved the final manuscript. Conception and Design: AAR; Analysis and Interpretation of Data: AAR; Final Approval of the version to be published: YS.

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None.

Conflict of Interest

None.

Availability of Data and Materials

Data used in our study were presented in the main text. The data are publicly available.

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Not applicable.

Generative AI and AI-Assisted Technologies in the Writing Process

Authors acknowledge that artificial intelligence (AI) tools were only used to assist in language editing and did not generate or alter the scientific content, analyses, or conclusions presented in this manuscript.

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