

# RISK FACTORS ASSOCIATED WITH LENGTH OF STAY IN PATIENTS WITH HEART FAILURE WITH REDUCED EJECTION FRACTION AT WALED REGIONAL HOSPITAL

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## Abstract

Heart failure with reduced ejection fraction (HFrEF) is a major cause of hospitalization, and prolonged length of stay (LOS) reflects clinical severity, resource use, and quality of care. This study analyzed factors associated with LOS among patients with HFrEF at Waled Regional Hospital, Cirebon Regency. A retrospective analytical observational study with a cross-sectional approach used medical-record data from January 2024 to December 2025. Total sampling yielded 150 eligible patients. Univariable analysis described patient characteristics; independent t-tests and one-way analysis of variance assessed bivariate associations; and a generalized linear model evaluated independent factors. Mean LOS was 4.24 days (range, 2-9 days). Blood pressure, arrhythmia, valvular heart disease, diabetes mellitus, renal dysfunction, anemia, hyponatremia, chronic obstructive pulmonary disease, and infection were associated with LOS in bivariate analyses ( $p < 0.05$ ), whereas age, sex, coronary artery disease, and potassium status were not. After multivariable adjustment, blood pressure categories, valvular heart disease, and infection remained independently associated with LOS. Early hemodynamic stabilization, prompt recognition of valvular disease, and rapid infection management may help reduce hospitalization duration in patients with HFrEF.

**Keywords:** Anemia; Heart Failure With Reduced Ejection Fraction; Infection; Length Of Stay; Valvular Heart Disease

## INTRODUCTION

Heart failure is a complex clinical syndrome caused by structural or functional cardiac abnormalities that impair ventricular filling or the ability of the heart to eject blood. Contemporary classifications use left ventricular ejection fraction to distinguish heart failure with reduced ejection fraction (HFrEF;  $\leq 40\%$ ), mildly reduced ejection fraction, preserved ejection fraction, and improved ejection fraction. This classification is clinically important because etiology, therapeutic response, risk of hospitalization, and prognosis vary across phenotypes (Heidenreich et al., 2022; Bozkurt et al., 2021). HFrEF represents a particularly high-burden phenotype. Coronary artery disease, older age, male sex, diabetes mellitus, smoking, elevated systolic blood pressure, increased body mass index, and impaired renal function contribute to its development (Gaziano et al., 2021). Beyond reduced pump function, myocardial inflammation, fibrosis, ventricular dilatation, and maladaptive remodeling progressively decrease contractility and cardiac output (Alcaide et al., 2024). These mechanisms predispose patients to congestion, hemodynamic instability, multiorgan dysfunction, repeated hospitalization, and death.

The global burden of heart failure continues to rise. Reviews based on international datasets describe substantial growth in prevalence during the last three decades, while cardiovascular disease remains a leading cause of mortality worldwide (World Health Organization, 2025; Ran et al., 2025; Savarese et al., 2022). In Indonesia, the 2023 Indonesian Health Survey reported that physician-diagnosed heart disease remains an important public-health problem, with notable variation across provinces and a substantial burden in West Java (Ministry of Health of the Republic of Indonesia, 2023). Length of stay (LOS) is the number of days between hospital admission and discharge within one episode of care. In heart failure, LOS is more than an administrative measure: it reflects disease severity, complications, treatment response, discharge readiness, bed utilization, and cost. Prolonged hospitalization has been associated with treatment interruption, high natriuretic peptide levels,

renal impairment, low systolic blood pressure, severe tricuspid regurgitation, and a larger comorbidity burden (Ignatavičiūtė et al., 2023; Tekle et al., 2022). Hospital expenditure also rises as LOS increases, and the cost of inpatient heart-failure treatment may exceed reimbursement in longer admissions (Hadning & Kubra, 2025).

Clinical pathways in Indonesia target efficient and standardized heart-failure management, with an optimal hospitalization duration of less than seven days when clinically appropriate (Indonesian Heart Association, 2016). However, the factors that lengthen admission are heterogeneous. They include hemodynamic status, arrhythmia, valvular disease, ischemic heart disease, diabetes, renal dysfunction, anemia, electrolyte disturbances, chronic obstructive pulmonary disease (COPD), and infection. These factors may operate independently or interact through congestion, neurohormonal activation, impaired oxygen delivery, inflammatory responses, and reduced organ reserve.

Evidence on LOS has largely originated from multicenter registries and hospitals outside Cirebon. Local case-mix, referral patterns, access to diagnostic services, and hospital management may modify the relative importance of each risk factor. The present study therefore aimed to analyze demographic and clinical factors associated with LOS among patients with HFrEF admitted to Waled Regional Hospital, Cirebon Regency, during January 2024–December 2025. The study also evaluated which factors remained independently associated with LOS after simultaneous adjustment.

## **LITERATURE REVIEW**

### **HFrEF and the Mechanisms of Prolonged Hospitalization**

HFrEF is characterized by impaired systolic performance and a left ventricular ejection fraction of 40% or less. Reduced forward flow activates the sympathetic nervous system and the renin-angiotensin-aldosterone system, producing vasoconstriction, sodium and water retention, and increased cardiac workload. Persistent activation promotes ventricular remodeling and congestion. During acute decompensation, stabilization may require intravenous diuretics, vasodilators, oxygen therapy, correction of precipitating factors, and careful titration of guideline-directed treatment; the time needed for these processes directly affects LOS (McDonagh et al., 2021; McDonagh et al., 2023).

Hospitalization duration also reflects the interaction between cardiac dysfunction and noncardiac disease. Patients with multiple comorbidities require more diagnostic evaluation, closer monitoring, treatment of competing conditions, and more complex discharge planning. Murru et al. (2025) reported that patterns of comorbidity differentially influence in-hospital outcomes, while the HEROES study identified greater heart-failure severity, higher New York Heart Association class, a larger number of comorbidities, longer intensive cardiac care, and higher mortality among patients with prolonged hospitalization (Lucki et al., 2025).

### **Demographic and Cardiovascular Factors**

Age may increase vulnerability through frailty, multimorbidity, impaired renal reserve, and reduced physiological adaptation; nevertheless, age alone is not consistently associated with LOS once disease severity and complications are considered. Heart failure is increasingly recognized among younger adults with major cardiovascular risk factors, indicating that chronological age should not be treated as a direct proxy for clinical complexity (Lecoeur et al., 2023). Sex differences influence heart-failure phenotype and etiology. HFrEF is more common in men, whereas women often develop heart failure later in life and with different metabolic and hypertensive profiles; however, sex-related differences do not necessarily translate into different hospitalization durations (Delco et al., 2023; Keshvani et al., 2023).

Blood pressure at admission is a key marker of hemodynamic phenotype. Chronic hypertension increases left ventricular afterload and induces hypertrophy, fibrosis, and remodeling, while very high pressure during decompensation may intensify pulmonary congestion and delay stabilization (Gallo & Savoia, 2024). Conversely, low blood pressure can indicate poor cardiac output and limits the use or titration of several therapies. Thus, the association between blood pressure and LOS may be nonlinear and dependent on the clinical reference category.

Arrhythmias reduce mechanical efficiency and can precipitate or worsen decompensation. Atrial fibrillation is common in heart failure and may reduce ventricular filling, produce rapid ventricular response, and increase thromboembolic risk. Ventricular arrhythmias and conduction disorders can require telemetry, antiarrhythmic medication, cardioversion, or device evaluation. Valvular heart disease similarly increases pressure or volume load and may produce refractory congestion. Patients with significant valve disease often require detailed echocardiographic assessment and more intensive therapeutic planning (Chioncel et al., 2023; Nishimura et al., 2025).

Coronary artery disease is a major cause of HFrEF because ischemia and myocardial infarction produce irreversible myocyte loss and adverse remodeling. Nevertheless, the presence of coronary disease may not independently determine LOS when it is stable or already treated. Acute ischemia, ongoing chest pain, revascularization needs, hemodynamic compromise, and concurrent organ dysfunction may be more relevant than a binary history of coronary artery disease.

### **Metabolic, Renal, Hematologic, Electrolyte, Pulmonary, and Infectious Factors**

Diabetes mellitus accelerates atherosclerosis, endothelial dysfunction, oxidative stress, and systemic inflammation. It is also associated with renal disease, infection, and impaired wound or tissue recovery. These mechanisms can complicate volume management and delay clinical improvement (Ye et al., 2022; Herwig et al., 2025). Renal dysfunction creates a bidirectional cardiorenal interaction: reduced renal perfusion and venous congestion impair filtration, while sodium and water retention increase preload and systemic congestion. The resulting therapeutic tension between decongestion and renal preservation can prolong hospitalization (Zoccali et al., 2023).

Anemia decreases oxygen-carrying capacity and increases compensatory cardiac workload. In HFrEF, where systolic reserve is already limited, anemia may intensify fatigue, dyspnea, tachycardia, and tissue hypoxia. A systematic review and meta-analysis linked anemia with worse clinical outcomes in acute heart failure (Pan et al., 2024). Serum sodium is another important prognostic marker. Hyponatremia frequently represents severe neurohormonal activation and dilutional water retention and has been associated with adverse in-hospital and long-term outcomes (Kaplon-Cieslicka et al., 2023; Zhao et al., 2023).

Potassium abnormalities can trigger arrhythmia and are influenced by renal function, loop diuretics, renin-angiotensin system inhibitors, and mineralocorticoid receptor antagonists. However, a single admission value may not fully represent the patient's exposure because potassium changes during treatment and is actively corrected (Beavers & Greene, 2025). COPD complicates HFrEF through hypoxemia, pulmonary hypertension, systemic inflammation, overlapping symptoms, and difficulties in balancing bronchodilator and cardiovascular therapy. Lin et al. (2023) found that COPD adversely affected hospitalization and mortality among patients with HFrEF.

Infection is a recognized precipitant of acute heart failure. Fever, tachycardia, vasodilatation, inflammatory cytokines, increased metabolic demand, and altered fluid balance can destabilize cardiac function. Infection may also require antimicrobial therapy, microbiological evaluation, and continued observation after cardiac symptoms improve. Its prompt identification is therefore central to shortening hospitalization and preventing complications (Bezati et al., 2023). The literature indicates that many factors may be associated with LOS in unadjusted analyses, but only a smaller number may remain independent after multivariable adjustment. This distinction is clinically important because significant bivariate findings may reflect shared pathways or confounding. The current study addresses this issue in a local HFrEF population by combining descriptive, bivariate, and generalized linear model analyses.

### **Hypothesis**

The null hypothesis ( $H_0$ ) states that age, sex, blood pressure, cardiac arrhythmias, valvular heart disease, coronary artery disease, diabetes mellitus, renal dysfunction, hemoglobin levels, sodium levels, potassium levels, chronic obstructive pulmonary disease, and infection are not significantly associated with the length of hospital stay among patients with heart failure with reduced ejection fraction (HFrEF) at Waled Regional Hospital, Cirebon. Furthermore, class I hypertension, valvular heart disease, and infection are not the factors most strongly associated with the length of hospitalization.

Conversely, the alternative hypothesis ( $H_1$ ) states that these demographic, cardiovascular, laboratory, and comorbidity-related risk factors are significantly associated with the length of hospital stay among patients with HFrEF. In addition, class I hypertension, valvular heart disease, and infection are hypothesized to be the factors most strongly associated with the duration of hospitalization.

## **METHOD**

### **Study Design, Setting, and Period**

This analytical observational study used a retrospective cross-sectional approach based on secondary medical-record data. The study was conducted at Waled Regional Hospital, Cirebon Regency. Records covered hospitalizations from January 2024 through December 2025, and data collection and analysis were performed from March to May 2026.

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## Population, Sample, and Eligibility

The target population comprised all patients with heart failure who were hospitalized at Waled Regional Hospital. The accessible population comprised patients with HFrEF admitted during the study period. Total sampling was applied. Among 487 patients hospitalized with heart failure, 239 had HFrEF and 150 met all eligibility criteria and were included in the analysis. Inclusion criteria were a diagnosis of HFrEF with an echocardiographic ejection fraction below 40%, inpatient treatment at Waled Regional Hospital, and a complete medical record. Exclusion criteria were death during hospitalization, referral to another hospital, discharge against medical advice, comorbid cancer, congenital heart disease, or pregnancy.

## Variables and Measurements

LOS was the dependent variable and was calculated as the total number of days from admission to discharge for one inpatient episode. Independent variables were age, sex, admission blood pressure, cardiac arrhythmia, valvular heart disease, coronary artery disease, diabetes mellitus, renal function, hemoglobin status, serum sodium, serum potassium, COPD, and infection. Age was grouped as adult (18-59 years), older adult (60-74 years), and old-old (75-90 years). Blood pressure was categorized as <120/<80, 120-129/<80, 130-139/80-89,  $\geq$ 140/ $\geq$ 90, and  $\geq$ 180/ $\geq$ 120 mmHg.

Arrhythmia was identified from the admission electrocardiogram and included supraventricular, ventricular, bradyarrhythmic, and other rhythm disturbances. Moderate-to-severe valvular disease was identified by echocardiography. Diabetes was based on the treating physician's diagnosis or random glucose  $\geq$ 200 mg/dL with confirmatory glycated hemoglobin  $\geq$ 6.5%. Renal function was categorized by estimated glomerular filtration rate (eGFR):  $\geq$ 90, 60-89, 45-59, 30-44, 15-29, and  $<$ 15 mL/min/1.73 m<sup>2</sup>. Anemia was defined as hemoglobin  $<$ 13 g/dL in men or  $<$ 12 g/dL in women. Sodium was categorized as normal or hyponatremic, and potassium as normal, hypokalemic, or hyperkalemic. COPD required a clinical diagnosis or compatible imaging with post-bronchodilator FEV1/FVC  $<$ 0.70. Infection was based on the treating physician's diagnosis or evidence including leukocytosis, an increased neutrophil-to-lymphocyte ratio, and/or antibiotic use documented at admission.

## Data Analysis and Ethics

Univariable analysis summarized frequencies, percentages, and LOS. Independent t-tests compared mean LOS across binary nominal variables, and one-way analysis of variance compared LOS across variables with more than two ordered categories. Variables included in the adjusted model were analyzed using a generalized linear model. Statistical significance was set at  $p < 0.05$ . The study received ethical approval from the Waled Regional Hospital Research Ethics Committee (No. 000.9.2/248/KEPK/IV/2026). Patient identifiers were not collected during extraction, processing, or analysis.

## RESULTS AND DISCUSSION

### Participant Selection and Length of Stay

Of 487 patients hospitalized with heart failure during the two-year period, 239 had HFrEF. After applying the inclusion and exclusion criteria, 150 patients were analyzed. Mean LOS was 4.24 days; the shortest admission was 2 days and the longest was 9 days. Thus, the average stay was below the local clinical-pathway target of seven days, although several high-risk subgroups had means approaching or exceeding that threshold.

Table 1. Demographic and clinical characteristics of patients with HFrEF (n=150)

| Characteristic                    | n  | %    |
|-----------------------------------|----|------|
| Age: adult (18-59 years)          | 72 | 48.0 |
| Age: older adult (60-74 years)    | 67 | 44.7 |
| Age: old-old (75-90 years)        | 11 | 7.3  |
| Male sex                          | 81 | 54.0 |
| Female sex                        | 69 | 46.0 |
| Blood pressure <120/<80 mmHg      | 40 | 26.7 |
| Blood pressure 120-129/<80 mmHg   | 34 | 22.7 |
| Blood pressure 130-139/80-89 mmHg | 27 | 18.0 |

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| Characteristic                            | n   | %    |
|-------------------------------------------|-----|------|
| Blood pressure $\geq 140/\geq 90$ mmHg    | 43  | 28.7 |
| Blood pressure $\geq 180/\geq 120$ mmHg   | 6   | 4.0  |
| Arrhythmia                                | 35  | 23.3 |
| No arrhythmia                             | 115 | 76.7 |
| Valvular heart disease                    | 87  | 58.0 |
| No valvular heart disease                 | 63  | 42.0 |
| Coronary artery disease                   | 119 | 79.0 |
| No coronary artery disease                | 31  | 21.0 |
| Diabetes mellitus                         | 42  | 28.0 |
| No diabetes mellitus                      | 108 | 72.0 |
| eGFR $\geq 90$ mL/min/1.73 m <sup>2</sup> | 69  | 46.0 |
| eGFR 60-89 mL/min/1.73 m <sup>2</sup>     | 13  | 8.7  |
| eGFR 45-59 mL/min/1.73 m <sup>2</sup>     | 13  | 8.7  |
| eGFR 30-44 mL/min/1.73 m <sup>2</sup>     | 13  | 8.7  |
| eGFR 15-29 mL/min/1.73 m <sup>2</sup>     | 25  | 16.7 |
| eGFR $< 15$ mL/min/1.73 m <sup>2</sup>    | 17  | 11.3 |
| Anemia                                    | 65  | 43.3 |
| No anemia                                 | 85  | 56.7 |
| Normonatremia                             | 93  | 62.0 |
| Hyponatremia                              | 57  | 38.0 |
| Normokalemia                              | 103 | 68.7 |
| Hypokalemia                               | 26  | 17.3 |
| Hyperkalemia                              | 21  | 14.0 |
| COPD                                      | 12  | 8.0  |
| No COPD                                   | 138 | 92.0 |
| Infection                                 | 21  | 14.0 |
| No infection                              | 129 | 86.0 |

Adults aged 18-59 years formed the largest age group (48.0%), closely followed by older adults aged 60-74 years (44.7%). Men represented 54.0% of participants. The largest blood-pressure category was  $\geq 140/\geq 90$  mmHg (28.7%). Most patients had no documented arrhythmia, but 58.0% had valvular heart disease and 79.0% had coronary artery disease. Diabetes was present in 28.0%, anemia in 43.3%, hyponatremia in 38.0%, COPD in 8.0%, and infection in 14.0%.

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## Bivariate Associations with Length of Stay

Table 2. Bivariate associations between patient factors and length of stay

| Factor/category            | n   | Mean LOS, days (SD) | p-value |
|----------------------------|-----|---------------------|---------|
| Age: adult                 | 72  | 4.222 (1.258)       | 0.986   |
| Age: older adult           | 67  | 4.254 (1.235)       |         |
| Age: old-old               | 11  | 4.273 (1.679)       |         |
| Male                       | 81  | 4.136 (1.243)       | 0.279   |
| Female                     | 69  | 4.362 (1.306)       |         |
| BP <120/<80 mmHg           | 40  | 3.550 (0.597)       | <0.001* |
| BP 120-129/<80 mmHg        | 34  | 3.618 (0.604)       |         |
| BP 130-139/80-89 mmHg      | 27  | 3.407 (0.694)       |         |
| BP ≥140/≥90 mmHg           | 43  | 5.395 (0.583)       |         |
| BP ≥180/≥120 mmHg          | 6   | 7.833 (0.753)       |         |
| Arrhythmia                 | 35  | 5.971 (1.071)       | <0.001* |
| No arrhythmia              | 115 | 3.713 (0.758)       |         |
| Valvular heart disease     | 87  | 4.989 (1.115)       | <0.001* |
| No valvular heart disease  | 63  | 3.206 (0.544)       |         |
| Coronary artery disease    | 119 | 4.190 (1.230)       | 0.380   |
| No coronary artery disease | 31  | 4.420 (1.430)       |         |
| Diabetes mellitus          | 42  | 5.810 (1.042)       | <0.001* |
| No diabetes mellitus       | 108 | 3.630 (0.705)       |         |
| eGFR ≥90                   | 69  | 3.880 (1.020)       | 0.005*  |
| eGFR 60-89                 | 13  | 4.150 (1.140)       |         |
| eGFR 45-59                 | 13  | 4.080 (1.040)       |         |
| eGFR 30-44                 | 13  | 4.380 (0.960)       |         |
| eGFR 15-29                 | 25  | 4.960 (1.540)       |         |
| eGFR <15                   | 17  | 4.710 (1.720)       |         |
| Anemia                     | 65  | 5.323 (1.105)       | <0.001* |
| No anemia                  | 85  | 3.412 (0.583)       |         |
| Normonatremia              | 93  | 3.462 (0.582)       | <0.001* |
| Hyponatremia               | 57  | 5.509 (1.054)       |         |
| Normokalemia               | 103 | 4.291 (1.326)       | 0.575   |
| Hypokalemia                | 26  | 4.000 (1.058)       |         |
| Hyperkalemia               | 21  | 4.286 (1.271)       |         |
| COPD                       | 12  | 7.083 (0.996)       | <0.001* |
| No COPD                    | 138 | 3.993 (0.955)       |         |

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| Factor/category | n   | Mean LOS, days (SD) | p-value |
|-----------------|-----|---------------------|---------|
| Infection       | 21  | 6.619 (0.921)       | <0.001* |
| No infection    | 129 | 3.853 (0.821)       |         |

\* Statistically significant at  $p < 0.05$ . Independent *t*-test was used for binary variables and one-way ANOVA for variables with more than two categories.

Age, sex, coronary artery disease, and potassium status were not significantly associated with LOS. In contrast, higher blood-pressure categories were strongly associated with longer admission. Patients with admission blood pressure  $\geq 180/\geq 120$  mmHg had a mean LOS of 7.833 days, compared with 3.407-3.618 days in the lower non-emergency categories ( $p < 0.001$ ).

Patients with arrhythmia stayed an average of 5.971 days compared with 3.713 days among those without arrhythmia. Valvular heart disease was associated with a mean LOS of 4.989 days versus 3.206 days without valve disease. Diabetes, impaired renal function, anemia, and hyponatremia were also associated with longer stays. The largest mean LOS values were observed in COPD (7.083 days) and infection (6.619 days), both significantly longer than their respective comparison groups.

## Multivariable Analysis

Table 3. Generalized linear model of factors associated with length of stay

| Category                   | B      | p-value | 95% CI           |
|----------------------------|--------|---------|------------------|
| BP <120/<80 mmHg           | -0.352 | <0.001  | -0.526 to -0.178 |
| BP 120-129/<80 mmHg        | -0.324 | <0.001  | -0.500 to -0.148 |
| BP 130-139/80-89 mmHg      | -0.398 | <0.001  | -0.575 to -0.222 |
| BP $\geq 140/\geq 90$ mmHg | -0.209 | 0.001   | -0.337 to -0.080 |
| Arrhythmia                 | 0.005  | 0.917   | -0.096 to 0.107  |
| Valvular heart disease     | 0.222  | <0.001  | 0.167 to 0.277   |
| Diabetes mellitus          | -0.002 | 0.975   | -0.121 to 0.117  |
| eGFR $\geq 90$             | -0.004 | 0.897   | -0.065 to 0.057  |
| eGFR 60-89                 | 0.013  | 0.750   | -0.069 to 0.095  |
| eGFR 45-59                 | -0.065 | 0.122   | -0.146 to 0.017  |
| eGFR 30-44                 | -0.049 | 0.253   | -0.134 to 0.035  |
| eGFR 15-29                 | 0.018  | 0.629   | -0.054 to 0.089  |
| Anemia                     | 0.007  | 0.884   | -0.085 to 0.098  |
| Hyponatremia               | -0.072 | 0.198   | -0.183 to 0.038  |
| COPD                       | 0.051  | 0.393   | -0.066 to 0.168  |
| Infection                  | 0.188  | <0.001  | 0.092 to 0.284   |

Source conversion note: detailed result tables were treated as the primary numerical source. Therefore, age is reported as  $p = 0.986$  (Table 11 of the source) rather than  $p = 0.422$  in the source abstract; the valvular-disease and infection coefficients are reported as  $B = 0.222$  and  $B = 0.188$ , respectively, as shown in the source multivariable table.

After simultaneous adjustment, blood pressure, valvular heart disease, and infection remained independently associated with LOS. Arrhythmia, diabetes, renal-function categories, anemia, hyponatremia, and COPD were no longer statistically significant, indicating that part of their unadjusted association may have been shared with hemodynamic severity, valve disease, infection, or other variables in the model.

## **Discussion of the Main Findings**

This study identified a broad set of factors associated with hospitalization duration at the bivariate level, but only blood pressure, valvular heart disease, and infection retained independent associations in the adjusted model. The difference between the bivariate and multivariable results is clinically meaningful. It suggests that prolonged LOS is generated by interacting pathways rather than by isolated diagnoses. Conditions such as diabetes, renal dysfunction, anemia, hyponatremia, and COPD may mark greater illness complexity, yet their independent effects were attenuated when major hemodynamic and precipitating factors were considered together.

Age was not associated with LOS, and mean values were nearly identical across the three age categories. This finding supports the view that chronological age alone does not determine hospitalization duration. Njoroge and Teerlink (2021) emphasized that acute decompensated heart failure is driven by congestion, perfusion, precipitating factors, and treatment response. An older patient with stable organ function and a rapid diuretic response may be discharged earlier than a younger patient with severe valve disease or infection. The large proportion of adults aged 18-59 years also highlights the presence of HFrEF in the productive-age population, consistent with changing epidemiology among younger adults (Lecoeur et al., 2023).

Sex was likewise unrelated to LOS. Women had a slightly higher mean stay than men, but the difference was not statistically significant. Biological and clinical differences between men and women influence the development and phenotype of heart failure, but hospital duration appears to depend more directly on admission severity and complications. This interpretation is compatible with registry evidence showing sex differences in long-term outcomes without implying that sex consistently determines the immediate duration of hospitalization (Keshvani et al., 2023).

Blood pressure showed one of the strongest associations with LOS. Mean LOS rose sharply in the  $\geq 140/\geq 90$  and  $\geq 180/\geq 120$  mmHg categories. Severe hypertension increases afterload and promotes pulmonary congestion, while its treatment may require intravenous therapy, repeated monitoring, and cautious transition to oral medication. Chronic hypertension also contributes to ventricular hypertrophy and adverse remodeling (Gallo & Savoia, 2024). The negative coefficients in Table 3 must be interpreted relative to the model's omitted reference category; they do not negate the clear gradient observed in the descriptive means. The overall finding confirms that admission hemodynamics are central to discharge timing.

Arrhythmia was associated with an approximately 2.3-day longer mean stay in the bivariate analysis. Atrial fibrillation was the most frequently identified rhythm disorder in the source study, although premature ventricular contractions, atrial flutter, supraventricular tachycardia, and ventricular tachycardia were also present. Rhythm disturbances can reduce stroke volume, worsen congestion, and require telemetry or rhythm/rate-control interventions. Their loss of significance after adjustment suggests that arrhythmia may prolong LOS primarily when it accompanies valve disease, severe blood-pressure abnormalities, infection, or advanced decompensation rather than acting as an independent determinant in every patient.

Valvular heart disease remained a strong independent factor. Patients with valve disease stayed almost 1.8 days longer on average than those without it, and the adjusted coefficient was positive and highly significant. Significant stenosis or regurgitation produces chronic pressure or volume overload, worsens chamber dilatation, and may make congestion resistant to routine therapy. Acute heart failure associated with valve disease often requires repeated echocardiographic interpretation, specialist evaluation, and planning for intervention, all of which increase complexity (Chioncel et al., 2023). The result supports early identification of clinically important valve lesions and integration of cardiology follow-up into discharge planning.

Coronary artery disease was common but not associated with LOS. This may reflect the binary definition used in the study. A history of coronary disease does not distinguish stable ischemic cardiomyopathy from active acute coronary syndrome, ongoing ischemia, or a need for urgent revascularization. Namvar et al. (2023) similarly showed that baseline etiologic characteristics do not always explain hospitalization duration, which is more directly influenced by the patient's current clinical state, complications, and response to treatment.

Diabetes was associated with a mean LOS more than two days longer in the unadjusted analysis. Diabetes can aggravate endothelial dysfunction, oxidative stress, inflammation, atherosclerosis, infection risk, and renal dysfunction (Ye et al., 2022; Herwig et al., 2025). However, it was not independently significant in the adjusted model. This pattern suggests mediation through complications such as infection, kidney disease, vascular disease, or hemodynamic instability. It also indicates that a diabetes diagnosis alone may be less informative than measures of glycemic control, chronic complications, insulin requirement, or acute metabolic disturbance. Renal dysfunction was significant by one-way analysis of variance, and the longest mean LOS occurred in the eGFR 15-29 mL/min/1.73 m<sup>2</sup> group. Impaired renal function limits sodium and water excretion, complicates decongestion, and

increases the risk of electrolyte abnormalities and medication intolerance. Nevertheless, none of the eGFR categories remained significant in the multivariable model. The broad eGFR grouping, small numbers in several categories, and interaction with anemia, sodium status, blood pressure, and infection may have reduced independent statistical power. Clinically, renal function remains essential because cardiorenal deterioration can delay both stabilization and safe treatment optimization (Zoccali et al., 2023).

Anemia was common and associated with a markedly longer mean stay in the bivariate analysis. Reduced oxygen-carrying capacity increases cardiac demand and may worsen dyspnea and fatigue. The finding is consistent with evidence linking anemia to adverse outcomes in acute heart failure (Pan et al., 2024). However, anemia was not independently associated with LOS after adjustment. In this sample, anemia may have functioned as a marker of renal dysfunction, chronic inflammation, nutritional deficiency, or hemodilution rather than an isolated driver of prolonged admission.

Hyponatremia was associated with a mean LOS approximately two days longer than normonatremia. This agrees with studies describing low sodium as a marker of severe neurohormonal activation, congestion, and poor outcomes (Kaplon-Cieslicka et al., 2023; Zhao et al., 2023). Its adjusted association was not significant, which may indicate overlap with blood pressure, valve disease, renal function, and infection. By contrast, potassium status was not associated with LOS even before adjustment. Admission potassium can change rapidly after diuretics, renin-angiotensin-aldosterone system inhibitors, supplementation, or renal management, so a single baseline category may not capture the clinically relevant trajectory (Beavers & Greene, 2025).

COPD had the highest mean LOS among binary comorbidities, at 7.083 days. Hypoxemia, airway obstruction, systemic inflammation, and overlapping cardiopulmonary symptoms can complicate diagnosis and treatment. Lin et al. (2023) similarly reported adverse hospitalization outcomes among patients with HFrEF and COPD. The lack of independent significance in the adjusted model may partly reflect the small COPD subgroup of only 12 patients, producing limited precision and making the estimate sensitive to coexisting infection and hemodynamic factors.

Infection remained independently associated with LOS and was one of the most important findings. Patients with infection stayed 6.619 days on average compared with 3.853 days among those without infection. Infection increases metabolic demand and inflammatory activation and can precipitate acute decompensation, hypotension, arrhythmia, renal dysfunction, and poor oral intake. It also introduces additional treatment milestones, including antibiotic administration, microbiological assessment, and confirmation of clinical response before discharge. These mechanisms explain why infection is consistently recognized as an underdiagnosed precipitant and prognostic factor in acute heart failure (Bezati et al., 2023; Amon et al., 2025; Scicchitano et al., 2025).

From a service perspective, the results support a risk-oriented admission pathway. Patients presenting with severe blood-pressure abnormalities, significant valve disease, or infection should be identified early for intensified monitoring and coordinated management. Rapid blood-pressure control, prompt echocardiographic review, early antibiotic treatment when indicated, and predefined criteria for clinical stability may reduce avoidable delays. At the same time, comorbid diabetes, renal dysfunction, anemia, hyponatremia, and COPD should not be disregarded simply because they were not independently significant; they contribute to complexity and may become important in larger or differently composed populations.

### **Clinical and Health-Service Implications**

The findings can be translated into a practical admission-risk profile for patients with HFrEF. Blood pressure, clinically important valvular disease, and infection were the factors that remained independently associated with LOS, so these domains deserve immediate attention during the first assessment. A structured admission form could record the exact blood-pressure category, signs of congestion or hypertensive emergency, the presence and severity of valve disease on available echocardiography, and evidence of infection. This approach does not replace comprehensive clinical judgment; rather, it helps identify patients whose stabilization is likely to require more time. Because the longest mean stays occurred in patients with COPD, severe blood-pressure elevation, and infection, early identification of respiratory compromise and precipitating illness should also remain part of the initial pathway, even when a variable does not retain statistical significance after adjustment.

Admission blood pressure should be interpreted as both a marker of hemodynamic status and a potential therapeutic target. Patients in the highest category had a mean LOS of 7.833 days, more than twice the mean observed in several lower categories. This difference indicates that severe blood-pressure elevation can signal a more complicated episode that requires gradual control, reassessment of symptoms and organ function, and careful adjustment of heart-failure therapy. The result is compatible with the pathophysiological link between

hypertension, increased left-ventricular afterload, pulmonary congestion, and adverse remodeling described by Gallo and Savoia (2024). At the service level, rapid measurement, repeated monitoring, clear escalation criteria, and timely conversion from intravenous to oral therapy may help avoid preventable delays while maintaining patient safety.

Valvular heart disease requires a similarly organized response. More than half of the participants had valve disease, and this factor remained independently associated with LOS in the generalized linear model. A patient admitted with HFrEF and significant stenosis or regurgitation may need more than routine decongestion because the structural lesion continues to impose pressure or volume overload. Early review of echocardiographic findings can clarify whether the valve abnormality is the primary driver of decompensation, a consequence of ventricular remodeling, or both. When indicated, consultation with cardiology and planning for further imaging or intervention should begin before the patient reaches the final stage of discharge preparation. Chioncel et al. (2023) emphasized the clinical complexity of acute heart failure with valve disease, supporting the need for integrated structural and heart-failure management.

Infection was present in 14% of the sample but was associated with a mean LOS of 6.619 days and remained significant after adjustment. This pattern shows that a relatively uncommon precipitant can have a disproportionate effect on hospitalization. Screening should therefore be based on clinical suspicion rather than prevalence alone. Temperature, respiratory symptoms, leukocyte count, neutrophil-to-lymphocyte ratio, chest findings, and other source-specific investigations can be reviewed early, with cultures and antimicrobial treatment used when clinically appropriate. Infection increases metabolic demand and systemic inflammation and may worsen hemodynamic instability in a patient whose cardiac reserve is already limited. The findings are consistent with evidence that infection is an under-recognized precipitant of acute heart failure and an important contributor to adverse outcomes (Bezati et al., 2023; Scicchitano et al., 2025).

The bivariate findings also identify supportive-care needs. Diabetes, impaired renal function, anemia, hyponatremia, and COPD were each associated with longer stays before multivariable adjustment. Their loss of independent significance should not be interpreted as clinical irrelevance. These conditions may interact with blood pressure, infection, congestion, and valve disease or may influence treatment tolerance. Renal dysfunction can constrain diuretic and renin-angiotensin-aldosterone system therapy; anemia can reduce oxygen delivery; hyponatremia may reflect neurohormonal activation and water retention; COPD can complicate the interpretation of dyspnea and oxygenation; and diabetes may slow recovery through vascular and inflammatory pathways. A multidisciplinary plan involving cardiology, internal medicine, pharmacy, nutrition, and respiratory or renal services may therefore be useful for patients with clustered comorbidities.

Discharge planning should begin early for patients who present with these risk patterns. A prolonged stay is not determined only by the time needed to relieve symptoms; it may also reflect the time required to stabilize laboratory abnormalities, complete diagnostic evaluation, educate the patient, reconcile medication, and arrange follow-up. A checklist linked to the clinical pathway could include euvolemia or clearly improving congestion, stable blood pressure, a defined plan for valve disease, controlled or treated infection, review of renal function and electrolytes, and patient understanding of medication and warning signs. The average LOS of 4.24 days indicates that many patients were stabilized efficiently, but the range of two to nine days shows substantial heterogeneity. Risk-based planning may preserve appropriate short stays while preventing premature discharge among patients with unresolved high-risk features.

From a hospital-management perspective, LOS should be interpreted together with quality and safety indicators. Reducing days of care is beneficial only when it does not increase early deterioration, unplanned readmission, or mortality. The study did not measure these outcomes, so the findings should be used to improve the efficiency of clinical processes rather than to impose a uniform discharge deadline. Monitoring the time from admission to echocardiography review, recognition of infection, blood-pressure stabilization, and completion of discharge medication may help identify modifiable bottlenecks. Local audit can then compare observed LOS with patient complexity and pathway milestones. This approach is consistent with the role of LOS as an indicator of service efficiency while acknowledging that more complex patients legitimately require longer treatment (Hadning & Kubra, 2025; Indonesian Heart Association, 2016).

The results also provide a basis for future prediction research. A larger multicenter cohort could test whether a simple score combining admission blood pressure, valvular disease, infection, renal function, anemia, sodium, COPD, functional class, and treatment variables accurately predicts prolonged hospitalization. Such a model would require external validation and should report discrimination, calibration, and clinical usefulness before implementation. Prospective data collection would allow investigators to distinguish pre-existing comorbidity from

changes developing during treatment and to evaluate discharge barriers that are not captured in medical records. The present study offers locally relevant candidate variables, but it should be regarded as an exploratory foundation rather than a finalized prediction instrument. This distinction is important because statistical association alone does not establish that changing a factor will necessarily shorten LOS.

### Study Limitations

The study relied on retrospective medical records, so measurement quality depended on the completeness and accuracy of prior documentation. It was conducted at one hospital, limiting generalizability to other institutions and referral systems. Only 150 of 487 patients with heart failure met the final criteria, and several clinically important categories, particularly COPD and extreme blood-pressure groups, contained small numbers. The analysis did not include ejection-fraction severity within the HFrEF range, New York Heart Association class, natriuretic peptides, treatment regimens, nutritional status, socioeconomic factors, discharge barriers, or changes in laboratory values during hospitalization. These variables may explain additional variation in LOS. Because the design was cross-sectional and retrospective, associations should not be interpreted as proof of causation.

### CONCLUSION

Based on the findings from 150 patients with heart failure with reduced ejection fraction (HFrEF) treated at Waled Regional Hospital, Cirebon, several clinical risk factors were significantly associated with the length of hospital stay. These factors included blood pressure, cardiac arrhythmias, valvular heart disease, diabetes mellitus, renal dysfunction, hemoglobin levels, sodium levels, chronic obstructive pulmonary disease, and infection. Meanwhile, age, sex, coronary artery disease, and potassium levels were not significantly associated with the duration of hospitalization. Among all evaluated variables, class I hypertension, valvular heart disease, and infection were identified as the factors most strongly associated with the length of hospital stay. These findings highlight the importance of early identification and appropriate management of cardiovascular abnormalities, comorbidities, and infections to reduce prolonged hospitalization among patients with HFrEF.

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