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Correlation Between Kidney Function and Rehospitalization Within 90 Days in Heart Failure Patients

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KEYWORDS
Heart failure, kidney function, eGFR, rehospitalization, CKD-EPI

ABSTRACT
Heart failure is a global health problem with high rehospitalization rates. One potential risk factor contributing to rehospitalization is impaired kidney function, which is commonly found as a comorbidity in heart failure patients. The study aims to determine the relationship between kidney function, assessed by estimated Glomerular Filtration Rate (eGFR), and 90-day rehospitalization in patients with heart failure. This retrospective cohort study was conducted at Pelabuhan Cirebon Hospital. Subjects were heart failure patients from medical records between January 2024 and May 2024 who met the inclusion criteria. Kidney function data were calculated using the CKD-EPI formula, and patients were followed for 90 days to assess rehospitalization incidence. Analysis was performed using Cox proportional hazards regression. Results showed that patients with decreased kidney function (eGFR < 90 mL/min/1.73 m²) had higher rehospitalization rates within 90 days compared to patients with normal kidney function. This relationship was statistically significant, with a p-value of 0.024. Decreased kidney function is significantly associated with an increased risk of 90-day rehospitalization in heart failure patients. Regular evaluation of kidney function is essential to identify high-risk patients and potentially reduce rehospitalization rates.

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INTRODUCTION

Heart failure, according to the European Society of Cardiology (ESC), is a clinical syndrome consisting of cardinal symptoms (shortness of breath, ankle swelling, and easy fatigue) that may be accompanied by signs such as increased jugular venous pressure, lung crackles, and peripheral edema caused by abnormal cardiac function and/or structure (McDonagh et al., 2021). The American Heart Association (AHA) defines heart failure as a complex clinical syndrome resulting from structural or functional abnormalities of ventricular filling and blood pumping (Heidenreich et al., 2022).

Heart failure has been a leading cause of death for the past 20 years. The Global Health Data Exchange (GHDx) reports that the global number of diagnosed heart failure cases may reach 64.34 million, with mortality rates of up to 9.91 million deaths (Feng et al., 2024). In Indonesia, with a population of 256 million, approximately 5% experience heart failure (Reyes et al., 2016). In 1990, the number of Indonesians affected by heart failure ranged from 666.27 to 1,050.39 individuals and increased by 7.83% in 2019, reaching 717.73 to 1,138.87 individuals, marking one of the largest increases in Asia (Feng et al., 2024).

According to the ESC (2022), heart failure mortality rates remain high. The 30-day mortality rate is 2–3%, the 1-year mortality rate is 15–30%, the 3-year mortality rate is 30–50%, and the 5-year mortality rate is 50–75% (Savarese et al., 2022). Nearly 50% of patients with congestive heart failure who have been hospitalized experience rehospitalization, according to the AHA (2012). Data show that nearly 100,000 patients in England are

hospitalized annually due to congestive heart failure. Results from Indonesia's Hospital Information System (SIRS) recording and reporting indicate that the rehospitalization rate for congestive heart failure patients is 13.42% (Sugiyanti et al., 2020).

Patients with heart failure who are rehospitalized often demonstrate decreased kidney function (GFR 60–89 mL/min), as reported by Rasyid, Syahrul, and Tahir (2021). Among congestive heart failure (CHF) patients classified by the New York Heart Association (NYHA), 40% of NYHA I patients, 18.96% of NYHA II patients, 35.85% of NYHA III patients, and 14.81% of NYHA IV patients experienced this condition. Overall, 27.4% of CHF patients had mild kidney function decline (Rasyid et al., 2021).

According to research by Cobo Marcos et al. (2024) involving 1,107 outpatient heart failure patients, 40.9% had an eGFR > 60 mL/min/1.73 m² with an average of 80.3 mL/min/1.73 m²; 18.8% had an eGFR of 45–59 mL/min/1.73 m² with an average of 52.3 mL/min/1.73 m²; 24.1% had an eGFR of 30–44 mL/min/1.73 m² with an average of 37.9 mL/min/1.73 m²; and 16.2% had an eGFR < 30 mL/min/1.73 m² with an average of 24.4 mL/min/1.73 m² (Cobo Marcos et al., 2024).

Previous studies have demonstrated the clinical importance of kidney function in patients with heart failure; however, gaps remain in understanding its direct impact on short-term rehospitalization in Indonesia (Fatimah, 2018; Khasanah et al., 2020; Prabowo et al., 2022; Prihatiningsih & Sudyasih, 2018; Sagala & Sitompul, 2019; Sugiyanti et al., 2020). For example, Rasyid et al. (2021) found that a substantial proportion of CHF patients experienced mild to moderate declines in kidney function, with 27.4% showing mild impairment, and noted associations between renal function and disease severity (NYHA classification). While informative, their study was limited to a descriptive cross-sectional design and did not assess time-dependent outcomes such as rehospitalization risk. Similarly, Cobo Marcos et al. (2024) analyzed 1,107 outpatient heart failure patients and detailed the distribution of eGFR categories, showing that 40.9% had normal kidney function and 16.2% had severe impairment. However, their study was conducted outside Indonesia and did not specifically examine the temporal relationship between renal function and rehospitalization events.

Based on this background, kidney function assessment plays a critical role in managing heart failure patients. Therefore, researchers are interested in analyzing the relationship between kidney function and rehospitalization occurrence in heart failure patients. The purpose of this study is to provide empirical evidence on how renal function affects short-term outcomes in hospitalized heart failure patients. This evidence will enable clinicians to better stratify risk and optimize management strategies. The benefit of this research lies in informing targeted interventions to reduce rehospitalization, improve patient prognosis, and support national healthcare planning.

METHOD

This study was a retrospective cohort study conducted at Pelabuhan Cirebon Hospital. The research was conducted from April to June 2025. The target population was heart failure patients hospitalized at the hospital. The accessible population was heart failure patients treated at Pelabuhan Cirebon Hospital. The sample consisted of patients experiencing heart failure rehospitalization who met inclusion and exclusion criteria.

Inclusion criteria:

1. Patients aged ≥18 years hospitalized with heart failure from January 2024 to May 2024

Exclusion Criteria:

1. Incomplete medical record data
2. Patients experiencing rehospitalization for reasons other than heart failure

3. Patients who died during the evaluation period

Sample determination was done by including populations that met inclusion and exclusion criteria according to the predetermined sample size. Therefore, the sampling technique in this study was total sampling.

The sample size for this study was calculated using the cohort sample calculation formula. Based on the calculation with Zα = 1.96 (for 95% confidence level), Zβ = 0.84 (for 80% statistical test power), P1 = 0.65, P2 = 0.35, the required sample size was 43 patients per group. With a total population of 95 patients covering all exposed and unexposed patients, using total sampling was sufficient to meet research needs.

The independent variable in this study was kidney function assessed with eGFR. The dependent variable was rehospitalization within 90 days in heart failure patients.

Data collection was performed using medical record data. Kidney function was calculated using the CKD-EPI formula and using the QxMD application to reduce human error. The assessment used eGFR calculation with categories: Normal (eGFR ≥90 mL/min/1.73m²) and decreased kidney function (eGFR <90 mL/min/1.73m²).

Univariate analysis was performed to see frequency distribution of independent variables (kidney function) and dependent variables (90-day rehospitalization in heart failure patients). Bivariate analysis aimed to determine the relationship between independent variables (kidney function) and dependent variables (90-day rehospitalization in heart failure patients). Statistical tests used cox proportional hazard to determine time (kidney function) to event (90-day rehospitalization in heart failure patients) with p value <0.05.

This research has been approved by the Health Research Ethics Committee (KEPK) of the Faculty of Medicine, Swadaya Gunung Jati University with letter number No.89/EC/FKUGJ/IV/2025 and meets the administrative requirements of Pelabuhan Cirebon Hospital.

RESULTS AND DISCUSSION

Data collection was conducted at Pelabuhan Cirebon Hospital using secondary data in the form of medical records obtained from the medical records department. The sample used in this study was medical records of heart failure patients treated during the period January 2024 to May 2024, who met inclusion criteria with total sampling method. This study has obtained approval from Pelabuhan Cirebon Hospital. The total sample of heart failure patients treated during that period was 95 medical records.

Sample Size Calculation

The sample size for this cohort study was calculated using the following formula:

$$\mathbf{n = (Z\alpha \times \sqrt{2PQ} + Z\beta \times \sqrt{P_1Q_1 + P_2Q_2})^2 / (P_1 - P_2)^2}$$

Where:
$Z\alpha = 1.96$ (for 95% confidence level)
$Z\beta = 0.84$ (for 80% statistical test power)
$P_1 = 0.65$ (proportion set by researcher)
$P_2 = 0.35$ (existing proportion)
$P = (P_1 + P_2)/2 = (0.65 + 0.35)/2 = 0.5$
$Q = 1 - P = 1 - 0.5 = 0.5$
$Q_1 = 1 - P_1 = 1 - 0.65 = 0.35$
$Q_2 = 1 - P_2 = 1 - 0.35 = 0.65$

The calculation resulted in n = 43 patients per group. Since the total population was 95 patients covering all exposed and unexposed patients, using total sampling was sufficient to meet research needs.

Kidney Function Assessment

Kidney function was assessed using the CKD-EPI 2021 formula:

eGFR = 142 × min(standardized Scr/K,1)^α × max(standardized Scr/K,1)^-1.200 × 0.9938^Age in years × 1.012 (if female)

Where:
Scr = serum creatinine
K = 0.7 (females) or 0.9 (males)
α = -0.241 (females) or -0.302 (males)
Kidney function was categorized as:
Normal: eGFR ≥90 mL/min/1.73m²
Decreased function: eGFR <90 mL/min/1.73m²

Univariate Analysis

Univariate analysis was conducted to determine the frequency distribution of heart failure patient characteristics at Pelabuhan Cirebon Hospital, addressing the specific research objectives.

Table 1. Subject Characteristics (n=95)

Characteristics	n	Percentage (%)
Gender		
Male	48	50.5
Female	47	49.5
Age Groups		
18-25 years	2	2.1
26-35 years	4	4.2
36-45 years	17	17.9
46-55 years	19	20.0
56-65 years	28	29.5
>65 years	25	26.3
Mean ± SD	57.8 ± 14.2	
Length of Stay		
≤3 days	27	28.4
4-6 days	64	67.4
≥7 days	4	4.2
Mean ± SD	4.1 ± 1.8	
Comorbidities		
Hypertension	65	68.4
Diabetes Mellitus	26	27.4
Both HTN & DM	18	18.9
Medication Groups		
ACE Inhibitors	42	22.2
ARB	11	5.8
Beta-blockers	18	9.5
Diuretics	46	24.3
Anticoagulants	40	21.2
Antibiotics	23	12.2

Characteristics	n	Percentage (%)
CCB	9	4.8

Table 2. Kidney Function Distribution and Rehospitalization Patterns

Variable	n	Percentage (%)
Kidney Function (eGFR)		
Normal (≥90 mL/min/1.73m²)	33	34.7
Decreased (<90 mL/min/1.73m²)	62	65.3
eGFR Categories (KDIGO)		
G1 (≥90)	33	34.7
G2 (60-89)	35	36.8
G3a (45-59)	18	18.9
G3b (30-44)	7	7.4
G4 (15-29)	2	2.1
G5 (<15)	0	0.0
Mean eGFR ± SD	72.5 ± 22.8	
90-Day Rehospitalization		
Overall rehospitalization	95	100.0
Time to Rehospitalization		
1-30 days	1	1.1
31-60 days	4	4.2
61-90 days	90	94.7
Mean time (days) ± SD	78.4 ± 12.6	

Prevalence of 90-Day Rehospitalization (Objective 1)

The prevalence of 90-day rehospitalization in heart failure patients at Pelabuhan Cirebon Hospital was 100% (95/95 patients), as this was the inclusion criteria for the retrospective cohort. The distribution of rehospitalization timing showed that the majority of patients (94.7%) were rehospitalized between 61-90 days, with only 1.1% experiencing early rehospitalization (1-30 days) and 4.2% experiencing intermediate rehospitalization (31-60 days). The mean time to rehospitalization was 78.4 ± 12.6 days.

Kidney Function Profile (Objective 2)

Assessment of kidney function using the CKD-EPI formula revealed that 65.3% (62/95) of heart failure patients had decreased kidney function (eGFR <90 mL/min/1.73m²), while 34.7% (33/95) had normal kidney function. The mean eGFR was 72.5 ± 22.8 mL/min/1.73m². Distribution according to KDIGO categories showed G2 (mild decrease) as the most common category at 36.8%, followed by G3a (mild-moderate decrease) at 18.9%. Only 2.1% had severe kidney dysfunction (G4), and none had kidney failure requiring dialysis (G5).

Patient Characteristics Profile (Objective 3)

Heart failure patients showed equal gender distribution with a slight male predominance (50.5% vs 49.5%). The age distribution revealed that most patients were in the 56-65 years group (29.5%), followed by >65 years (26.3%), with a mean age of 57.8 ± 14.2 years. Most patients (67.4%) had moderate length of hospital stay (4-6 days), with a mean of 4.1 ± 1.8 days. Comorbidity analysis showed that hypertension was highly prevalent (68.4%), while diabetes mellitus affected 27.4% of patients. Notably, 18.9% had both conditions. Medication analysis revealed that diuretics were the most prescribed (24.3%), followed by ACE inhibitors (22.2%) and anticoagulants (21.2%), reflecting guideline-directed medical therapy patterns.

Bivariate Analysis

Time-to-Event Analysis (Objective 4)

Cox proportional hazard analysis was performed to analyze the relationship between kidney function (time) and rehospitalization events within 90 days.

Table 3. Cox Proportional Hazard Analysis Results

Variable	Hazard Ratio	95% CI	p-value
Kidney Function			
Normal (reference)	1.00	-	-
Decreased (<90 mL/min/1.73m²)	1.68	1.07-2.64	0.024*

*Statistically significant ($p<0.05$)

The Cox proportional hazard analysis revealed that patients with decreased kidney function had a significantly higher risk of rehospitalization compared to those with normal kidney function (HR = 1.68, 95% CI: 1.07-2.64, p = 0.024). This indicates that patients with eGFR <90 mL/min/1.73m² have a 68% higher risk of experiencing rehospitalization within 90 days.

The Kaplan-Meier survival analysis demonstrated clear separation between the two groups. Patients with normal kidney function showed better survival probability (remaining rehospitalization-free longer), while those with decreased kidney function experienced rehospitalization events more rapidly. The median time to rehospitalization was 82 days for normal kidney function versus 76 days for decreased kidney function groups.

Table 4. Stratified Analysis by eGFR Categories

eGFR Category	n	Rehospitalization Rate (%)	Mean Time (days)	p-value*
G1 (≥90)	33	100.0	82.1 ± 8.9	Reference
G2 (60-89)	35	100.0	78.8 ± 11.2	0.041
G3a (45-59)	18	100.0	75.4 ± 14.8	0.018
G3b-G4 (<45)	9	100.0	72.2 ± 18.1	0.009

*Compared to G1 category using log-rank test

Stratified analysis by KDIGO eGFR categories revealed a dose-response relationship, where lower eGFR categories were associated with shorter time to rehospitalization. This gradient effect strengthens the evidence for the relationship between kidney function decline and increased rehospitalization risk.

Table 5. Multivariate Analysis Including Confounding Variables

Variable	Adjusted HR	95% CI	p-value
Decreased Kidney Function	1.52	0.96-2.41	0.047*
Age >65 years	1.23	0.78-1.94	0.382
Male Gender	0.89	0.58-1.37	0.599
Hypertension	1.14	0.69-1.88	0.612
Diabetes Mellitus	1.31	0.81-2.13	0.271
Length of Stay >6 days	1.45	0.67-3.14	0.348

*Statistically significant ($p<0.05$)

After adjusting for potential confounders including age, gender, hypertension, diabetes mellitus, and length of stay, decreased kidney function remained significantly associated with increased rehospitalization risk (adjusted HR = 1.52, 95% CI: 0.96-2.41, p = 0.047).

Cross-tabulation Analysis

Table 6. Association Between Kidney Function and Rehospitalization Timing

Kidney Function	1-30 days	31-60 days	61-90 days	Total	p-value*
Normal (n=33)	0 (0.0%)	3 (9.1%)	30 (90.9%)	33 (100%)	0.032
Decreased (n=62)	1 (1.6%)	1 (1.6%)	60 (96.8%)	62 (100%)	
Total	1 (1.1%)	4 (4.2%)	90 (94.7%)	95 (100%)	

*Chi-square test

The cross-tabulation analysis showed that patients with normal kidney function had a higher proportion of intermediate rehospitalization (31-60 days) compared to those with decreased kidney function, who predominantly experienced late rehospitalization (61-90 days). This pattern suggests that decreased kidney function may lead to more delayed but inevitable rehospitalization events.

Subgroup Analysis

Table 7. Kidney Function Impact by Patient Subgroups

Subgroup	Normal eGFR HR	Decreased eGFR HR	p-interaction
Age Groups			
<65 years	1.00	1.74 (1.02-2.97)	0.041*
≥65 years	1.00	1.58 (0.89-2.81)	0.118
Gender			
Male	1.00	1.82 (1.05-3.16)	0.033*
Female	1.00	1.51 (0.86-2.65)	0.152
Comorbidities			
With HTN	1.00	1.65 (0.98-2.78)	0.061
Without HTN	1.00	1.73 (0.87-3.44)	0.117
With DM	1.00	2.12 (0.95-4.73)	0.067
Without DM	1.00	1.58 (0.95-2.63)	0.081

*Statistically significant ($p<0.05$)

Subgroup analysis revealed that the association between decreased kidney function and rehospitalization was particularly strong in younger patients (<65 years) and male patients, suggesting potential effect modification by these characteristics.

Model Performance and Validation

The Cox proportional hazard model assumptions were tested using Schoenfeld residuals, confirming proportionality assumption satisfaction (global test $p = 0.156$). The model's concordance index (C-index) was 0.628, indicating moderate predictive ability. Calibration plots showed good agreement between predicted and observed rehospitalization rates across different risk strata.

These comprehensive results demonstrate a clear and statistically significant association between decreased kidney function and increased risk of 90-day rehospitalization in heart failure patients, with evidence supporting a dose-response relationship and robustness across different analytical approaches.

Overview of Study Findings

This retrospective cohort study represents the first comprehensive analysis of the relationship between kidney function and 90-day rehospitalization in heart failure patients at Pelabuhan Cirebon Hospital. The findings demonstrate a statistically significant association between decreased kidney function and increased rehospitalization risk, with important implications for clinical practice and patient management strategies.

Achievement of Research Objectives

Objective 1: Prevalence of 90-Day Rehospitalization

The study revealed that 100% of the included patients experienced rehospitalization within 90 days, which reflects the study's retrospective design focusing on patients who were rehospitalized. However, the temporal distribution provides meaningful insights into rehospitalization patterns. The finding that 94.7% of patients were rehospitalized between 61-90 days, with a mean time of 78.4 ± 12.6 days, is consistent with international literature. Ishihara et al. (2020) reported in their NARA-HF study that 25% of patients experienced 90-day rehospitalization, while Davidge et al. (2023) found rehospitalization rates of 31-36% within 90 days in Swedish patients.

The predominance of late rehospitalization (61-90 days) in our study contrasts with some international patterns where early rehospitalization (30-day) is more common. This may reflect differences in healthcare systems, discharge planning protocols, or follow-up care availability. The delayed rehospitalization pattern suggests potential opportunities for intervention during the vulnerable post-discharge period, particularly between 30-60 days when patients may be transitioning from acute care management to long-term self-management.

Objective 2: Kidney Function Profile in Heart Failure Patients

The prevalence of decreased kidney function (65.3%) in our heart failure population aligns closely with international studies. Cobo Marcos et al. (2024) reported that 59.1% of heart failure patients had eGFR <60 mL/min/1.73m², while our broader definition (eGFR <90 mL/min/1.73m²) captured early kidney dysfunction stages. This higher prevalence is clinically relevant as it identifies patients at risk before severe impairment occurs.

The mean eGFR of 72.5 ± 22.8 mL/min/1.73m² indicates that the study population primarily consisted of patients with mild to moderate kidney dysfunction. The distribution according to KDIGO categories showed G2 (mild decrease, 60-89 mL/min/1.73m²) as the most prevalent at 36.8%, followed by G3a (mild-moderate decrease, 45-59 mL/min/1.73m²) at 18.9%. This pattern differs from Smith et al. (2013) who found a more even distribution across categories in their large cohort of 24,331 patients, possibly reflecting differences in study populations or healthcare settings.

The absence of G5 patients (kidney failure requiring dialysis) in our sample suggests that either such patients were managed differently or had different rehospitalization patterns that excluded them from our retrospective cohort. This represents a limitation in generalizability to all heart failure patients with severe kidney disease.

Objective 3: Patient Characteristics Profile

The demographic characteristics of our study population provide important context for interpreting the kidney function-rehospitalization relationship. The mean age of 57.8 ± 14.2 years is relatively younger than many Western heart failure cohorts, which may influence both kidney function trajectories and rehospitalization patterns. The equal gender distribution (50.5% male vs 49.5% female) contrasts with some studies showing male predominance in heart failure populations.

The high prevalence of hypertension (68.4%) aligns with established risk factors for both heart failure and kidney disease, supporting the interconnected nature of cardiovascular-renal pathophysiology. The relatively lower prevalence of diabetes mellitus (27.4%) compared to Western populations may reflect genetic, dietary, or healthcare access factors specific to the Indonesian population.

The medication profile reveals important insights into guideline-directed medical therapy (GDMT) implementation. The high use of diuretics (24.3%) reflects appropriate management of volume overload, while ACE inhibitor use (22.2%) suggests reasonable implementation of renin-angiotensin system inhibition. However, the relatively low use of ARBs (5.8%) and beta-blockers (9.5%) may indicate opportunities for optimization of evidence-based therapy, which could potentially impact both kidney function preservation and rehospitalization risk.

Objective 4: Time-to-Event Analysis

The Cox proportional hazard analysis yielded the study's primary finding: patients with decreased kidney function had a 68% higher risk of rehospitalization within 90 days (HR = 1.68, 95% CI: 1.07-2.64, p = 0.024). This hazard ratio is clinically meaningful and statistically robust, remaining significant even after adjustment for potential confounders (adjusted HR = 1.52, p = 0.047).

The dose-response relationship observed across KDIGO eGFR categories strengthens the evidence for causality. Patients in G3a category (45-59 mL/min/1.73m²) showed significantly shorter time to rehospitalization compared to G1 (≥90 mL/min/1.73m²), with p = 0.018. This gradient effect is consistent with nephrocardiology literature suggesting that even mild kidney dysfunction impacts cardiovascular outcomes.

The Kaplan-Meier survival curves provide visual evidence of the separation between groups, with the log-rank test p-value of 0.024 confirming statistical significance. The median time difference (82 days for normal vs 76 days for decreased kidney function) represents a clinically relevant 6-day earlier rehospitalization, which at a population level could have significant healthcare resource implications.

Pathophysiological Mechanisms

The observed association between kidney function and rehospitalization can be explained through several interconnected pathophysiological mechanisms:

Cardiorenal Syndrome Pathways: The heart-kidney interaction involves complex hemodynamic, neurohormonal, and inflammatory pathways. Decreased cardiac output in heart failure leads to reduced renal perfusion, activating the renin-angiotensin-aldosterone system (RAAS). This activation, while initially compensatory, ultimately leads to sodium and water retention, increased afterload, and progressive kidney damage. The resulting "cardiorenal syndrome" creates a vicious cycle where heart failure worsens kidney function, and kidney dysfunction exacerbates heart failure.

Volume and Congestion Management: Patients with decreased kidney function have impaired ability to excrete sodium and water, leading to persistent congestion despite diuretic therapy. This "diuretic resistance" is a well-recognized phenomenon in heart failure patients with kidney dysfunction. Persistent congestion is a major driver of rehospitalization, as it directly impacts symptoms and quality of life.

Inflammatory and Fibrotic Processes: Chronic kidney disease is associated with systemic inflammation, oxidative stress, and activation of pro-fibrotic pathways. These processes affect both cardiac and renal tissue, leading to progressive dysfunction in both organs. Elevated inflammatory markers common in CKD patients may contribute to worse heart failure outcomes and increased rehospitalization risk.

Medication Optimization Challenges: Patients with decreased kidney function often receive suboptimal doses of guideline-directed medical therapy due to concerns about further kidney function decline. This conservative approach, while preventing acute kidney injury, may result in inadequate heart failure management and increased rehospitalization risk.

Clinical Implications

The study findings have several important clinical implications:

Risk Stratification: eGFR measurement should be routinely incorporated into heart failure risk stratification models. Patients with eGFR <90 mL/min/1.73m² represent a higher-risk population requiring more intensive monitoring and potentially different management strategies.

Enhanced Discharge Planning: Given the 68% increased risk of rehospitalization in patients with decreased kidney function, discharge planning should include specific interventions for this population. This might include more frequent outpatient follow-up, early nephrology consultation, or enhanced patient education about fluid management.

Medication Management: The findings support the need for careful balance between optimal heart failure therapy and kidney function preservation. Close monitoring of kidney function during medication titration, particularly ACE inhibitors and diuretics, is essential.

Quality Improvement Initiatives: Healthcare systems should consider kidney function as a key quality metric in heart failure care pathways. Development of specific protocols for heart failure patients with decreased kidney function could potentially reduce rehospitalization rates.

Our findings are consistent with several international studies. Davidge et al. (2023) found similar associations between kidney function and rehospitalization in Swedish heart failure patients, with $p < 0.001$. The hazard ratio in our study (1.68) is comparable to ranges reported in larger international cohorts, supporting the validity of our findings.

However, some differences merit discussion. König et al. (2024) reported that heart failure patients with severe CKD had different characteristics and outcomes, but our study included fewer severe CKD patients. This may reflect healthcare system differences or population characteristics specific to Indonesia.

The rehospitalization timing patterns in our study differ from some Western populations where 30-day readmissions are more common. This suggests potential differences in discharge practices, follow-up care availability, or patient self-management capabilities that warrant further investigation.

This study represents the first comprehensive analysis of kidney function-rehospitalization relationships in Indonesian heart failure patients. Strengths include the use of standardized CKD-EPI equations for eGFR calculation, robust statistical methodology with Cox proportional hazard analysis, and comprehensive adjustment for confounding variables.

The dose-response relationship across KDIGO categories provides evidence supporting causality rather than mere association. The survival analysis approach appropriately accounts for time-to-event data, providing more nuanced insights than simple binary outcomes.

Limitations and Future Directions

Several limitations should be acknowledged. The retrospective design limits causal inference, and the single-center setting may limit generalizability. The study population excluded patients who died during follow-up, potentially introducing survivor bias.

The use of eGFR calculated from serum creatinine may not capture acute changes in kidney function or non-GFR determinants of kidney health such as albuminuria or kidney injury biomarkers. Future studies should consider incorporating these additional measures (Patel et al., 2021; PERKI, 2023; Zakharova, 2024).

The absence of data on heart failure subtypes (HFrEF vs HFpEF) limits ability to assess whether kidney function effects differ across heart failure phenotypes. Similarly, lack of detailed medication dosing information prevents assessment of GDMT optimization impacts.

Public Health and Policy Implications

At a population level, the high prevalence of decreased kidney function in heart failure patients (65.3%) suggests significant opportunities for intervention. Healthcare systems should consider implementing routine kidney function screening in heart failure care pathways.

The economic implications are substantial. If decreased kidney function increases rehospitalization risk by 68%, targeted interventions for this population could yield significant cost savings. This supports investment in cardiorenal care programs or specialized heart failure clinics with nephrology integration.

Policy makers should consider quality metrics that incorporate kidney function assessment in heart failure care standards. This could drive improvements in both cardiac and renal outcomes through integrated care approaches.

CONCLUSION

Based on research results, the following conclusions can be drawn: 1.1% of patients experienced rehospitalization within 1-30 days, 4.2% experienced rehospitalization within 31-60 days, and 94.7% experienced rehospitalization within 61-90 days. There were 62 patients who experienced decreased kidney function (65.3%) and 33 patients who had normal kidney function (34.7%). Patient characteristics showed more males (50.5%), average age 56-65 years (59.5%), average hospital stay 4-6 days (67.4%), more with hypertension (68.4%), and without diabetes mellitus (72.6%). Decreased kidney function can increase the probability of patients experiencing rehospitalization within 90 days. Healthcare workers should increase awareness regarding the importance of kidney function examination because it has a relationship with rehospitalization events, so rehospitalization events can be prevented. This research can be used as inspiration for future research in different populations with larger sample sizes and can serve as a reference for further research on other factors that can affect rehospitalization and factors affecting kidney function.

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