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Kidney Outcomes Among Medicare Beneficiaries After Hospitalization for Heart Failure

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IMPORTANCE Kidney health has received increasing focus as part of comprehensive heart failure (HF) treatment efforts. However, the occurrence of clinically relevant kidney outcomes in contemporary populations with HF has not been well studied.

OBJECTIVE To examine rates of incident dialysis and acute kidney injury (AKI) among Medicare beneficiaries after HF hospitalization.

DESIGN, SETTING, AND PARTICIPANTS This retrospective cohort study evaluated adults aged 65 years or older who were hospitalized for HF across 372 sites in the Get With The Guidelines–Heart Failure registry in the US between January 1, 2014, and December 31, 2018. Patients younger than 65 years or requiring dialysis either during or prior to hospitalization were excluded. Data were analyzed from May 4, 2021, to March 8, 2024.

MAIN OUTCOMES AND MEASURES The primary outcome was inpatient dialysis initiation in the year after HF hospitalization and was ascertained via linkage with Medicare claims data. Other all-cause and cause-specific hospitalizations were also evaluated. The covariate-adjusted association between discharge estimated glomerular filtration rate (eGFR) and 1-year postdischarge outcomes was examined using Cox proportional hazards regression models.

RESULTS Overall, among 85 298 patients included in the analysis (mean [SD] age, 80 [9] years; 53% women) mean (SD) left ventricular ejection fraction was 47% (16%) and mean (SD) eGFR was 53 (29) mL/min per 1.73 m^2; 54 010 (63%) had an eGFR less than 60 mL/min per 1.73 m^2. By 1 year after HF hospitalization, 6% had progressed to dialysis, 7% had progressed to dialysis or end-stage kidney disease, and 7% had been readmitted for AKI. Incident dialysis increased steeply with lower discharge eGFR category: compared with patients with an eGFR of 60 mL/min per 1.73 m^2 or more, individuals with an eGFR of 45 to less than 60 and of less than 30 mL/min per 1.73 m^2 had higher rates of dialysis readmission (45 to <60: adjusted hazard ratio [AHR], 2.16 [95% CI, 1.86-2.51]; <30: AHR, 28.46 [95% CI, 25.25-32.08]). Lower discharge eGFR (per 10 mL/min per 1.73 m^2 decrease) was independently associated with a higher rate of readmission for dialysis (AHR, 2.23; 95% CI, 2.14-2.32), dialysis or end-stage kidney disease (AHR, 2.34; 95% CI, 2.24-2.44), and AKI (AHR, 1.25; 95% CI, 1.23-1.27), with similar findings for all-cause mortality, all-cause readmission, and HF readmission. Baseline left ventricular ejection fraction did not modify the covariate-adjusted association between lower discharge eGFR and kidney outcomes.

CONCLUSIONS AND RELEVANCE In this study, older adults with HF had substantial risk of kidney complications, with an estimated 6% progressing to dialysis in the year after HF hospitalization. These findings emphasize the need for health care approaches prioritizing kidney health in this high-risk population.

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Supplemental content

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Chronic kidney disease (CKD) is prevalent across the heart failure (HF) spectrum, with the HF-CKD intersection associated with an especially high risk of adverse clinical outcomes.[1-3] As such, kidney health has received renewed focus as part of HF prevention and treatment efforts, and kidney end points are increasingly incorporated in major HF trials.[4] However, analyses investigating the occurrence of clinically relevant kidney outcomes in contemporary populations with HF are lacking, especially among older adults. In this cohort study using Get With The Guidelines-Heart Failure (GWTG-HF) registry data, we examined rates of incident dialysis and acute kidney injury (AKI) among Medicare beneficiaries after HF hospitalization.

Key Points

Question What is the incidence of clinically relevant kidney outcomes among older adults after heart failure (HF) hospitalization?

Findings In this cohort study including 85 298 Medicare beneficiaries hospitalized for HF, by 1 year after HF hospitalization, 6% of individuals progressed to dialysis; 63% were discharged with an estimated glomerular filtration rate less than 60 mL/min per 1.73 m^2, and risk of adverse kidney outcomes increased steeply with lower discharge estimated glomerular filtration rate.

Meaning In this study, older adults had substantial risk of dialysis and other kidney complications early after hospitalization for HF, highlighting the need for health care approaches prioritizing kidney health in this high-risk population.

Methods

Study Design

The objectives, design, and protocols of the GWTG-HF program have been previously described.[5] In brief, GWTG-HF is a quality improvement program based at participating hospitals in the US and prospectively collects data regarding patients with a primary discharge diagnosis of HF. A waiver of informed consent was granted under the Common Rule (6 CFR §46) as the GWTG-HF registry's primary purpose is quality improvement. The GWTG-HF protocol was approved by or received waivers from institutional review boards at each participating site. Analyses were approved by the institutional review board of Duke Clinical Research Institute. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Patient Population

This analysis included adult hospitalizations between January 1, 2014, and December 31, 2018, across 488 GWTG-HF sites. To enable linkage with Centers for Medicare & Medicaid Services (CMS) Part A inpatient claims data, we excluded individuals younger than 65 years. Additional exclusion criteria are reviewed in the eMethods in Supplement 1. The 2021 race-free Chronic Kidney Disease Epidemiology Collaboration equation was used to calculate estimated glomerular filtration rate (eGFR) using demographic data and serum creatinine levels at or closest to the time of discharge (eg, if missing).[6]

Statistical Analysis

Data were analyzed from May 4, 2021, to March 8, 2024. Patients were categorized into 5 prespecified eGFR groups according to Kidney Disease: Improving Global Outcomes classification (≥90, 60 to <90, 45 to <60, 30 to <45, and <30 mL/min per 1.73 m^2). Pearson χ^2 and Kruskal-Wallis tests were used to compare categorical and continuous variables, respectively.

Cox proportional hazards regression models were used to evaluate the association between discharge eGFR and the primary outcome of postdischarge dialysis initiation by 1 year of follow-up. Secondary outcomes included other kidney events (readmission for dialysis or end-stage kidney disease [ESKD] and readmission for AKI) and other clinical outcomes (all-cause mortality, all-cause readmission, and HF readmission). Clinical outcomes were established via linkage with CMS data. Administrative coding definitions for kidney events are displayed in eTable 1 in Supplement 1. Cause-specific event rates were determined using primary discharge diagnoses with the exception of dialysis and ESKD, for which nonprimary diagnoses were also considered. When applicable, a cumulative incidence function was used to account for competing risk of death. Additional Cox proportional hazards regression models were constructed to evaluate for modification of the association between continuous eGFR and clinical outcomes by left ventricular ejection fraction (LVEF) category (≤40%, 41%-49%, and ≥50%).

Associations between discharge eGFR and clinical outcomes were adjusted for prespecified patient-level sociodemographic and clinical covariates as well as hospital characteristics (eMethods in Supplement 1). Incomplete model covariates were imputed according to the procedure in the eMethods in Supplement 1. The proportional hazards assumption was upheld for all models, and robust variance estimators were used to account for within-hospital clustering.

Race and ethnicity were ascertained by self-report and included because burden of kidney disease and adverse kidney outcomes may be disproportionately high in racial and ethnic minority populations. Race and ethnicity were categorized as African American or Black, Asian, Hispanic, and White.

Associations were summarized as adjusted hazard ratios (AHRs) with 95% CIs, with eGFR of 60 mL/min per 1.73 m^2 or more as the reference group for analyses focusing on dialysis, ESKD, or both (otherwise, eGFR≥90 mL/min per 1.73 m^2 was used). Discharge eGFR was additionally modeled as a continuous variable, reported as AHR (95% CI) per 10-unit decrement in eGFR. Analyses were performed using SAS, version 9.4 (SAS Institute Inc). Two-tailed *P* values <.05 were considered statistically significant.

Results

Of 148 028 hospitalizations at 488 GWTG-HF sites between January 1, 2014, and December 31, 2018, 62 730 were excluded (eFigure 1 in Supplement 1), yielding a final cohort of

Table. Baseline Characteristics, by Discharge eGFR Category

Characteristic	Individuals, by discharge eGFR category, mL/min per 1.73 m^2[a]					*P* value[b]
	≥90 (n = 6231)	60 to <90 (n = 25 057)	45 to <60 (n = 19 299)	30 to <45 (n = 20 158)	<30 (n = 14 553)	
Demographics						
Age, mean (SD), y	73 (6)	80 (9)	81 (9)	82 (8)	81 (9)	<.001
Sex						
Female	2748 (44)	12 812 (51)	9959 (52)	11 263 (56)	8418 (58)	<.001
Male	3483 (56)	12 245 (49)	9340 (48)	8895 (44)	6135 (42)	
Race and ethnicity						
African American or Black	448 (7)	1757 (7)	1702 (9)	1965 (10)	2092 (14)	<.001
Asian	69 (1)	277 (1)	221 (1)	252 (1)	260 (2)	
Hispanic	301 (5)	962 (4)	673 (3)	674 (3)	617 (4)	
White	5282 (85)	21 528 (86)	16 333 (85)	16 860 (84)	11 247 (77)	
Medical history						
AF or AFL	2644 (42)	12 324 (49)	9753 (51)	10 024 (50)	6130 (42)	<.001
COPD or asthma	2645 (42)	8295 (33)	6294 (33)	6359 (32)	4332 (30)	<.001
Stroke or TIA	939 (15)	4224 (17)	3375 (17)	3676 (18)	2686 (18)	<.001
Peripheral vascular disease	674 (11)	2548 (10)	2265 (12)	2661 (13)	2202 (15)	<.001
Previous MI	1102 (18)	4274 (17)	3843 (20)	4147 (21)	2899 (20)	<.001
Hypertension	4941 (79)	20 702 (83)	16 245 (84)	17 315 (86)	12 767 (88)	<.001
Diabetes	2281 (37)	8307 (33)	7434 (39)	8888 (44)	7647 (53)	<.001
Smoking history	1259 (20)	2358 (9)	1259 (8)	1268 (6)	990 (7)	<.001
LVEF, mean (SD), %	46 (16)	47 (16)	46 (16)	46 (16)	47 (16)	<.001
HFrEF (LVEF≤40%)	2271 (36)	8736 (35)	6978 (36)	7073 (35)	4783 (33)	<.001
Discharge vital signs and laboratory measurements						
Body mass index, mean (SD)[c]	29 (8)	28 (8)	29 (8)	29 (8)	29 (8)	<.001
Heart rate, mean (SD), /min	79 (15)	77 (14)	76 (14)	75 (14)	74 (14)	<.001
Systolic blood pressure, mean (SD), mm Hg	123 (20)	124 (20)	124 (20)	126 (20)	130 (21)	<.001
Potassium level, median (IQR), mEq/L	3.9 (3.7-4.2)	4.0 (3.7-4.3)	4.0 (3.7-4.3)	4.0 (3.7-4.4)	4.1 (3.8-4.5)	<.001
NT-proBNP level, median (IQR), pg/mL	2777 (1330-5797)	3615 (1818-7205)	4453 (2128-9123)	5507 (2609-11 450)	8670 (3853-19 077)	<.001
eGFR, median (IQR), mL/min per 1.73 m^2	94 (92-97)	72 (66-81)	52 (49-56)	38 (34-41)	23 (18-27)	<.001
Hospital characteristics						
Teaching hospital	4824 (77)	19 356 (77)	14 963 (78)	15 587 (77)	11 310 (78)	.34
Geographic region						
West	1172 (19)	4349 (17)	2971 (15)	2823 (14)	1990 (14)	<.001
South	1882 (30)	7335 (29)	5915 (31)	6311 (31)	4680 (32)	
Midwest	1420 (23)	5552 (22)	4388 (23)	4747 (24)	3327 (23)	
Northeast	1757 (28)	7821 (31)	6025 (31)	6277 (31)	4556 (31)	
Length of stay, median (IQR), d	4 (3-6)	4 (2-5)	4 (3-5)	4 (3-6)	4 (3-6)	<.001

Abbreviations: AF, atrial fibrillation; AFL, atrial flutter; COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate; HFrEF, heart failure with reduced ejection fraction; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NT-proBNP, *N*-terminal fragment of the prohormone brain natriuretic peptide; TIA, transient ischemic attack.

SI conversion: To convert potassium to millimoles per liter, multiply by 1.0.

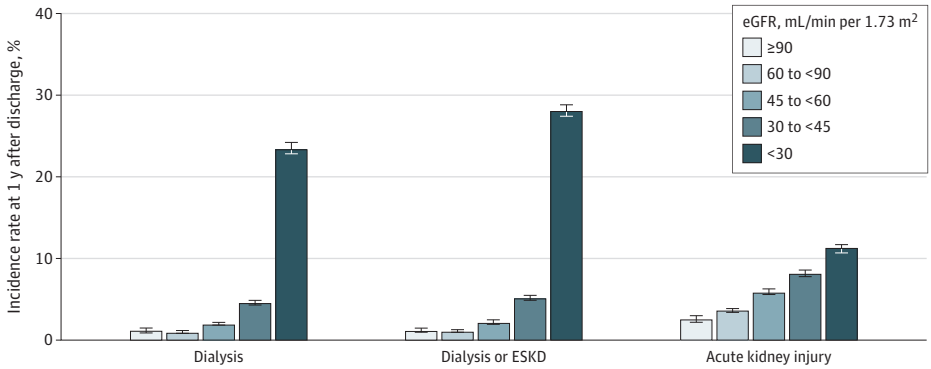
[a] Data are presented as number (percentage) of individuals unless otherwise indicated. Categorical variables were compared using the Pearson χ^2 test, and continuous variables were compared using the Kruskal-Wallis test.

[b] Estimated after accounting for ordinal eGFR group comparisons using χ^2 rank correlations and χ^2 rank-based group mean score statistics.

[c] Calculated as weight in kilograms divided by height in meters squared.

85 298 hospitalizations from 372 sites. Among 85 298 patients (mean [SD] age, 80 [9] years; 47% men; 53% women; mean [SD] LVEF, 47% [16%]) included in the analysis, the mean (SD) eGFR was 53 (29) mL/min per 1.73 m^2 and 54 010 (63%) had an eGFR of less than 60 mL/min per 1.73 m^2. Of the patients, 9% were African American or Black, 1% were Asian, 4% were Hispanic, and 84% were White. Patients with lower eGFR were more likely to be older, women, and Black (**Table**). Lower

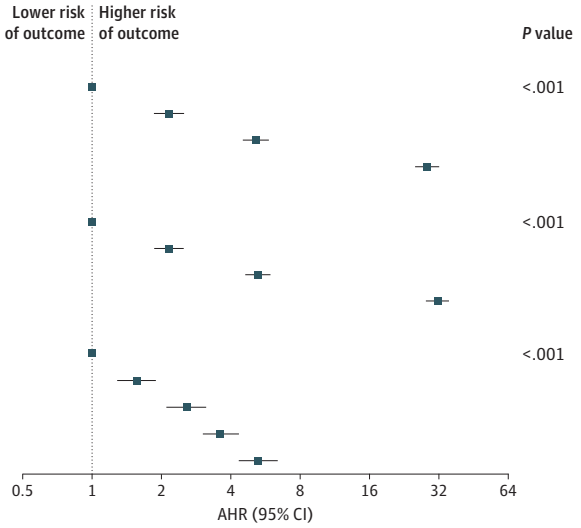
Figure 1. Incidence of Kidney Outcomes 1 Year After Heart Failure (HF) Hospitalization, by Discharge Estimated Glomerular Filtration Rate (eGFR) Group



Incidence rates were estimated using Cox proportional hazards regression models with cumulative incidence function accounting for competing risk of death. *P* < .001 for all comparisons. Error bars indicate 95% CIs. ESKD indicates end-stage kidney disease.

Figure 2. Kidney Outcomes 1 Year after Heart Failure Hospitalization, by Discharge Estimated Glomerular Filtration Rate Group

Outcome by eGFR, mL/min per 1.73 m^2	AHR (95% CI)	*P* value
Dialysis		
60 to <90	1 [Reference]	<.001
45 to <60	2.16 (1.86-2.51)	
30 to <45	5.15 (4.52-5.86)	
<30	28.46 (25.25-32.08)	
Dialysis or ESKD		
60 to <90	1 [Reference]	<.001
45 to <60	2.16 (1.87-2.50)	
30 to <45	5.25 (4.63-5.95)	
<30	31.62 (28.16-35.51)	
Acute kidney injury		
≥90	1 [Reference]	<.001
60 to <90	1.57 (1.29-1.90)	
45 to <60	2.58 (2.11-3.14)	
30 to <45	3.62 (3.03-4.34)	
<30	5.26 (4.33-6.40)	



Models adjusted for relevant prespecified sociodemographic, clinical, and hospital characteristics. AHR indicates adjusted hazard ratio; ESKD, end-stage kidney disease.

eGFR was additionally associated with higher LVEF, natriuretic peptides, and potassium levels as well as a higher prevalence of hypertension, diabetes, prior myocardial infarction, peripheral vascular disease, and stroke or transient ischemic attack.

Postdischarge Kidney Outcomes by Discharge eGFR Category

By 1 year after discharge, 6% had progressed to dialysis, 7% had progressed to dialysis or ESKD, and 7% were readmitted for AKI (eTable 2 in Supplement 1). Adults with a dialysis end point were generally younger and more likely to be men, Black, and Hispanic and to have cardiovascular-kidney-metabolic risk factors and lower eGFR (eTable 3 in Supplement 1).

In addition, 34% had died of any cause, 65% were readmitted for any cause, and 30% were readmitted for HF. The 1-year cumulative incidence of kidney outcomes increased significantly with worse eGFR category (**Figure 1**). Incidences of other clinical outcomes by discharge eGFR category are displayed in eFigure 2 in Supplement 1.

Lower discharge eGFR category was independently associated with a higher rate of incident dialysis. Compared with discharge eGFR of 60 mL/min per 1.73 m^2 or more, eGFR of 45 to less than 60 mL/min per 1.73 m^2 was associated with a higher rate of dialysis initiation (AHR, 2.16; 95% CI, 1.86-2.51; *P* < .001), as was eGFR of less than 30 mL/min per 1.73 m^2 (AHR, 28.46; 95% CI, 25.25-32.08; *P* < .001) (**Figure 2** and eTable 4 in Supplement 1). Similar findings were observed for dialysis or ESKD, readmission for AKI, and other clinical outcomes (Figure 2 and eFigure 3 in Supplement 1).

Postdischarge Kidney Outcomes by Discharge eGFR as a Continuous Variable

When evaluated as a continuous variable, lower discharge eGFR (per 10 mL/min per 1.73 m^2 decrease) was independently associated with a higher rate of readmission for dialysis (AHR, 2.23; 95% CI, 2.14-2.32; *P* < .001), readmission for dialysis or ESKD (AHR, 2.34; 95% CI, 2.24-2.44; *P* < .001), and readmission for AKI (AHR, 1.25; 95% CI, 1.23-1.27; *P* < .001). Similar findings were observed for all-cause mor-

tality, all-cause readmission, and HF readmission (eTable 5 in Supplement 1).

Postdischarge Kidney Outcomes by LVEF Category

Baseline LVEF did not modify the covariate-adjusted association between lower discharge eGFR and kidney outcomes (eFigure 4 in Supplement 1). However, decrements in eGFR were associated with a modestly higher rate of all-cause mortality, all-cause readmission, and HF readmission when LVEF was 40% or less compared with 41% to 49% and 50% or more (eFigure 4 in Supplement 1).

Discussion

In this nationwide GWTG-HF analysis, kidney disease was highly prevalent among older adults hospitalized for HF in the US, with 63% of Medicare beneficiaries discharged with an eGFR less than 60 mL/min per 1.73 m^2. Risk of adverse kidney outcomes increased steeply with lower discharge eGFR, with 6% of Medicare beneficiaries progressing to dialysis and 7% progressing to dialysis or ESKD within 1 year after HF hospitalization, without significant differences by LVEF category. The 1-year risk of AKI was also noteworthy at 11% of individuals in the lowest eGFR category. Overall, these findings highlight the importance of prioritizing kidney health as part of comprehensive approaches to HF care.

This analysis addressed an important research gap related to understanding of contemporary, patient-centered clinical outcomes, such as dialysis and other kidney-related readmissions, after HF hospitalization. The majority of antecedent research efforts examining these cardiovascular-kidney interactions have leveraged populations from HF trials and, therefore, have largely reported only on biomarker-based outcomes (eg, eGFR slope).[4,7] Furthermore, data in older adults are scarce. These findings support and extend those of major HF trials, may enhance shared decision-making around kidney-related screening and treatment efforts, and support positioning of kidney health as an important focus of health care delivery efforts designed to meet the comprehensive needs of older adults with HF. Wider uptake of newer disease-modifying pharmacotherapies in populations with concomitant HF and CKD, among whom implementation is historically limited,[3,8-10] has the potential to simultaneously improve HF and kidney outcomes.[11-15]

Limitations

This analysis has some limitations. First, because HF and AKI readmissions were captured only as primary discharge diagnoses, these events may be underestimated. Noncapture of ambulatory AKI and dialysis initiation may have additionally contributed to underestimation of these events. Second, residual measured and unmeasured confounding may have influenced these findings. Third, urinary albumin-to-creatinine ratio and serum cystatin C were not available, and exclusion of individuals with unavailable eGFR in the database may have introduced bias. Furthermore, eGFR calculation during acute care episodes may be less accurate compared with stable outpatient care. Fourth, the voluntary nature of GWTG-HF and the use of Medicare-linked data may limit the generalizability of these findings to other populations. Despite these limitations, we believe this is among the largest experiences tracking kidney events after hospitalization for HF and is especially relevant for those caring for older adults.

Conclusions

In this cohort study, older adults had substantial risk of kidney complications, readmission, and death early after HF hospitalization. These findings emphasize the need for health care delivery approaches prioritizing both cardiovascular and kidney health in this high-risk population.

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Concept and design: Ostrominski, Greene, DeVore, Butler, Huang, Kittleson, Linganathan, McDermott, Owens, Peterson, S.D. Solomon, Fonarow, Vaduganathan.
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