

Causes and Temporal Patterns of 30-Day Readmission Among Older Adults Hospitalized With Heart Failure With Preserved or Reduced Ejection Fraction

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Background—It is unknown whether causes and temporal patterns of 30-day readmission vary between heart failure (HF) with preserved ejection fraction (HFpEF) and HF with reduced ejection fraction (HFrEF). We sought to address this question by examining a 5% national sample of Medicare beneficiaries.

Methods and Results—We included individuals who experienced a hospitalization for HFpEF or HFrEF between 2007 and 2013. We identified causes of 30-day readmission based on primary discharge diagnosis and further classified causes of readmission as HF-related, non-HF cardiovascular-related, and non-cardiovascular-related. We calculated the cumulative incidence of these classifications for HFpEF and HFrEF in a competing risks model and calculated subdistribution hazard ratios of these classifications by comparing those with HFpEF and those with HFrEF. Among 60 640 Medicare beneficiaries, we identified 13 785 unique older adults hospitalized with HFpEF and 15 205 who were hospitalized with HFrEF. Noncardiovascular diagnoses represented the most common causes of 30-day readmission (HFpEF: 59%; HFrEF: 47%), a pattern that was observed for each week of the 30-day study period for both HFpEF and HFrEF participants. In comparing readmission diagnoses in an adjusted model, non-cardiovascular-related diagnoses were more common and HF-related diagnoses were less common in HFpEF participants.

Conclusions—Non-cardiovascular-related diagnoses represented the most common causes of 30-day readmission following HF hospitalization for each week of the 30-day postdischarge period. HF diagnoses were less common among those with HFpEF compared with HFrEF. Future interventions aimed at reducing 30-day readmissions following an HF hospitalization would benefit from an increased focus on noncardiovascular comorbidity and interventions that target HFpEF and HFrEF separately. (*J Am Heart Assoc.* 2018;7:e007785. DOI: 10.1161/JAHA.117.007785.)

Key Words: comorbidities heart failure • epidemiology • heart failure • patient readmission

One in 4 older adults hospitalized with heart failure (HF) in the United States are readmitted within 30 days of discharge.¹ Costing >\$1.7 billion annually,² readmissions put a substantial burden on the healthcare system. To control costs associated with potentially preventable readmissions, the Centers for Medicare and Medicaid Services (CMS) now impose penalties on hospitals with excessive readmission rates,³ prompting hospitals across the country to search for ways to reduce their 30-day readmission rates.

Interventions aimed at reducing readmission rates in HF have produced mixed results⁴ for reasons that are not yet fully elucidated. A possible contributor may be the heterogeneity of the HF disease state. Clinically, HF is typically dichotomized by the presence or absence of a reduced ejection fraction, described as HF with preserved ejection fraction (HFpEF) and HF with reduced ejection fraction (HFrEF). Given important differences in patient demographics,⁵ comorbidity profiles,⁶ natural history,^{7,8} and availability of evidence-based

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An accompanying Figure S1 is available at <http://jaha.ahajournals.org/content/7/9/e007785/DC1/embed/inline-supplementary-material-1.pdf>

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Clinical Perspective

What Is New?

- The most common 30-day readmission diagnoses for heart failure (HF) with either preserved or reduced ejection fraction were noncardiovascular conditions.
- Noncardiovascular diagnoses composed the majority of readmissions for each week of the 30-day postdischarge period for HF with either preserved or reduced ejection fraction.
- Readmission specifically for heart failure was less common among those with HF with preserved ejection fraction compared with those with HF with reduced ejection fraction.

What Are the Clinical Implications?

- A paradigm shift with an increased emphasis on noncardiovascular comorbidities in patients admitted for HF may be warranted, independent of ejection fraction.
- Our observation that the most common readmission diagnoses following discharge were noncardiovascular suggests that follow-up with a primary care physician may be as important as follow-up with a cardiologist.
- Given differences in patterns of readmission, interventions aimed at reducing 30-day readmissions may need to be tailored for HF with preserved or reduced ejection fraction separately.

therapies,⁹ causes of and temporal patterns in 30-day readmission may vary for HFpEF and HFrEF. This could have important implications for developing interventions aimed at curbing readmission rates.

Accordingly, we compared and contrasted the causes and temporal patterns of 30-day readmissions among patients with HFpEF and HFrEF using a 5% national random sample of Medicare beneficiaries.

Methods

The data, analytic methods, and study materials cannot be made available to other researchers for purposes of reproducing the results or replicating the procedure, as our Medicare data reuse agreement prohibits sharing these data.

We drew the study population from a national 5% sample of Medicare beneficiaries and included individuals who experienced a hospitalization for HFpEF or HFrEF between 2007 and 2013, lived in the United States, had full fee-for-service and prescription drug coverage in the year before hospitalization, and were aged 65 to 109 years on the day of admission. HFpEF hospitalizations were identified as inpatient claims with an *International Classification of Diseases, Ninth Revision (ICD-9)* primary discharge diagnosis of 428.3x (diastolic HF), and

HFrEF hospitalizations were identified as inpatient claims with an *ICD-9* primary discharge diagnosis of 428.2x (systolic HF) or 428.4x (combined systolic and diastolic HF). Only the first HF hospitalization was used for each individual (Figure S1).

We assessed characteristics of the Medicare beneficiaries by using claims and enrollment data for the year before the hospitalization. These characteristics included age, race, sex, Medicaid eligibility, eligibility for Part D prescription drug coverage subsidies, US Census region, history of coronary heart disease, chronic kidney disease, diabetes mellitus, atrial fibrillation, hypertension, chronic obstructive pulmonary disease, Charlson comorbidity index, length of stay, nursing home residence,¹⁰ and skilled nursing facility stay in the prior year. We also identified intensive care unit stays during the HF hospitalization as a proxy for severity of illness.

Medicare beneficiaries were followed for readmission for up to 30 days after discharge. To avoid counting hospital transfers as readmissions, we considered hospital admissions that occurred on the day of a hospital discharge or the day after hospital discharge with a hospital transfer code as a single episode of care. We assessed causes of readmission by using the primary discharge diagnosis, grouped using the Healthcare Cost and Utilization Project Clinical Classifications software.¹¹ We further classified causes of readmission into HF-related (primary discharge diagnoses 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, or 428), non-HF cardiovascular-related (the first 3 digits of primary discharge diagnoses 390–459 except those listed previously for HF), and noncardiovascular-related (any inpatient claims except primary discharge diagnoses 390–459).

We calculated means and standard deviations for continuous characteristics and numbers and percentages for categorical beneficiary characteristics stratified by HF type (HFpEF versus HFrEF). We also calculated numbers and percentages for causes of readmission following HFpEF and HFrEF hospitalizations separately. We then calculated the cumulative incidence of HF-related, non-HF cardiovascular-related, and noncardiovascular-related readmissions for HFpEF and HFrEF participants, treating other causes of hospitalization and mortality as competing risks.¹² We also calculated subdistribution hazard ratios of HF-related, non-HF cardiovascular-related, and noncardiovascular-related readmissions comparing beneficiaries hospitalized for HFpEF and those hospitalized for HFrEF.¹² These models considered other causes of hospitalization and mortality as competing risks. For the HF-related readmissions, for example, non-HF cardiovascular-related and noncardiovascular-related readmissions, as well as mortality, were treated as competing risks. Models were initially adjusted for age, race, sex, eligibility for Medicaid and Part D subsidies, and region (model 1). We then additionally adjusted for history of coronary heart disease, chronic kidney disease, diabetes mellitus, atrial fibrillation, hypertension, chronic obstructive

pulmonary disease, Charlson comorbidity index, nursing home residence, skilled nursing facility stay in the prior year, length of stay (quartiles), and intensive care unit stay during the HF hospitalization as a proxy for severity of illness (model 2). To examine whether the association of HF type and cause-specific readmission varied by time since discharge, we included interactions between time since discharge and cause-specific readmission in our models. In addition, we calculated hazard ratios for the association between HF type and cause-specific readmission for each week of the month following discharge.

This research was approved by the CMS privacy board and the institutional review board of the University of Alabama at Birmingham with a waiver of consent.

Results

Among 60 640 Medicare beneficiaries hospitalized for HF from 2007 to 2013, we identified 13 785 unique older adults hospitalized with HFpEF and 15 205 unique older adults hospitalized with HFrEF. Older adults with HFpEF were slightly older, were more commonly women, and had a higher mean Charlson comorbidity index compared with those with HFrEF (Table 1). Older adults with HFpEF were more likely to have hypertension and chronic obstructive pulmonary disease; older adults with HFrEF were more likely to have coronary heart disease. Length of stay was similar for HFpEF and HFrEF participants. Notably, older adults with HFpEF were less likely to require intensive care unit–level care and were more likely to be nursing home residents.

Older adults with HFpEF experienced a 30-day readmission rate of 22.3%, and older adults with HFrEF experienced a 30-day readmission rate of 22.1%. Noncardiovascular causes of readmission occurred more frequently than HF-related and non-HF cardiovascular-related causes for both HFpEF and HFrEF participants (Table 2).

We examined temporal patterns of readmission diagnoses separately among participants with HFpEF and HFrEF (Figure). Among those with HFpEF, non–cardiovascular-related diagnoses composed the majority of readmissions over the course of the 30-day study period. This observation was noted during the first week following discharge and continued to compose the majority of readmissions during each week of the 30-day period. Similar to HFpEF participants, the majority of readmission diagnoses for those with HFrEF were non–cardiovascular-related for each week of the 30-day study period, although this was less marked compared with HFpEF participants. HF-related diagnoses were the next most common causes of readmission for each week of the study, followed by non-HF cardiovascular-related diagnoses.

In comparing readmission diagnoses for HFpEF and HFrEF participants, HF-related diagnoses were less common with HFpEF, even after adjusting for sociodemographics and

Table 1. Summary Statistics of Sample by Type of HF

Variable	HFpEF (n=13 785)	HFrEF (n=15 205)
Age, y, mean (SD)	78.6 (11.5)	76.5 (12.1)
Race		
Black	1827 (13.3)	2184 (14.4)
Other	800 (5.8)	852 (5.6)
White	11 158 (80.9)	12 169 (80.0)
Women	9853 (71.5)	7869 (51.8)
Medicare Part D subsidy	6869 (49.8)	7291 (48.0)
Dual eligibility for Medicare and Medicaid	5960 (43.2)	6146 (40.4)
US Census region		
Northeast	3144 (22.8)	3074 (20.2)
Midwest	3545 (25.7)	3909 (25.7)
South	5463 (39.6)	6257 (41.2)
West	1633 (11.8)	1965 (12.9)
Coronary heart disease	7726 (56.0)	10 932 (71.9)
Chronic kidney disease	8333 (60.4)	9244 (60.8)
COPD	7180 (52.1)	7338 (48.3)
Diabetes mellitus	6822 (49.5)	7439 (48.9)
Atrial fibrillation	6676 (48.4)	7193 (47.3)
Hypertension	12 081 (87.6)	12 337 (81.1)
Dementia	2487 (18.0)	2375 (15.6)
Liver disease	713 (5.2)	710 (4.7)
Cerebrovascular disease	2531 (18.4)	2654 (17.5)
Cancer	3013 (21.9)	3059 (20.1)
Charlson comorbidity index		
0	5328 (38.7)	5811 (38.2)
1–3	1588 (11.5)	1865 (12.3)
4–5	2139 (15.5)	2314 (15.2)
6–7	1763 (12.8)	2032 (13.4)
8–9	1528 (11.1)	1717 (11.3)
≥10	1439 (10.4)	1466 (9.6)
Length of stay, mean (SD)	6.3 (4.3)	6.3 (4.9)
ICU stay	2863 (20.8)	3530 (23.2)
Nursing home residence	2438 (17.7)	2112 (13.9)
Skilled nursing facility stay	2916 (21.2)	2481 (16.3)

Data are shown as n (%) except as noted. COPD indicates chronic obstructive pulmonary disease; HF, heart failure; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction; ICU, intensive care unit.

comorbidity burden (Table 3). This pattern remained for each of the 4 weeks of the 30-day readmission period studied ($P=0.63$ for interaction with time). Non-HF cardiovascular-related diagnoses were also less common in HFpEF compared to HFrEF, in both unadjusted and adjusted models.

Table 2. Causes of 30-Day Readmission Among Medicare Beneficiaries With HFpEF vs HFrEF

Cause	HFpEF Readmissions (n=3075)	HFrEF Readmissions (n=3367)
	n (%)	n (%)
HF	743 (24.2)	1105 (32.8)
Non-HF cardiovascular-related	517 (16.8)	673 (20.0)
Dysrhythmia	139 (4.5)	142 (4.2)
Acute myocardial infarction	54 (1.8)	108 (3.2)
Coronary atherosclerosis	60 (2.0)	97 (2.9)
Hypertension with complications	77 (2.5)	89 (2.6)
Non-cardiovascular-related	1815 (59.0)	1589 (47.2)
Acute renal failure	168 (5.5)	167 (5.0)
Septicemia	160 (5.2)	155 (4.6)
Pneumonia	150 (4.9)	106 (3.1)
Adult respiratory failure	141 (4.6)	104 (3.1)
COPD	99 (3.2)	84 (2.5)
Fluid/electrolyte diagnosis	82 (2.7)	81 (2.4)
Urinary tract infection	73 (2.4)	60 (1.8)

Values are numbers of readmission and percentages of those readmitted within 30 days. COPD indicates chronic obstructive pulmonary disease; HF, heart failure; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction.

Differences did not meet statistical significance for any single week of the 30-day readmission period ($P=0.50$ for interaction with time). Meanwhile, non-cardiovascular-related diagnoses were more common in HFpEF even after adjusting for

sociodemographics and comorbidity burden. This pattern was stable for each of the 4 weeks of the 30-day readmission period ($P=0.39$ for interaction with time).

Discussion

Our study revealed several important findings regarding causes and temporal patterns of 30-day readmission among older adults hospitalized with HFpEF and HFrEF. First, the most common diagnoses for 30-day readmission for both HFpEF and HFrEF were non-cardiovascular-related. Second, non-cardiovascular-related diagnoses composed the majority of readmissions for each week of the 30-day postdischarge period for both HFpEF and HFrEF participants. Finally, readmission for HF was less common among those with HFpEF compared with those with HFrEF.

The sociodemographic and clinical characteristics observed in this cohort were largely consistent with other cohorts that have reported key differences between HFpEF and HFrEF.^{13–15} Those with HFpEF were older, more commonly women, and more commonly white. They were also more likely to have hypertension and chronic obstructive pulmonary disease, comorbidities that have been implicated in the pathophysiology of HFpEF.¹⁶

Prior examination of Medicare data has revealed that HF accounts for a minority of 30-day readmissions among Medicare beneficiaries.¹⁷ Our data extend these findings by specifically comparing HFpEF and HFrEF participants, showing that the most common readmission diagnoses among both groups were noncardiovascular, with HF-related diagnoses accounting for a smaller proportion of readmissions. These

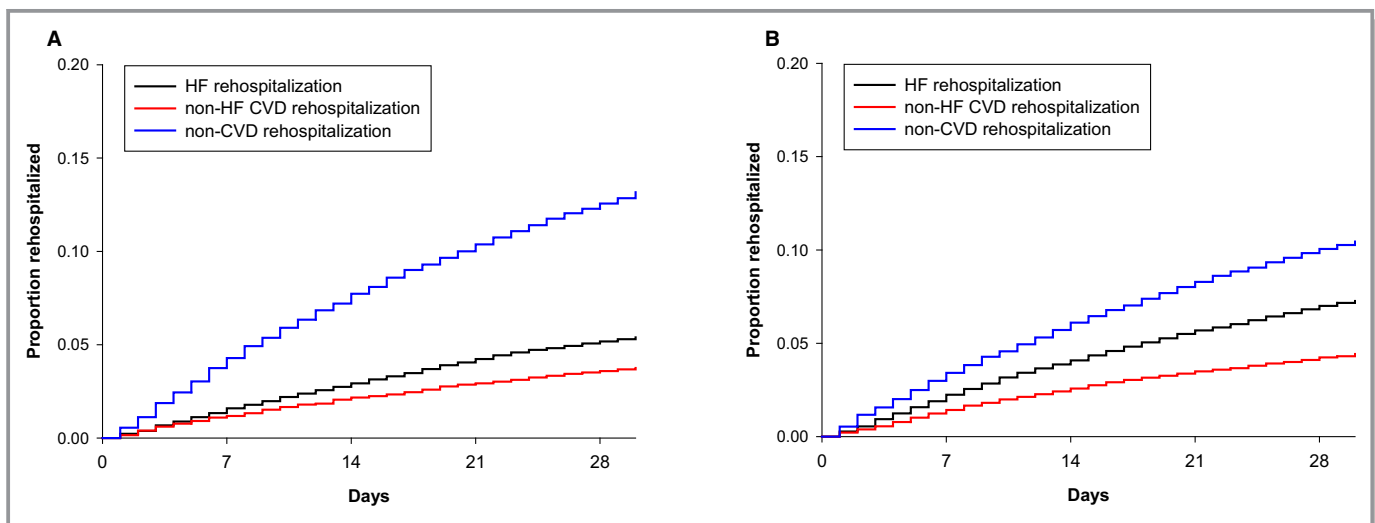


Figure. Temporal patterns for causes of readmission among Medicare beneficiaries with HFpEF versus HFrEF. A, Medicare beneficiaries hospitalized for HFpEF. B, Medicare beneficiaries hospitalized for HFrEF. CVD indicates cardiovascular-related; HF, heart failure; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction.

Table 3. HRs for Causes of Readmissions Comparing Medicare Beneficiaries With HFpEF vs HFrEF, Stratified by Week Following Hospital Discharge

	Overall		Week 1		Week 2		Week 3		Week 4	
	HR (95% CI)	P Value	HR (95% CI)	P Value	HR (95% CI)	P Value	HR (95% CI)	P Value	HR (95% CI)	P Value
HF-related readmission										
Model 1	0.73 (0.67–0.81)	<0.001	0.71 (0.59–0.84)	<0.001	0.72 (0.60–0.87)	<0.001	0.80 (0.66–0.97)	0.021	0.72 (0.59–0.88)	0.002
Model 2	0.74 (0.67–0.82)	<0.001	0.71 (0.60–0.85)	<0.001	0.73 (0.61–0.88)	0.001	0.81 (0.66–0.98)	0.028	0.73 (0.60–0.89)	0.002
Non-HF cardiovascular-related readmission										
Model 1	0.85 (0.75–0.95)	0.005	0.84 (0.68–1.03)	0.087	0.86 (0.69–1.08)	0.195	0.82 (0.63–1.05)	0.116	0.88 (0.69–1.13)	0.31
Model 2	0.88 (0.78–0.99)	0.033	0.87 (0.71–1.07)	0.176	0.89 (0.71–1.12)	0.329	0.85 (0.65–1.09)	0.197	0.91 (0.71–1.17)	0.464
Non-cardiovascular-related readmission										
Model 1	1.28 (1.19–1.37)	<0.001	1.26 (1.12–1.42)	<0.001	1.30 (1.14–1.48)	<0.001	1.24 (1.06–1.43)	0.006	1.33 (1.14–1.54)	<0.001
Model 2	1.23 (1.15–1.32)	<0.001	1.21 (1.08–1.37)	0.002	1.26 (1.10–1.44)	0.001	1.19 (1.03–1.39)	0.021	1.28 (1.11–1.49)	0.001

Model 1 adjusted for age, race, sex, eligibility for Medicaid and Part D subsidies, and region. Model 2 adjusted for variables in model 1 plus history of coronary heart disease, chronic kidney disease, diabetes mellitus, atrial fibrillation, hypertension, chronic obstructive pulmonary disease, Charlson comorbidity index, nursing home residence, skilled nursing facility stay in the prior year, length of stay, and intensive care unit stay during the HF hospitalization. CI indicates confidence interval; HF, heart failure; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction; HR, hazard ratio.

data likely reflect the significant burden of comorbidity that afflicts older adults with HF^{13,18} and highlight the importance of addressing concurrent comorbid conditions both during and after hospitalization. Approximately 90% of older adults with HF have at least 3 other comorbid conditions and >50% have at least 5 other comorbid conditions¹⁹; consequently, the most common comorbidity among older adults with HF is *multimorbidity*, the condition of having multiple conditions.²⁰ Although efforts to improve posthospitalization outcomes have historically focused on HF-specific strategies like increasing guideline-directed medical therapy and promoting HF self-care through nurse education,²¹ our findings suggest the need for a paradigm shift with increased emphasis on noncardiovascular comorbidity. To date, major guidelines have addressed the importance of treating comorbidity in HFpEF but have been less explicit for HFrEF.^{22,23} Based on our study, increased focus on comorbidity is applicable to all types of HF, regardless of ejection fraction.

A recommended strategy to reduce readmissions of HF patients has been ensuring adequate postdischarge outpatient follow-up.²² Although data suggest that early follow-up is associated with a reduction in 30-day readmissions,^{24,25} almost no data inform the subspecialty with which to schedule appointments following hospital discharge. Although hospitalization for a principal diagnosis of HF would intuitively suggest that follow-up with a cardiologist is most warranted, our observation that the most common readmission diagnoses following discharge are non-cardiovascular-related suggests that follow-up with a primary care physician may be as important, if not more so. Future studies that examine whether physician specialty moderates the relationship between early follow-up and rates of readmission would be

helpful to delineate the optimal postdischarge follow-up strategy for HF patients.

Our study also showed that readmissions for HF were less common among HFpEF compared with HFrEF participants. This finding also has important implications for designing interventions to prevent readmissions. To date, few interventions have consistently demonstrated efficacy in reducing 30-day readmissions.⁴ A potential contributor to the current state of the literature is that most studies have overlooked HFpEF or have combined HFpEF and HFrEF in a single cohort. Failure to examine HFpEF in isolation is problematic, given the rising prevalence of HFpEF hospitalizations, which compose about half of all HF hospitalizations.^{13,26} Combining HFpEF and HFrEF is similarly problematic because the heterogeneity that stems from combining disease entities with key differences in sociodemographics, pathophysiology, and causes of readmission, as we have shown, may contribute to negative findings, similar to the manner in which heterogeneity has been cited as the cause of failed clinical trials in HF.^{27,28} Taken together, these findings suggest that future interventions aimed at reducing 30-day readmissions should probably target HFpEF and HFrEF separately.

Some important limitations should be noted. First, this retrospective cohort study was derived from a 5% sample of Medicare, which does not provide direct measures of health status, severity of concurrent comorbidities, or in-hospital treatment. Data on, for example, blood pressure and heart rate, need for home oxygen, medication use, and laboratory values like baseline renal function and B-type natriuretic peptide were unavailable. Nonetheless, Medicare data have been used extensively to examine patterns of readmission among older adults with HF,^{17,29} representing a nationally

representative and geographically diverse sample. Second, we identified HF cases based on the presence of HF-based ICD-9 codes as the principal diagnosis. Although the sensitivity of utilizing claims data to identify HF has been validated,³⁰ it is possible that we included cases for which HF was a secondary issue but classified as a principal diagnosis (ie, upcoded) for billing purposes. Finally, echocardiographic data were not available to confirm ejection fraction. Prior studies have demonstrated that patients with HFpEF and HFrEF based on claims data have characteristics and outcomes similar to patients enrolled in registries and community-based studies,^{13,29} supporting their validity for examining subtypes of HF.

In conclusion, our study revealed that non-cardiovascular-related diagnoses represented the most common causes of 30-day readmission following HF hospitalization for each week of the 30-day postdischarge period for both HFpEF and HFrEF participants. We also showed that HF readmissions were less common among those with HFpEF compared with HFrEF. Future interventions aimed at reducing 30-day readmissions following an HF hospitalization would benefit from an increased focus on noncardiovascular comorbidity and interventions that target HFpEF and HFrEF separately.

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SUPPLEMENTAL MATERIAL

Figure S1. Flowchart for included cases.

