Association of post-discharge specialty outpatient visits with readmissions and mortality in high-risk heart failure patients

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Background Heart failure (HF) outcomes are especially poor in high-risk patients with certain comorbidities including diabetes mellitus (DM), chronic kidney disease (CKD), and chronic obstructive pulmonary disease (COPD). Whether early specialty or primary care provider (PCP) follow-up after HF discharge affects outcomes in high-risk patients is unknown.

Methods We analyzed patients discharged from a Get With The Guidelines HF-participating hospital from 2007–2012 with linked Medicare claims to investigate the association of medical specialist visit within 14 days of discharge stratified by comorbidity with the primary outcome of 90-day HF readmission. Secondary outcomes included 90-day and 1-year all-cause mortality.

Results Out of 33,243 patients, 39.4% had DM, 19.8% had CKD, 30.0% had COPD, and 36.3% had no key comorbidity. Nephrologist visit in patients with CKD was associated with a 35% reduction in 90-day HF readmission (hazard ratio [HR] 0.65, 95% confidence interval [CI] 0.49–0.85). Pulmonologist visit in patients with COPD was associated with a 29% reduction in 90-day HF readmission (HR 0.71, 95% CI 0.55–0.91). In patients with no key comorbidity, PCP and Cardiologist visits were associated with decreased 90-day mortality (HR for PCP 0.79, 95% CI 0.66–0.94; HR for Cardiologist 0.78, 95% CI 0.63–0.96). In patients with DM, Endocrinologist visit was associated with a 42% reduction of 90-day mortality (HR 0.58, 95% CI 0.34–0.99).

Conclusions Specialist and PCP visit in the immediate post-discharge period may improve 90-day HF readmission and mortality in certain high-risk groups of patients with HF. (Am Heart J 2019;212:101-12.)

Heart failure (HF) readmission remains a system-wide financial burden and portends an increased risk of poor outcomes including mortality.[1-4] Hospitals and providers have implemented early outpatient follow-up strategies (typically within 7–14 days of HF discharge) to combat readmissions. Hospitals adhering to this early follow-up strategy have lower 30-day readmission rates.[5]

Certain comorbidities significantly influence readmission rates for patients with HF with up to 70% of readmissions within 30 days having a primary diagnosis other than HF.[6] While patients with chronic kidney disease (CKD) or diabetes mellitus (DM) are more likely to have an early follow-up visit after HF discharge, the impact of subspecialty follow-up on outcomes remains unclear.[7] Prior studies of subspecialty care for HF patients have focused solely on Cardiology and Primary Care visits on outcomes with mixed results.[8-10]

Using data from the Get With The Guidelines (GWTG) HF registry and linked fee-for-service Medicare claims data, we investigated the association between the type of specialist visits within 14 days of discharge for high-risk HF patients with concomitant DM, CKD, or pulmonary disease (chronic obstructive pulmonary disease [COPD] or asthma) and HF readmission at 90 days. Secondary outcomes included 90-day and 1-year all-cause mortality.

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Methods

Data sources

We utilized participant data from the American Heart Association (AHA) GWTG-HF registry with linked Medicare Parts A and B claims data for this study. Complete details of the GWTG-HF registry have been published previously.[11] In brief, the GWTG-HF registry is a hospital-based quality improvement initiative started by the AHA in 2005 with the goal of improving guideline adherence in the management of patients hospitalized for HF. The GWTG-HF registry includes a diverse collection of academic and community hospitals of various size distributed throughout the United States. Trained personnel from each participating center reviewed and collected pre-specified data on patients admitted with a new diagnosis or exacerbation of HF during the index admission.

Data abstraction complied with standards set forth by both the Centers for Medicare and Medicaid and the Joint Commission on the Accreditation of Healthcare Organizations. Participating institutions obtained institutional review board (IRB) approval and complied with local regulatory guidelines. Per the Common Rule, participating institutions waived informed consent as the data was collected for quality improvement. This study was approved by the Duke IRB.

Participating sites collected data on 188 variables spanning demographic data, medical history, and medications during admission and at discharge. Sites entered data using the AHA's internet-based Patient Management Tool (Quintiles Real-World & Late Phase Research, Cambridge, MA). The Duke Clinical Research Institute (Durham, NC) served as the data analysis center.

Study population

We included patients 65 years of age or older discharged alive after HF admission to a GWTG-HF participating hospital with linked Medicare claims data between January 1st, 2007 and November 30th, 2012. We excluded patients not enrolled in Medicare during the index hospitalization, admitted to sites with less than 75% data completeness on medical history or lab data, or who were on chronic dialysis. We also excluded any patients who left against medical advice, died within 14 days after discharge, or were discharged to a short-term hospital, rehabilitation center, or Hospice care.

Outcome and covariate definitions

The primary outcome was HF hospitalization at 90 days after discharge. Secondary outcomes included all-cause mortality at 90 days and 1 year after discharge. We collected data on hospitalizations and mortality after discharge by linking registry participants with Medicare Part A claims using limited identifiers including sex, date of birth, and dates of hospitalization as described previously.[12] We defined HF hospitalization as any hospitalization after the index hospitalization (excluding transfers to another hospital) with a primary diagnosis of HF per *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, and 428.9. We defined all-cause mortality following discharge by determining the date of death from Medicare denominator files.

We evaluated the following comorbidities: CKD, DM, and COPD/asthma. Participating sites indicated the presence of each comorbidity on a pre-specified form on the Patient Management Tool. For the purposes of the GTWG-HF registry, CKD was defined as a baseline creatinine greater than 2 mg/dL.

Standard patient- and hospital-level covariates included demographics (age, sex, race, ethnicity), medical history (anemia, atrial arrhythmia, ventricular arrhythmia, COPD, asthma, CKD, coronary artery disease, DM, smoking history, hyperlipidemia, hypertension, and peripheral vascular disease), admission clinical measurements (heart rate, left ventricular ejection fraction, systolic blood pressure, serum creatinine, and serum sodium), and hospital factors (hospital size, teaching status, region, rural/urban location). We also reported the prevalence of HF diagnosis prior to admission.

Outpatient specialty provider visits during the 14-day period after discharge were the exposure for this study. We used the National Provider Identifier (NPI) taxonomy codes from Medicare outpatient claims identify Primary Care, Cardiology, Nephrology, Endocrinology, and Pulmonology outpatient visits. Primary care provider (PCP) codes included physician, nurse practitioner, and physician assistant visits within Internal Medicine, Family Medicine, and Geriatric Medicine. We defined the eligibility for follow up with each specialty provider by comorbidity: Cardiology or Primary Care (all patients), Nephrology (only patients with CKD), Endocrinology (only patients with DM), and Pulmonology (only patients with COPD or asthma). Comorbidities were not mutually exclusive. For example, if a patient had both CKD and DM, he or she would be eligible to see a Cardiologist, PCP, Nephrologist, or Endocrinologist.

Statistical analyses

We compared baseline characteristics, medical history, laboratory, and hospital-level data for each patient stratified by comorbidity. Categorical variables were presented as counts and corresponding proportions. We presented continuous variables as means along with their standard deviations.

To determine the frequency of follow-up within each comorbidity group, we displayed histograms for each

Table I. Baseline characteristics of patients stratified by comorbidity group

Variable	Overall*, % (N = 33,243)	No key comorbidity, % (N = 12,074)	DM, % (N = 13,113)	CKD, % (N = 6585)	COPD/ Asthma, % (N = 9960)
Demographics					
Age, mean (SD)	80.9 (8.2)	83.3 (7.9)	78.3 (7.8)	80.3 (8.0)	79.1 (8.0)
Male gender	46.4	43.3	47.4	53.2	47.9
Asian race	3.3	3.2	3.5	3.6	2.7
Black race	10.4	8.3	12.8	12.9	10.5
White race	78.5	81.1	74.2	75.9	79.9
Hispanic (any race)	5.2	4.1	7.2	5.0	4.6
Medical history					
Anemia	22.3	16.0	25.5	35.2	24.8
Smoking	8.9	5.5	8.6	7.4	16.9
Atrial fibrillation	40.1	42.6	36.1	38.8	41.5
Atrial flutter	2.7	2.7	2.7	2.9	2.7
Coronary disease	52.9	45.1	59.4	59.5	56.3
COPD or asthma	30.8	0.0	33.0	31.7	100.0
CVA/TIA	17.2	15.3	19.1	18.6	17.9
Depression	10.4	8.4	11.9	10.5	13.6
Previous MI	20.7	17.4	23.6	22.9	22.8
Peripheral vascular disease	15.2	9.8	18.8	21.0	18.6
HF	66.0	59.7	69.2	72.6	72.5
Hyperlipidemia	49.0	40.8	57.5	53.5	51.5
Hypertension	77.9	73.2	83.2	79.3	78.9
CKD (SCr >2)	22.5	0.0	28.9	100.0	23.1
Ischemic history	60.1	52.5	66.8	66.5	63.1
Meds prior to admission					
Statin use	38.3	30.6	47.3	39.7	41.8
Vital signs at admission					
Systolic blood pressure (mmHg), mean (SD)	141.3 (29.0)	140.3 (28.4)	143.6 (29.4)	142.4 (30.2)	140.1 (28.7)
Weight (kg), mean (SD)	78.8 (22.3)	72.6 (19.3)	86.3 (23.6)	82.1 (22.0)	81.3 (23.9)
BMI, mean (SD)	28.4 (7.4)	26.4 (6.3)	30.9 (8.0)	29.2 (7.4)	29.1 (8.1)
Heart rate (bpm), mean (SD)	82.7 (19.3)	82.8 (19.7)	81.9 (18.8)	80.1 (18.4)	84.6 (19.7)
Respiratory rate (bpm), mean (SD)	21.3 (4.7)	21.0 (4.5)	21.3 (4.6)	21.2 (4.5)	21.9 (5.0)
Ejection fraction					
HFpEF	55.6	55.2	55.9	53.4	58.9
Ejection fraction (%), mean (SD)	43.9 (16.6)	43.7 (16.8)	44.1 (16.4)	43.2 (16.6)	45.0 (16.5)
Labs and imaging at admission					
HbA1C (%), mean (SD)	6.8 (1.4)	6.1 (1.0)	7.1 (1.4)	6.9 (1.3)	6.8 (1.3)
Sodium (mEq/L), mean (SD)	137.3 (7.6)	137.1 (7.9)	137.4 (7.7)	137.8 (7.2)	137.4 (7.3)
BUN (mg/dL), mean (SD)	31.2 (18.2)	26.8 (14.5)	34.1 (19.5)	44.9 (22.0)	30.2 (17.8)
Serum creatinine (mg/dL), mean (SD)	1.7 (2.6)	1.4 (2.3)	1.9 (2.8)	2.5 (3.5)	1.7 (1.9)
BNP (pg/mL), mean (SD)	1268.7 (1518.4)	1286.8 (1495.0)	1195.1 (1515.0)	1493.1 (1691.4)	1140.7 (1449.3)
Hemoglobin (g/dL), mean (SD)	11.7 (3.6)	12.0 (3.9)	11.5 (3.6)	11.1 (3.3)	11.7 (3.5)
Medications at discharge					
ACEI/ARB	57.8	60.7	59.0	41.5	55.6
ASA	53.5	51.3	56.5	53.1	53.2
Beta blocker	78.6	78.3	80.8	82.2	74.4
Aldosterone antagonist	14.0	14.0	14.4	11.2	14.1
Statins	43.8	36.0	52.5	45.7	46.8
Hydralazine	11.3	7.7	14.7	20.2	11.2
Loop Diuretic	61.6	58.5	64.7	60.1	64.7
Hospital characteristics					
West region	8.8	8.7	8.7	7.7	9.4
South region	27.8	27.8	28.3	25.5	26.8
Midwest region	29.9	29.6	29.9	32.7	29.9
Northeast region	33.5	34.0	33.1	34.2	34.0
Teaching hospital	75.6	75.4	76.0	74.7	76.0
Number of beds, mean (SD)	430.1 (209.0)	427.6 (211.1)	432.3 (206.9)	434.8 (213.5)	427.2 (204.3)
Rural location	5.5	5.6	5.2	5.0	5.9

*Comorbidity groups are not mutually exclusive. SD, standard deviation; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; TIA, transient ischemic attack; MI, myocardial infarction; HF, heart failure; CKD, chronic kidney disease; BMI, body mass index; HbA1c, hemoglobin A1c; BUN, blood urea nitrogen; BNP, brain natriuretic peptide; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker.

group with the total number of visits defined as the number of visits with a qualifying specialist as follows: no key comorbidity (PCP, Cardiology), CKD (PCP, Cardiology, Nephrology), DM (PCP, Cardiology, Endocrinology), COPD/asthma (PCP, Cardiology, Pulmonology). Groups were not mutually exclusive so the number of qualifying specialists increased with each additional comorbidity.

We generated unadjusted Kaplan–Meier and cumulative incidence curves for HF admissions at 90 days (primary outcome), 90-day all-cause mortality, and 1-year all-cause mortality using Gray's test to account for the competing risk of death and HF admission. Cox proportional hazards regression models were used to evaluate hazard ratio (HR) of each outcome, adjusting for age, sex, race, ethnicity, pertinent medical history (anemia, atrial arrhythmia, ventricular arrhythmia, COPD, asthma, CKD, coronary artery disease, DM, smoking history, hyperlipidemia, hypertension, and peripheral vascular disease), admission clinical measurements (heart rate, left ventricular ejection fraction, systolic blood pressure, serum creatinine, and serum sodium), and hospital factors (hospital size, teaching status, region, rural/urban location).

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Results

Baseline characteristics

The baseline characteristics of the patients within each comorbidity group are shown in Table I. We included a total of 33,243 patients in this analysis. In the overall cohort, 55.6% had HF with preserved ejection fraction (HFpEF) and 44.4% had HF with reduced ejection fraction (44.4%). The distribution between HFpEF and HFrEF was similar among all comorbidity subgroups with HFrEF most common in patients with CKD (46.6%) and least common in patients with COPD (41.1%). Of these patients, 36.3% had no key comorbidity defined in this study, 39.4% had DM, 19.8% had CKD, and 30.0% had COPD/asthma. Prior to admission, 66% of patients had a previous diagnosis of HF. The mean age of each comorbidity group was older than 78 years. Most patients were white (>74% in each comorbidity group). Anemia was most common in the CKD subgroup (35.2%) and least common in patients without a key comorbidity (16.0%). Coronary artery disease was most common in patients with CKD (59.5%) and least common in patients without a key comorbidity (45.1%). Ejection fraction at admission was similar across all subgroups. The mean serum creatinine in the CKD subgroup was 2.5 mg/dL and ranged from 1.4–1.9 mg/dL in other comorbidity groups. Patients without a key comorbidity were most likely to be discharged on angiotensin converting enzyme inhibitor or angiotensin receptor blocker (60.7%) compared to 41.5% of patients with CKD. Patients with DM were most likely to be discharged on statin therapy (52.5%) whereas patients without a key comorbidity were the least likely (36.0%).

Table II. Frequency of outpatient visits within 14 days of discharge stratified by comorbidity

Number of visits	Overall, %	No key comorbidity, %	DM, %	CKD, %	COPD/ asthma, %
0	58.9	60.2	58.1	56.3	58.6
1	23.3	22.7	23.7	24.1	23.6
2	10.9	10.4	11.3	12.1	11.0
3	4.02	4.03	4.13	4.34	3.83
4	1.64	1.58	1.56	1.96	1.64
5	0.61	0.51	0.60	0.65	0.68
6	0.29	0.33	0.32	0.20	0.30
7	0.12	0.10	0.15	0.12	0.14
8	0.06	0.05	0.05	0.08	0.03
9	0.03	0.03	0.02	0.02	0.03
10	0.02	0.01	0.05	0.05	0.01
11	0.01	0.02	0	0	0
12	0.02	0.02	0.02	0.05	0.01
13	0.01	0.01	0.01	0.02	0
14	0.01	0.02	0.01	0	0.01
15	0.01	0	0.01	0.02	0.01

DM, diabetes mellitus; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

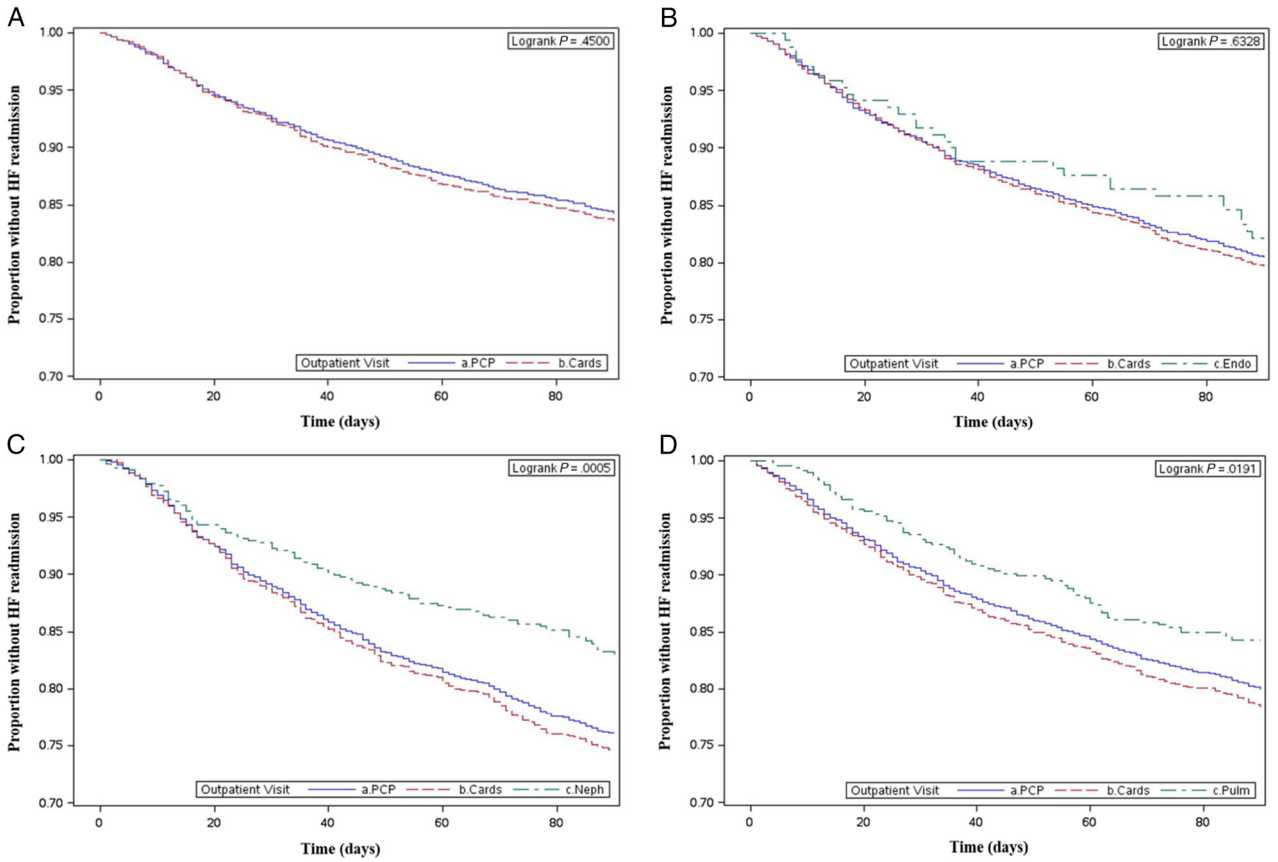
Outpatient visit frequency

Overall, 41.1% of patients had at least one qualifying outpatient provider visit during the exposure period (Table II). Patients with CKD had the highest visit frequency (43.7% with at least one visit). Patients without a key comorbidity had the lowest visit frequency with 39.8% having at least one visit.

Ninety-day readmissions

Kaplan–Meier curves for 90-day HF readmission and absolute rates of admission for each comorbidity group are shown in Figure 1 and Table III, respectively. In these unadjusted analyses, visits with a Nephrologist for patients with CKD and visits with a Pulmonologist for patients with COPD/asthma were associated with significant reductions in 90-day HF readmission. In adjusted multivariate analyses, visit with a Nephrologist was associated with a 35%

Figure 1



A-D. Kaplan–Meier curves for 90-day heart failure readmission stratified by specialist and comorbidity. (A) No key comorbidity, (B) Diabetes mellitus, (C) Chronic kidney disease, and (D) Obstructive pulmonary disease. PCP, Primary Care provider; Cards, Cardiologist; Endo, Endocrinologist; Neph, Nephrologist; Pulm, Pulmonologist.

Table III. Absolute event rates for each outcome stratified by comorbidity group

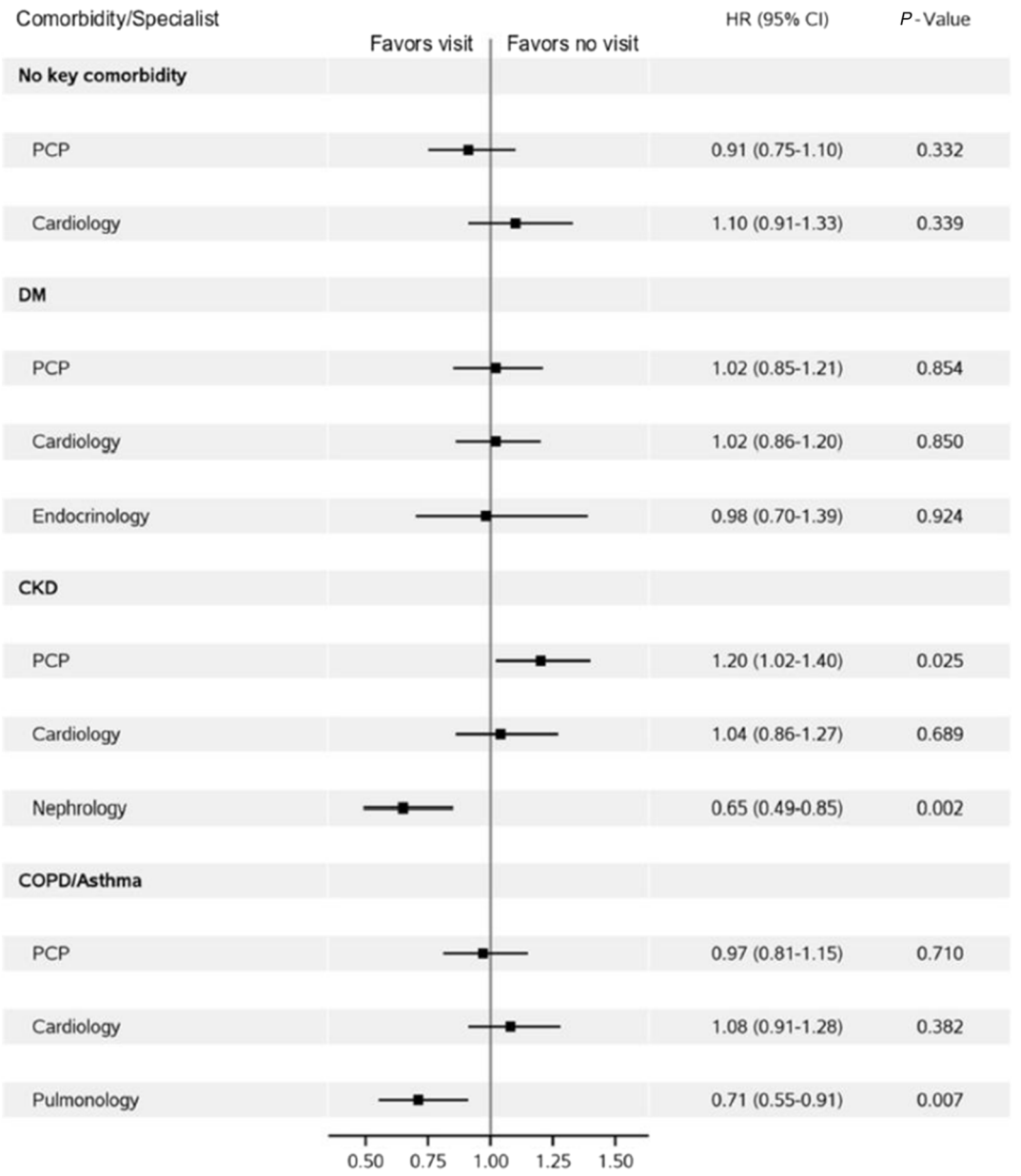
Event	Overall, %	No key comorbidity, %	DM, %	CKD, %	COPD/ asthma, %
All-cause readmission, 90 days	37.9	45.0	48.3	46.9	37.9
Heart failure admission, 90 days	15.3	18.9	22.1	18.9	15.3
All-cause mortality, 90 days	13.7	13.1	17.2	15.3	13.7
All-cause mortality, 1 year	38.7	38.1	45.8	42.3	38.7

DM, diabetes mellitus; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

reduction in 90-day HF readmission (HR 0.65, 95% CI 0.49–0.85) in patients with CKD (Figure 2). Visit with a Pulmonologist was associated with a 29% reduction in 90-day HF readmission (HR 0.71, 95% CI 0.55–0.91) in patients with COPD/asthma (Figure 2).

As for HF readmissions, Nephrologist visit for patients with CKD was associated with a 20% reduction in the risk of all-cause, 90-day readmission (Figure 3). In contrast, Pulmonologist visit was not associated with a reduction in all-cause readmissions for patients with COPD/asthma.

Figure 2



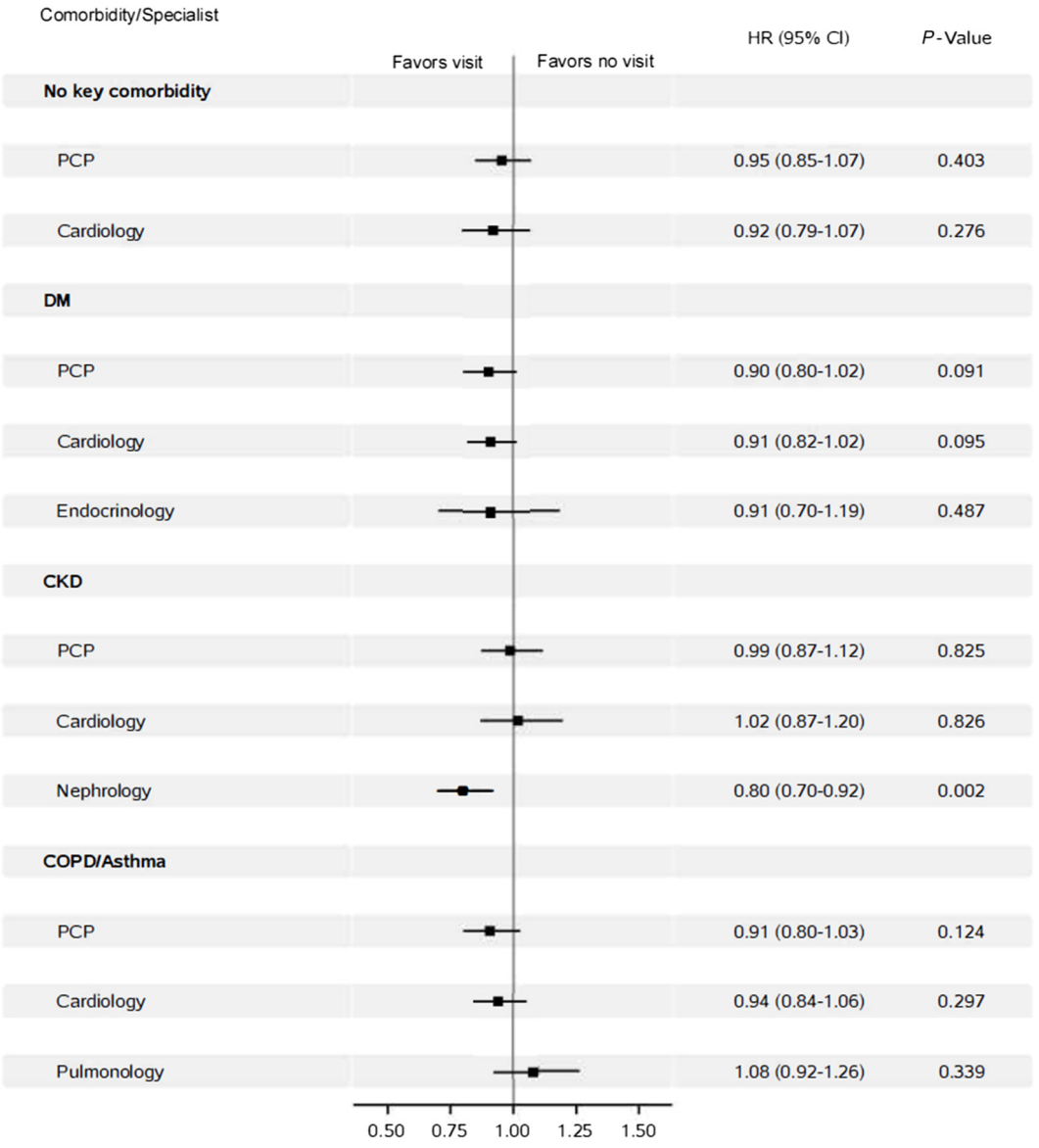
Forest plot of adjusted hazard ratios for 90-day heart failure readmission stratified by specialist and comorbidity with no outpatient visit serving as the referent. HR, hazard ratio; CI, confidence interval; PCP, primary care provider; DM, diabetes mellitus; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

No other specialist visit was associated with a significant reduction in 90-day, all-cause readmission rates.

Mortality

The association of specialist visit with all-cause mortality is shown in Figures 4 and 5. For those without a key comorbidity, PCP visit was associated with a decrease in all-cause mortality at 90 days (HR 0.79, 95% CI 0.66–0.94; Figure 4). Cardiologist visit was associated with a decrease in all-cause mortality at 90 days (HR 0.78, 95% CI 0.63–0.96; Figure 4) and 1 year (HR 0.76, 95% CI 0.66–0.88; Figure 5) in patients without a key comorbidity. For patients with DM, visit with an Endocrinologist was associated with a decrease in all-cause mortality at 90 days (HR 0.58, 95% CI 0.34–0.99; Figure 4) and 1 year (HR 0.68, 95% CI 0.48–0.95; Figure 5). For patients with COPD/asthma, only PCP was

Figure 3



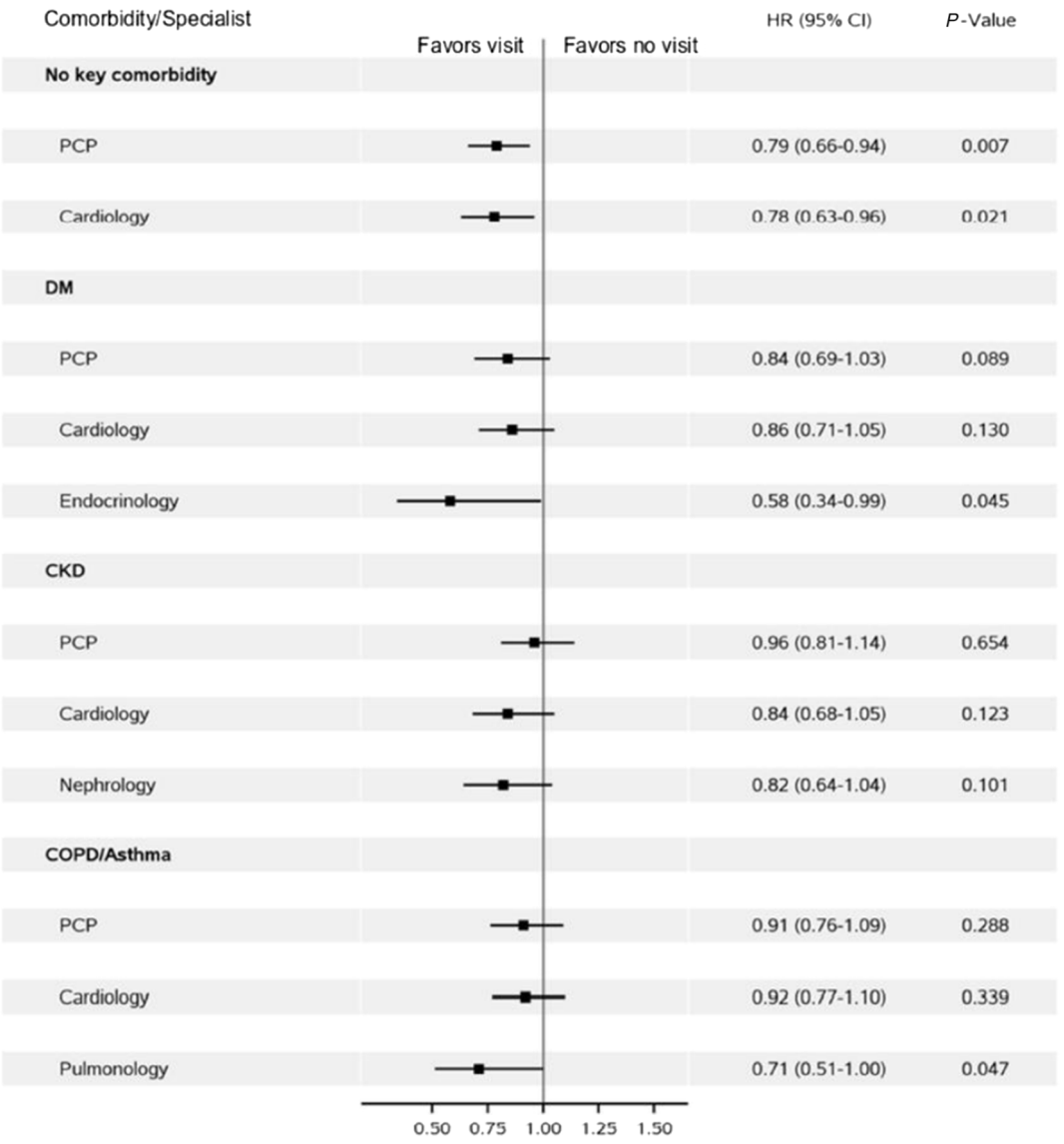
Forest plot of adjusted hazard ratios for 90-day all-cause readmission stratified by specialist and comorbidity with no outpatient visit serving as the referent. HR, hazard ratio; CI, confidence interval; PCP, primary care provider; DM, diabetes mellitus; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

associated with decrease all-cause mortality at 1 year (HR 0.84, 95% CI 0.75–0.94; Figure 5). No outpatient specialist visits were associated with a decrease in all-cause mortality for patients with CKD.

Discussion

High HF readmission and mortality rates have led to efforts to improve the quality of care and application of high-quality therapies to this patient population. In our analysis of specialist follow-up in over 33,000 patients discharged after HF admission, the utilization and associations of specialty care in high-risk HF patients with outcomes varied among the comorbidities present. Despite the Class IIa recommendation by the 2013 American College of Cardiology Foundation (ACCF)/AHA guidelines for early outpatient follow-up within 7–14 days of HF discharge, only 41% of patients had at least one follow-up visit with any qualifying provider during this period. The present study finds that when visits did take place in the early post-discharge period, specialist and PCP visits were associated with improved 90-day HF

Figure 4



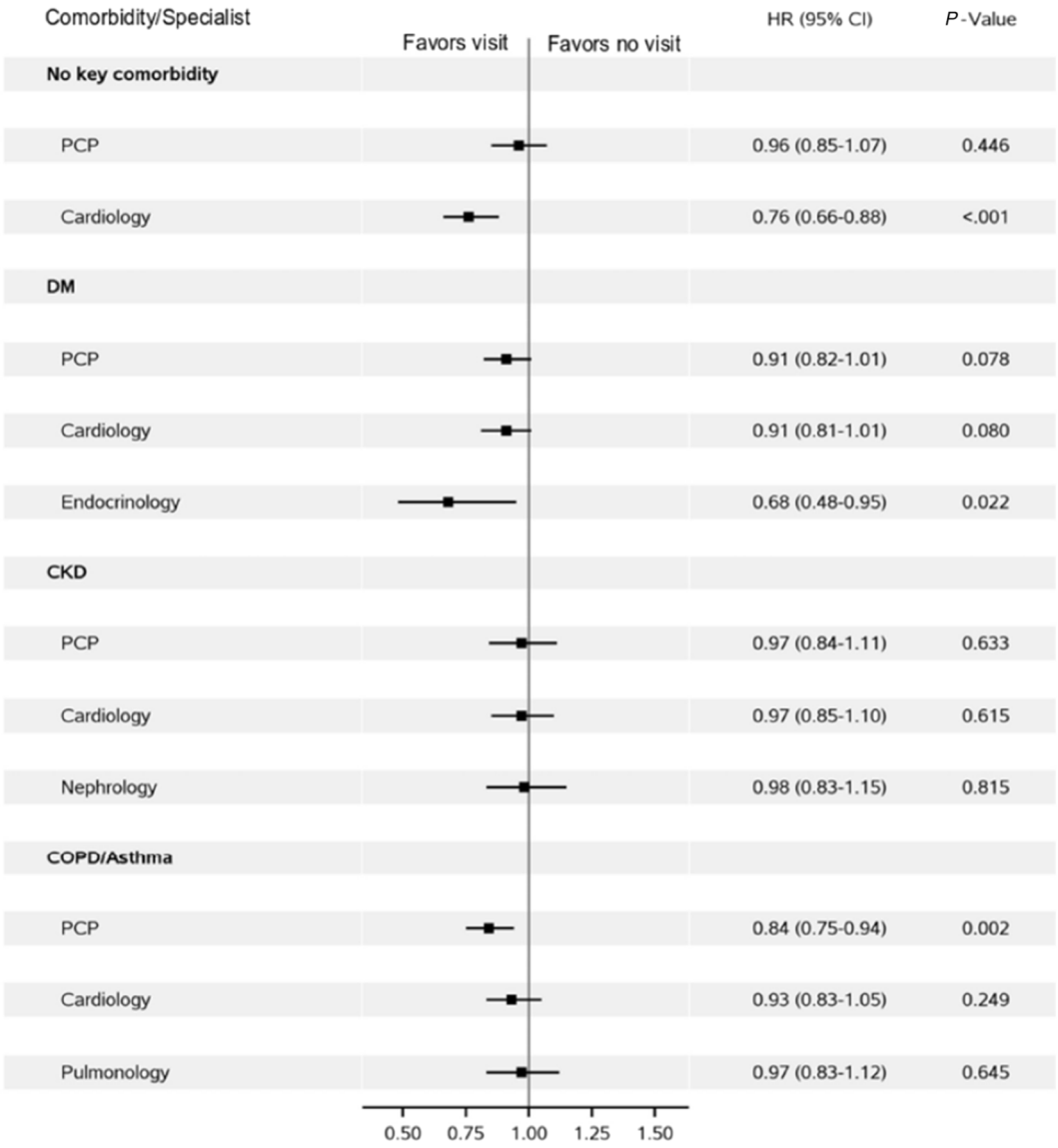
Forest plot of adjusted hazard ratios for 90-day all-cause mortality stratified by specialist and comorbidity with no outpatient visit serving as the referent. HR, hazard ratio; CI, confidence interval; PCP, primary care provider; DM, diabetes mellitus; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

readmission and mortality in certain high-risk groups of patients with HF. Specialist follow-up visits occurring early after discharge among patients with a comorbid condition corresponding that the specialist, with some exceptions, were associated with significantly improved outcomes. These findings have important implications for system-based approaches to improving care transitions and outcomes for patient hospitalized with HF.

The most striking associations with the primary outcome of 90-day HF readmission were seen in the CKD and COPD/asthma comorbidity groups. Visit with a nephrologist during the 14 days after discharge was associated with a 35.5% reduction in HF readmission risk in patients with CKD which was not observed with PCP or Cardiologist visit. Pulmonologist visit in patients with COPD/asthma was associated with a similar risk reduction (29.2%). While Nephrologist visit remained significantly associated with reduced 90-day all-cause readmission, visit with a Pulmonologist was no longer associated with a reduction in readmission.

The association of specialist visit with mortality yielded different results. In patients without a key comorbidity,

Figure 5



Forest plot of adjusted hazard ratios for 1-year all-cause mortality stratified by specialist and comorbidity with no outpatient visit serving as the referent. HR, hazard ratio; CI, confidence interval; PCP, primary care provider; DM, diabetes mellitus; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

both visits with a PCP and a Cardiologist were associated with an approximately 22% reduction in 90-day, all-cause mortality. Endocrinology visits were associated with a 41.8% reduction in 90-day mortality in patients with DM. Pulmonology visits were associated with a 28.7% decrease in 90-day mortality in patients with COPD/asthma. In patients with CKD, no provider visits were associated with a significant decrease in mortality.

Most comparisons between Cardiologist and PCP management of HF have focused on guideline adherence during inpatient management.[13-19] These studies produced conflicting findings with regard to the impact of these differences on readmissions and mortality.[13-19] Few studies have compared outcomes in patients with HF based on outpatient follow-up with a Cardiologist versus a PCP. In a Canadian cohort of patients discharged after incident HF admission, the combination of specialist and PCP follow-up in the year after discharge was associated with lower one-year mortality than either provider alone.[8] Of note, both Internists and Cardiologists were considered "specialty" care in this study. A study of Veterans Health Administration patients found

the lowest 1-year mortality for those veterans followed by both a PCP and Cardiologist in the year after discharge.[10] In a study by Ansari and colleagues, patients with significant outpatient Cardiologist care in the 2 years after incident HF diagnosis had a significantly lower rate of a composite of all-cause mortality and cardiovascular hospitalization at 2 years.[20]

While our study demonstrates no clear improvement in 90-day HF readmissions with either PCP or Cardiology visit for any comorbidity group, both PCP and Cardiologist visits were associated with decreased 90-day all-cause mortality for patients without a key comorbidity. The decrease in mortality is consistent with the prior studies comparing Cardiology and PCP outpatient visits. The reason for a lack of associated improvement in HF readmissions with PCP or Cardiologist follow-up is unclear. Perhaps the sickest patients were readmitted prior to follow-up with a PCP or Cardiologist.

Despite the high rates of CKD in patients with HF, no prior studies have evaluated the impact of Nephrologist care on outcomes after HF discharge.[21-24] Our study found a significant associated reduction in 90-day HF readmissions in those patients with CKD followed by a Nephrologist in the post-discharge period. While visits with any provider group failed to be associated with improved mortality outcomes, the CKD comorbidity group had the lowest survival of any subgroup in our study which may affect this outcome. We defined CKD using a creatinine cut-off of >2 mg/dl on the GWTG-HF data entry form rather than CKD category based on estimated glomerular filtration rate (eGFR) and albuminuria as defined by the 2012 Kidney Disease: Improving Global Outcomes (KDIGO) Clinical Practice Guidelines.[25] The use of this creatinine cut-off is likely very specific for CKD at the expense of underestimating the prevalence of CKD in this population. We excluded chronic dialysis patients as the Medicare billing for dialysis provider contacts is by visits per month rather than date of service. Accurate adjudication of HF admission versus volume overload from insufficient ultrafiltration is also difficult in this population.

The burden of noncardiovascular comorbidities in patients hospitalized for HF has increased over time.[26] DM affects up to 40% of patients with HF and may increase mortality risk by up to 50%.[27,28] Interest in these comorbid conditions has exploded with the recognition of improved HF outcomes with certain DM therapies such as glucagon-like peptide-1 receptor (GLP-1) agonists and sodium-glucose cotransporter-2 (SGLT2) inhibitors.[29-31] How these findings will affect the role of the Endocrinologist in patients with HF and the role of the Cardiologist in the management of patients with DM remains unclear. Our study represents the first study evaluating Endocrinologist visit in the immediate period after HF discharge. While 90-day HF readmission did not differ by provider visits in the post-discharge period, Endocrinology visit in this period was associated with an almost 42% lower 90-day mortality risk in patients with DM and HF.

Approximately 37% of patients with HF suffer from obstructive airway disease.[32] Parsing the overlapping symptom burden and prescribing the optimal management strategy for these patients requires a concerted effort among PCPs, Cardiologists, and Pulmonologists. Indeed, patients with both HF and COPD may be less likely to receive appropriate spirometry assessment compared to patients with COPD alone.[33] Pulmonology visit for patients with comorbid HF and COPD/asthma was associated with a lower risk of 90-day HF readmissions and 90-day all-cause mortality in our study. These findings support the early incorporation of a Pulmonologist into the care of patients with HF and obstructive lung disease.

HF rarely occurs or remains in a vacuum. Indeed, a bidirectional relationship has been described for HF and a number of comorbidities – CKD, DM, and pulmonary disease chief among them.[34] A multidisciplinary approach to the management of HF patients logically should improve outcomes. Although the definition of multidisciplinary varied widely, a Cochrane systematic review of studies utilizing a multidisciplinary model of care for HF patients demonstrated a significant reduction in HF readmissions without a reduction in mortality.[35] In a randomized trial of standard versus multidisciplinary outpatient care after HF discharge, multidisciplinary care including Cardiologists, other specialists, nurses, dieticians, and social workers reduced all-cause hospitalizations.[36] Other similar interventions including a multidisciplinary model (though excluding other medical specialists) produced similar results.[37,38] Both the 2013 ACCF/AHA joint guidelines for HF and the 2016 European Society of Cardiology guidelines support the implementation of such multidisciplinary teams in "high-risk" patients with HF.[39,40]

Our study has several limitations. The patients included in our analysis were discharged from GWTG-participating hospitals. The inpatient management and outpatient referral patterns of these institutions may differ from non-participating hospitals. Though our findings remained consistent after adjustment in multivariate analyses, the observational nature of our study increases the risk of selection bias and unmeasured confounding factors. These unmeasured factors are particularly important when considering the decision to refer a patient to specialty care and the patient decision to attend such a visit. The relatively low frequency of HFrEF (44.4%) in our study cohort may also affect generalizability of our results. Also, the average systolic blood pressure at admission (141.3 mmHg) and prevalence of comorbid hypertension (77.9%) suggest a robust myocardial reserve and significant contribution of hypertensive heart disease in this population. We excluded patients dying in the 14-day period after discharge and only included patients discharged home likely excluding a very sick cohort of HF patients. We also

included Medicare beneficiaries which limits extrapolation to younger and/or privately-insured populations. The average BMI was relatively low in this population. While likely due to the advanced age of the cohort, this limitation must be considered when interpreting the study results.[41,42] Importantly, the last qualifying heart failure admissions included in our study occurred in November of 2012. As such, much of our cohort was admitted prior to the enforcement of Medicare payment adjustment penalties for excess readmissions in October of 2012. As heart failure admissions have decreased in response to this penalty, it is unclear if our results extrapolate to current practice patterns. Finally, the presence of each comorbidity was limited to the data recorded into the GWTG-HF data management portal and may over- or under-estimate the true prevalence of each comorbidity.

In conclusion, our study supports that not only do outcomes differ for patients with HF by comorbidity burden, but incorporation of certain specialists into the post-discharge follow-up plan may be associated with improved HF readmissions and mortality outcomes. These findings also support the need for randomized trials of post-discharge, multidisciplinary teams including medical specialists for patients with HF and certain comorbidities.

Disclosures

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References

1. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med 2009;360(14):1418-28.
2. Krumholz HM, Merrill AR, Schone EM, et al. Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission. Circ Cardiovasc Qual Outcomes 2009;2(5):407-13.
3. Ross JS, Chen J, Lin Z, et al. Recent national trends in readmission rates after heart failure hospitalization. Circ Heart Fail 2010;3(1):97-103.
4. Krumholz HM, Lin Z, Keenan PS, et al. Relationship between hospital readmission and mortality rates for patients hospitalized with acute myocardial infarction, heart failure, or pneumonia. JAMA 2013;309(6):587-93.
5. Hernandez AF, Greiner MA, Fonarow GC, et al. Relationship between early physician follow-up and 30-day readmission among Medicare beneficiaries hospitalized for heart failure. JAMA 2010;303(17):1716-22.
6. Davis JD, Olsen MA, Bommarito K, et al. All-Payer Analysis of Heart Failure Hospitalization 30-Day Readmission: Comorbidities Matter. Am J Med 2017;130(1):93.e9-93.e28.
7. DeVore AD, Cox M, Eapen ZJ, et al. Temporal trends and variation in early scheduled follow-up after a hospitalization for heart failure: Findings from Get With The Guidelines–Heart Failure. Circ Heart Fail 2016;9(1).
8. Ezekowitz JA, van Walraven C, McAlister FA, et al. Impact of specialist follow-up in outpatients with congestive heart failure. CMAJ 2005;172(2):189-94.
9. McAlister FA, Youngson E, Kaul P, et al. Early follow-up after a heart failure exacerbation: the importance of continuity. Circ Heart Fail 2016;9(9).
10. Indridason OS, Coffman CJ, Oddone EZ. Is specialty care associated with improved survival of patients with congestive heart failure? Am Heart J 2003;145(2):300-9.
11. Smaha LA, American Heart A. The American Heart Association Get With The Guidelines program. Am Heart J 2004;148(5 Suppl):S46-8.
12. Hammill BG, Hernandez AF, Peterson ED, et al. Linking inpatient clinical registry data to Medicare claims data using indirect identifiers. Am Heart J 2009;157(6):995-1000.
13. Philbin EF, Weil HF, Erb TA, et al. Cardiology or primary care for heart failure in the community setting: process of care and clinical outcomes. Chest 1999;116(2):346-54.
14. Auerbach AD, Hamel MB, Davis RB, et al. Resource use and survival of patients hospitalized with congestive heart failure: differences in care by specialty of the attending physician. SUPPORT Investigators. Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments. Ann Intern Med 2000;132(3):191-200.
15. Bellotti P, Badano LP, Acquarone N, et al. Specialty-related differences in the epidemiology, clinical profile, management and outcome of patients hospitalized for heart failure; the OSCUR study. Oucome dello Scompenso Cardiaco in relazione all'Utilizzo delle Risore. Eur Heart J 2001;22(7):596-604.
16. Jong P, Gong Y, Liu PP, et al. Care and outcomes of patients newly hospitalized for heart failure in the community treated by cardiologists compared with other specialists. Circulation 2003;108(2):184-91.
17. Avaldi VM, Lenzi J, Urbinati S, et al. Effect of cardiologist care on 6-month outcomes in patients discharged with heart failure: results from an observational study based on administrative data. BMJ Open 2017;7(11), e018243.
18. Dehoney SB, Dickerson LM, Nappi JM. Comparison of chronic systolic heart failure guideline adherence for two ambulatory clinics. Pharm Pract (Granada) 2010;8(1):56-61.
19. Morton G, Philip L, Gilpin T, et al. Does specialist review for patients with suspected heart failure predict better outcomes? An observational study on the utility of compliance with NICE guidelines. BMJ Open 2018;8(8), e021856.
20. Ansari M, Alexander M, Tutar A, et al. Cardiology participation improves outcomes in patients with new-onset heart failure in the outpatient setting. J Am Coll Cardiol 2003;41(1):62-8.
21. Bansal N, Katz R, Robinson-Cohen C, et al. Absolute rates of heart failure, coronary heart disease, and stroke in chronic kidney disease: an analysis of 3 community-based cohort studies. JAMA Cardiol 2017;2(3):314-8.
22. Kottgen A, Russell SD, Loehr LR, et al. Reduced kidney function as a risk factor for incident heart failure: the atherosclerosis risk in communities (ARIC) study. J Am Soc Nephrol 2007;18(4):1307-15.
23. Foley RN. Clinical epidemiology of cardiac disease in dialysis patients: left ventricular hypertrophy, ischemic heart disease, and cardiac failure. Semin Dial 2003;16(2):111-7.

24. US Renal Data System 2016 Annual Data Report: epidemiology of kidney disease in the United States. Am J Kidney Dis 2017;69 (3S1):A4.
25. Stevens PE, Levin A, Kidney Disease: Improving Global Outcomes Chronic Kidney Disease Guideline Development Work Group M. Evaluation and management of chronic kidney disease: synopsis of the kidney disease: improving global outcomes 2012 clinical practice guideline. Ann Intern Med 2013;158(11):825-30.
26. Sharma A, Zhao X, Hammill BG, et al. Trends in noncardiovascular comorbidities among patients hospitalized for heart failure: insights From the Get With The Guidelines-Heart Failure Registry. Circ Heart Fail 2018;11(6), e004646.
27. Matsue Y, Suzuki M, Nakamura R, et al. Prevalence and prognostic implications of pre-diabetic state in patients with heart failure. Circ J 2011;75(12):2833-9.
28. Gustafsson I, Brendorp B, Seibaek M, et al. Influence of diabetes and diabetes-gender interaction on the risk of death in patients hospitalized with congestive heart failure. J Am Coll Cardiol 2004;43(5):771-7.
29. Neal B, Perkovic V, Matthews DR. Canagliflozin and cardiovascular and renal events in type 2 diabetes. N Engl J Med 2017;377(21):2099.
30. Zinman B, Wanner C, Lachin JM, et al. Empagliflozin, cardiovascular outcomes, and mortality in type 2 diabetes. N Engl J Med 2015;373(22):2117-28.
31. Marso SP, Daniels GH, Brown-Frandsen K, et al. Liraglutide and cardiovascular outcomes in type 2 diabetes. N Engl J Med 2016;375(4):311-22.
32. Macchia A, Rodriguez Moncalvo JJ, Kleinert M, et al. Unrecognised ventricular dysfunction in COPD. Eur Respir J 2012;39(1):51-8.
33. Pirina P, Martinetti M, Spada C, et al. Prevalence and management of COPD and heart failure comorbidity in the general practitioner setting. Respir Med 2017;131:1-5.
34. Moe G. Heart failure with multiple comorbidities. Curr Opin Cardiol 2016;31(2):209-16.
35. Takeda A, Taylor SJ, Taylor RS, et al. Clinical service organisation for heart failure. Cochrane Database Syst Rev 2012(9), CD002752.
36. Ducharme A, Doyon O, White M, et al. Impact of care at a multidisciplinary congestive heart failure clinic: a randomized trial. CMAJ 2005;173(1):40-5.
37. Kasper EK, Gerstenblith G, Hefter G, et al. A randomized trial of the efficacy of multidisciplinary care in heart failure outpatients at high risk of hospital readmission. J Am Coll Cardiol 2002;39 (3):471-80.
38. Rich MW, Beckham V, Wittenberg C, et al. A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. N Engl J Med 1995;333(18):1190-5.
39. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. Eur Heart J 2016;37(27): 2129-200.
40. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2013;62 (16):e147-239.
41. Sharma A, Lavie CJ, Borer JS, et al. Meta-analysis of the relation of body mass index to all-cause and cardiovascular mortality and hospitalization in patients with chronic heart failure. Am J Cardiol 2015;115(10):1428-34.
42. Kenchaiah S, Pocock SJ, Wang D, et al. Body mass index and prognosis in patients with chronic heart failure: insights from the Candesartan in Heart failure: Assessment of Reduction in Mortality and morbidity (CHARM) program. Circulation 2007;116(6):627-36.