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Noncardiac Comorbidity Increases Preventable Hospitalizations and Mortality Among Medicare Beneficiaries With Chronic Heart Failure

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OBJECTIVES We studied the impact of noncardiac comorbidity on potentially preventable hospitalizations and mortality in elderly patients with chronic heart failure (CHF).

BACKGROUND Chronic HF disproportionately affects older individuals, who typically have extensive comorbidity. However, little is known about how noncardiac comorbidity complicates care in these patients.

METHODS This was a cross-sectional study of 122,630 individuals age ≥65 years with CHF identified through a 5% random sample of all U.S. Medicare beneficiaries. We assessed the relationship of the 20 most common noncardiac comorbidities to one-year potentially preventable hospitalizations and total mortality. Preventable hospitalizations were determined by admissions for ambulatory care sensitive conditions using predefined criteria.

RESULTS Sixty-five percent of the sample had at least one hospitalization, of which 50% were potentially preventable. Exacerbations of CHF accounted for 55% of potentially preventable hospitalizations. Nearly 40% of patients with CHF had ≥5 noncardiac comorbidities, and this group accounted for 81% of the total inpatient hospital days experienced by all CHF patients. The risk of hospitalization and potentially preventable hospitalization strongly increased with the number of chronic conditions (both $p < 0.0001$). After controlling for demographic factors and other diagnoses, comorbidities that were associated consistently with notably higher risks for CHF-preventable and all-cause preventable hospitalizations, and mortality, included chronic obstructive pulmonary disease/bronchiectasis, renal failure, diabetes, depression, and other lower respiratory diseases (all $p < 0.01$).

CONCLUSIONS Noncardiac comorbidities are highly prevalent in older patients with CHF and strongly associate with adverse clinical outcomes. Cardiologists and other providers routinely caring for older patients with CHF may improve outcomes in this high-risk population by better recognizing non-CHF conditions, which may complicate traditional CHF management strategies. (J Am Coll Cardiol 2003;42:1226–33) © 2003 by the American College of Cardiology Foundation

Despite advances in the care of individuals with chronic heart failure (CHF), uncertainty remains about how best to manage CHF in elderly patients with complex comorbidities (1). Although a few reports have examined the impact of chronic disease comorbidity in elderly patients with CHF (2–8), most of these have been limited by their use of index scores rather than specific conditions to describe comorbidity (7,8), or use of local, non-U.S. representative (6,8) or non-U.S. samples (2,4,5). Brown and Cleland (2) studied a Scottish cohort of 25,000 individuals with a hospital diagnosis of CHF, and evaluated the relationship of comorbidities to death and hospitalization. They concluded that non-CHF conditions that may be overlooked during routine CHF management frequently precipitate, complicate, or contribute to admissions. Redelmeier and colleagues (9) demonstrated that when one serious condition is the central focus of care, care for other chronic disorders is compromised.

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In this study, we examined whether noncardiac chronic diseases influence potentially preventable hospitalizations and mortality in Medicare beneficiaries with CHF. We focused on individuals age ≥65 years because they account for approximately 80% (10) of the one million reported CHF-related hospitalizations (11) and 88% (12) of the 287,000 annually reported CHF deaths (11). We defined potentially preventable hospitalizations by admissions for ambulatory care sensitive conditions (ACSCs). Widely viewed as an indicator of adequate primary care, ACSCs reflect conditions for which timely and effective primary care can reduce the risks of hospitalization by preventing condition onset, controlling an acute episodic illness, or managing a chronic condition (13–15). We hypothesized that for Medicare beneficiaries with CHF, the probability of preventable hospitalization due to any ACSC, and more specifically to CHF-related ACSC, would increase with greater numbers of noncardiac comorbidities. We also

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Abbreviations and Acronyms

ACSC = ambulatory care sensitive conditions
CCS = Clinical Classification System
CHF = chronic heart failure
COPD = chronic obstructive pulmonary disease
DM = diabetes mellitus
ICD-9 = International Classification of Diagnoses-9th revision

hypothesized that comorbidities typically responsive to regular outpatient management (such as diabetes mellitus [DM] or chronic renal failure) would be associated with higher probabilities of preventable hospitalization and mortality. The presence of such relationships would suggest the need for physicians caring for CHF to better recognize non-CHF conditions that complicate management of older individuals.

METHODS

Study design and sample population. This was a cross-sectional analysis of U.S. Medicare beneficiaries age ≥65 years. We obtained data from a 5% nationally representative random sample of Medicare beneficiaries with both Part A (hospitalization services costs) and Part B (mainly physician and outpatient services costs) fee-for-service coverage in 1999. This file, managed by the Centers for Medicare and Medicaid Services (formerly the Health Care Financing Administration), is commonly used for research purposes. The enrollment file contains demographic information; the claims files contain fee-for-service expenditures, health care utilization (that is hospital and physician visits, services used and procedures performed), and primary and secondary inpatient and outpatient diagnosis billing data at the individual beneficiary level for all Medicare covered services. We combined the enrollment and claims files to develop individual records for each beneficiary included in our sample. We supplemented these data with county of residence data from the 1999 Area Resource File (Health Resources and Services Administration).

We used the Clinical Classification System (CCS) (16), developed by the Agency for Health Research and Quality, to identify individuals with CHF and chronic comorbidities. The CCS system clusters diagnoses and procedures assigned by providers based on International Classification of Diagnoses-9th revision (ICD-9) codes into clinically homogenous categories. To be classified with CHF, beneficiaries required at least two claims with CCS code 108 (ICD-9 codes 398.91, 428, 428.0, 428.1, and 428.9) for non-hypertensive CHF, with at least one claim originating from Medicare Part B outpatient visit data. We used the criteria of two claims rather than one to increase the specificity of diagnoses and to eliminate "rule out" encounters. We defined a chronic form of heart failure using CCS code 108, rather than one that also included ICD-9 code 402.11, which is heart failure with hypertension, because we felt this latter diagnosis better represented an acute cardiovascular diagnosis (one that might be coded during a hospitalization) than a chronic disease state. Including ICD-9 code 402.11 into our CHF definition expanded the sample by <0.1% and insignificantly influenced results. Therefore, we used only CCS code 108 to define our sample.

Initially, 148,384 beneficiaries qualified as having CHF. We excluded beneficiaries if they were age <65 years (n = 11,276), had incomplete enrollment (n = 7,826) or county data (n = 80), had any non-death-related termination of coverage during 1999 (n = 2,751), were non-U.S. residents (n = 1,356), had zero-dollar claims associated with qualifying CCS codes (n = 61), or were enrolled in managed care during any part of 1999 (n = 2,404), because these latter patients frequently have incomplete utilization data. Our final sample consisted of 122,630 individuals.

We used similar exclusions to create the analysis file for all Medicare beneficiaries. Beginning with 2,055,561 beneficiaries, we excluded those <65 years (n = 363,564), without parts A and B coverage for all 12 months (n = 105,017), with HMO coverage (331,591), or of non-U.S. residence (n = 16,493). Remaining were 1,285,895 Medicare beneficiaries, of which 122,630 (9.5%) met CHF sample definition.

Dependent variables. Main outcomes in this analysis were potentially preventable hospitalizations, designated as either ACSC hospitalization due to CHF (CHF-ACSC) or any ACSC hospitalization (ACSC), and all-cause mortality occurring at any time in 1999. We also examined total hospitalizations to determine the percentage potentially preventable. On the basis of a previously published method (17), we defined ACSCs using ICD-9 codes listed as either a primary or secondary billing diagnosis from inpatient hospitalization administrative claims. Examples of ACSCs beyond CHF exacerbation include bronchopneumonia, dehydration, gastroenteritis, and diabetes with hyperosmolar, nonketotic coma. Mortality was coded present when a beneficiary had a 1999 date of death specified administratively.

Measures of noncardiac comorbidity. We characterized Medicare beneficiaries by their number and types of noncardiac comorbidities. Noncardiac comorbidities were identified using CCS coding and included all conditions except the following cardiac comorbidities: coronary atherosclerosis, cardiac dysrhythmias, valvular disorders, pericarditis, endocarditis and myocarditis cardiomyopathy, and conduction disorders.

We combined a few CCS codes (such as Type 1 and 2 DM) to simplify chronic disease classification and group clinically similar conditions (available upon request). We identified the 20 most common noncardiac comorbidities among CHF beneficiaries and treated these conditions as independent variables associated with preventable hospitalization and mortality.

Other independent variables. Our regression models for preventable hospitalization and mortality included other explanatory variables: gender, age, race, and primary provider type defined by the provider type that most filed outpatient claims during 1999 (categorized as cardiologist; generalist [general practice, family practice, internal medicine, obstetrics/gynecology, geriatric medicine, preventive medicine], or noncardiac specialist). We included the Deyo-Charlson comorbidity score (18), which is a general comorbidity index used for case-mix adjustment, and the five cardiac comorbidities defined here in preliminary analyses. Because these variables did not significantly alter parameter estimates of individual noncardiac comorbidities, however, we excluded them from final models. Because availability of hospitals and specialist care for chronic conditions can influence clinical outcomes, we accounted for patients' local access to hospital services, physicians, and cardiovascular physicians at the resident county level. We also evaluated the impact of living in a Health Professional Shortage Area; we excluded it from final models, however, because it did not influence results.

Data analysis. We used descriptive statistics to examine demographic characteristics and noncardiac comorbidity. The probability of experiencing hospitalization or hospitalization due to CHF-ACSC or any ACSC was calculated for the entire population and by burden of noncardiac comorbidity. A test of linear trend tested the hypothesis that hospitalizations were associated with greater comorbidity.

We calculated period prevalences for the 20 most frequent noncardiac comorbidities. We used multivariable log-linear Poisson regression to assess the impact of each noncardiac comorbidity on probability of a beneficiary experiencing outcomes: CHF-ACSC or any ACSC hospitalization, and mortality, while adjusting for potential confounders. The Poisson regression allows for an unbiased estimate of risk conferred by an exploratory variable on an outcome that occurs frequently, as was the case for the three outcomes we measured. Dummy-coded variables in the final regression models included: age (65 to 69, 70 to 74, 75 to 79, 80 to 84, 85+), gender, race (white or nonwhite), primary provider type (cardiologist, generalist, or noncardiac specialist), and each of the 20 most prevalent noncardiac conditions. We performed age- and gender-stratified models in preliminary analyses, but refrained from reporting them because interactions between these variables and comorbidities did not materially influence findings. Data from the regression models are reported as maximum likelihood risk ratios (RR) with 95% confidence limits, where risk of outcome in the presence of exploratory variable is compared to risk of outcome in the absence of exploratory variable. We used Stata v7.0 (Stata Corporation, College Station, Texas) and SAS v8.0 (SAS, Cary, North Carolina) for all analyses.

Table 1. Characteristics of Patients Age ≥65 Years With CHF

Characteristics	Total Sample n = 122,630 (%)
Gender	
Men	48,690 (40)
Women	73,940 (60)
Race	
White	108,093 (88)
Black	10,673 (9)
Other	3,864 (3)
Age, yrs (%)	
65–69	13,821 (11)
70–74	21,562 (18)
75–79	25,958 (21)
80–84	26,330 (21)
85+	34,959 (29)
Primary provider type in 1999	
Cardiologist	12,479 (10)
Generalist	64,183 (52)
Noncardiac specialist	45,968 (38)
Associated cardiac conditions	
Coronary atherosclerosis and other related heart disease	62,087 (51)
Cardiac dysrhythmias	50,826 (41)
Valvular disorders	26,941 (22)
Peri-, endo-, and myocarditis, cardiomyopathy	14,180 (12)
Conduction disorders	12,693 (10)
Total # of noncardiac comorbidities	
0	5,122 (4)
1	12,360 (10)
2	18,204 (15)
3	19,961 (16)
4	18,599 (15)
5	15,029 (12)
6	11,283 (9)
7	7,860 (6)
8	5,418 (4)
9	3,383 (3)
10+	5,411 (4)
Any inpatient stay, % (SE)	65 (0.1)
Inpatient stay for any ACSC, % (SE)	32 (0.1)
Inpatient stay for CHF ACSC, % (SE)	17 (0.1)
Mortality in 1999	22,481 (18)

ACSC = ambulatory care sensitive conditions; CHF = chronic heart failure; SE = standard error.

RESULTS

Patient characteristics. Most CHF beneficiaries were women (60%) and white (88%). Mean age was 79.6 years. Although these data are consistent with demographics of the entire Medicare population, beneficiaries with CHF were, on average, 4.4 years older than the overall Medicare population (19). Generalist physicians were the most frequent source of care for 64,183 (52%) patients, noncardiologist specialists for 38%, and cardiologists for 10% of patients. The most common forms of cardiac comorbidity were atherosclerotic heart disease, cardiac dysrhythmias, and valvular disorders (Table 1).

Noncardiac comorbidities were highly prevalent (Tables 1 and 2). Thirty-nine percent of patients had ≥5 noncardiac conditions, and only 4% had CHF alone. The most com-

Table 2. Twenty Most Common Noncardiac Chronic Disease Conditions for Patients Age ≥65 Years With CHF (n = 122,630)

Chronic Disease Defined by CCS Code	% Prevalence (n)
Essential hypertension	55 (67,211)
Diabetes mellitus	31 (38,175)
COPD and bronchiectasis	26 (32,275)
Ocular disorders (retinopathy, macular disease, cataract, glaucoma)	24 (29,548)
Hypercholesterolemia	21 (25,219)
Peripheral and visceral atherosclerosis	16 (20,027)
Osteoarthritis	16 (19,929)
Chronic respiratory failure/insufficiency/ arrest or other lower respiratory disease excluding COPD/bronchiectasis	14 (17,610)
Thyroid disorders	14 (16,751)
Hypertension with complications and secondary hypertension	11 (13,732)
Alzheimer's disease/dementia	9 (10,839)
Depression/affective disorders	8 (9,371)
Chronic renal failure	7 (8,652)
Prostatic hyperplasia	7 (8,077)
Intravertebral injury, spondylosis, or other chronic back disorders	7 (8,469)
Asthma	5 (6,717)
Osteoporosis	5 (6,688)
Renal insufficiency (acute and unspecified renal failure)	4 (5,259)
Anxiety, somatoform disorders, and personality disorders	3 (3,978)
Cerebrovascular disease, late effects	3 (3,750)

CCS = Clinical Classification System; CHF = chronic heart failure; COPD = chronic obstructive pulmonary disease.

mon noncardiac conditions were: essential hypertension (55%), DM (31%), and chronic obstructive pulmonary disease (COPD)/bronchiectasis (26%) (Table 2). Seventy-five percent of patients with CHF had at least one of these three conditions, and 93% had at least one of the 20 conditions specified in Table 2.

Approximately 65% of CHF beneficiaries had at least one hospitalization during 1999. Mean CHF-ACSC and ACSC hospitalization rates were 17% and 32%, respectively (Table 1). The most common ACSCs besides CHF (55%) were pneumonia (21%), COPD exacerbation (13%), and dehydration (5%). Death occurred in 22,481 patients (18%).

Noncardiac chronic disease burden and hospitalization rates. Figure 1 depicts the relationship between number of noncardiac comorbidities and probability of hospitalization. Beneficiaries with CHF and no other comorbidities had a mean probability of hospitalization of 35% (SE 1%). The probability increased to 72% for five comorbidities and 94% for ≥10 comorbidities ($p < 0.0001$). Although patients with ≥5 comorbidities comprised only 39% of the population, they accounted for 81% of total hospital days.

Among beneficiaries with CHF and no comorbidities, the probability of CHF-ACSC was 10%. This probability increased to 19% in the presence of five comorbidities and 29% in the presence of ≥10 comorbidities. For any ACSC hospitalization, the probability was 17% in patients with CHF alone, 35% in the presence of five comorbidities, and 52% in the presence of ≥10 comorbidities ($p < 0.001$ for both CHF-ACSC and any ACSC hospitalization).

To determine whether high probabilities of ACSC hospitalizations were unique to CHF beneficiaries and not elderly patients in general, we compared risks of hospitalization and ACSC hospitalization in CHF beneficiaries to risks in non-CHF beneficiaries from the overall Medicare population, while controlling for number of comorbidities. Relative to non-CHF beneficiaries, CHF beneficiaries had a 1.27-fold (≥10 comorbidities) to 8.75-fold (no comorbidities) higher risk of overall hospitalization and a 3.25-fold (≥10 comorbidities) to 21-fold (no comorbidities) higher risk of any ACSC hospitalization. Non-CHF beneficiaries also had close to zero percent risk for experiencing CHF-ACSC hospitalization (data not shown).

Specific noncardiac comorbidity on CHF-ACSC and any ACSC admissions, and total mortality. Tables 3, 4, and 5 present results of the unadjusted and adjusted Poisson regressions to determine how each of the 20 most prevalent conditions influenced the risk of a CHF beneficiary experiencing CHF-ACSC, any ACSC, and death, respectively. Complicated or secondary hypertension conveyed the greatest adjusted RR of CHF-ACSC admission (RR 1.51, 95% CI = 1.45 to 1.56), followed by chronic renal failure (RR 1.43, 95% CI = 1.36 to 1.50) and COPD/bronchiectasis (RR 1.40, 95% CI = 1.36 to 1.44) (Table 3).

Pulmonary conditions, including COPD/bronchiectasis, lower respiratory disease/failure/or insufficiency, and asthma were associated with the highest unadjusted RR of any ACSC hospitalization in CHF beneficiaries (Table 4). After adjustment, pulmonary conditions remained strongly associated with ACSC hospitalization, as did essential and complicated hypertension, late-stage cerebrovascular disease, chronic renal failure, Alzheimer's disease/dementia, DM, and depression/affective disorders.

Chronic lower respiratory disease/failure/insufficiency was associated with the greatest adjusted risk for death among our study population (RR 2.34, 95% CI = 2.27 to 2.41) (Table 5). Renal failure conferred the next highest adjusted RR (1.65, 95% CI = 1.58 to 1.73). Interestingly, some conditions (such as essential hypertension and hyperlipidemia) appeared "protective" for mortality, with risk ratios significantly below 1.00.

Although not the focus of our study, the influences of some demographic variables we used in our multivariable models on patient outcomes were of some clinical interest. Age, although an important determinant of mortality (RR 2.04, 95% CI = 1.93 to 2.15 for those 85+ relative to those 65 to 69), had only weak positive associations with CHF-ACSC and ACSC hospitalizations. Gender and race minimally influenced outcomes.

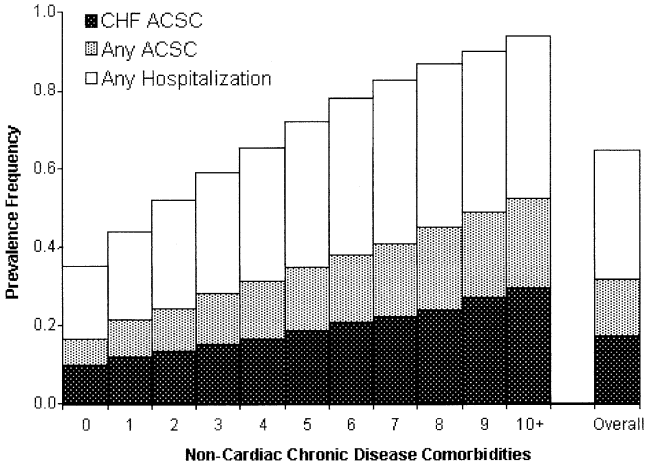

Figure 1. Impact of noncardiac comorbidity burden on the annual probability of a Medicare beneficiary with chronic heart failure (n = 122,630) experiencing a hospitalization due to any cause, a preventable hospitalization or a preventable hospitalization due to chronic heart failure (CHF). Data are represented as mean probabilities. $p < 0.0001$ for linear trend for all outcomes. ACSC = ambulatory care sensitive conditions.

DISCUSSION

Whereas burden of chronic illness complicates the management of all seniors (19), the adverse impact of chronic disease comorbidity on the care of elderly individuals with CHF appears especially profound. In our sample, patients with ≥5 comorbidities comprised approximately 40% of Medicare beneficiaries with CHF but accounted for 81% of total inpatient hospital days. Approximately 65% of patients had at least one hospitalization. Half of these hospitalizations were regarded as potentially preventable, of which 55% were CHF-related. Individuals with CHF, at any level of chronic disease comorbidity, had markedly higher risks for experiencing at least one preventable hospitalization relative to individuals without CHF.

Although our study is the first to report trends for ACSC hospitalizations in aged CHF patients, several reports have identified inadequacies in primary care for older individuals with multiple chronic illnesses (9,20). Wolff et al. (19) demonstrated in a nonselective group of Medicare beneficiaries, that chronic disease burden is strongly associated with one's risk of experiencing both ACSC admissions and preventable complications incurred during hospitalization. Recognizing that access to care powerfully predicts ACSC hospitalizations (14), multiple comorbidities may impede appropriate access to primary care that could forestall acute events requiring hospitalization (19). The fact that multiple comorbidities predispose individuals to medical undertreatment supports this hypothesis (9).

Our observations of potentially preventable hospitalizations among patients with CHF are consistent with previously published data, mainly from smaller samples (3,7,10,21,22). Vinson et al. (21) determined that among 161 patients age ≥70 years with index CHF hospitalizations, approximately 50% of readmissions by 90 days were either possibly or probably preventable. Michalsen et al. (22) studied 179 elderly patients hospitalized with decompensated preexisting CHF and identified 54.2% of admissions as preventable.

A number of reasons may explain why older CHF

Table 3. Association of Noncardiac Comorbidity With Ambulatory Care Sensitive CHF Hospitalization Among Medicare Beneficiaries With CHF

	Risk Ratio (95% CI) (n = 122,630)	
Condition	**Unadjusted**	**Adjusted***
Chronic renal failure	1.91 (1.83–1.99)	1.43 (1.36–1.50)
Acute and unspecified renal failure	1.83 (1.74–1.93)	1.18 (1.11–1.25)
Hypertension—with complications or secondary	1.82 (1.76–1.88)	1.51 (1.45–1.56)
Lower respiratory disease, failure or insufficiency	1.57 (1.52–1.63)	1.34 (1.30–1.39)
COPD/bronchiectasis	1.49 (1.45–1.53)	1.40 (1.36–1.44)
Diabetes mellitus	1.41 (1.37–1.44)	1.33 (1.29–1.37)
Essential hypertension	1.31 (1.28–1.35)	1.23 (1.20–1.27)
Asthma	1.31 (1.23–1.39)	1.05 (1.00–1.11)
Anxiety, somatoform disorders, and personality disorders	1.22 (1.14–1.31)	1.15 (1.07–1.23)
Peripheral or visceral atherosclerosis	1.19 (1.15–1.23)	1.08 (1.04–1.11)
Depression/affective disorders	1.16 (1.10–1.21)	1.11 (1.05–1.16)
Thyroid disorders	1.05 (1.01–1.09)	1.04 (1.00–1.08)
Chronic back disorders†	1.01 (0.96–1.06)	1.00 (0.95–1.06)
Osteoarthritis	1.01 (0.97–1.05)	1.01 (0.97–1.05)
Cerebrovascular disease, late effects	0.98 (0.91–1.07)	0.91 (0.84–0.98)
Ocular disorders	0.98 (0.95–1.01)	0.96 (0.93–0.99)
Prostatic hyperplasia	0.93 (0.88–0.99)	0.92 (0.86–0.97)
Osteoporosis	0.91 (0.86–0.97)	0.93 (0.87–0.99)
Hypercholesterolemia	0.90 (0.87–0.93)	0.84 (0.81–0.87)
Alzheimer's disease/dementia	0.82 (0.78–0.86)	0.81 (0.77–0.85)

*Adjusted for patient race (white or nonwhite), age (65–69, 70–74, 75–79, 80–84, 85+) and gender, primary caring provider type (cardiologist, generalist, non-cardiac specialist), patient's county of residence per capita hospital beds, total physicians and cardiovascular specialists; †Includes intravertebral injury, spondylosis, or other chronic back disorders.

CHF = chronic heart failure; CI = confidence interval; COPD = chronic obstructive pulmonary disease.

Table 4. Association of Noncardiac Comorbidity With Any Ambulatory Care Sensitive Condition Hospitalization Among Medicare Beneficiaries With CHF

	Risk Ratio (95% CI) (n = 122,630)	
Condition	**Unadjusted**	**Adjusted***
COPD/bronchiectasis	1.92 (1.88–1.96)	1.46 (1.42–1.51)
Lower respiratory disease, failure or insufficiency	1.82 (1.77–1.86)	1.70 (1.65–1.76)
Asthma	1.54 (1.48–1.60)	1.13 (1.07–1.19)
Acute and unspecified renal failure	1.51 (1.45–1.57)	1.09 (1.02–1.16)
Chronic renal failure	1.51 (1.46–1.56)	1.22 (1.16–1.28)
Hypertension—with complications or secondary	1.44 (1.40–1.48)	1.29 (1.24–1.34)
Anxiety, somatoform disorders and personality disorders	1.35 (1.29–1.42)	1.11 (1.04–1.19)
Depression/affective disorders	1.30 (1.26–1.35)	1.17 (1.12–1.23)
Cerebrovascular disease, late effects	1.22 (1.16–1.29)	1.39 (1.30–1.48)
Diabetes mellitus	1.21 (1.18–1.23)	1.17 (1.14–1.21)
Peripheral or visceral atherosclerosis	1.20 (1.17–1.23)	1.13 (1.09–1.16)
Essential hypertension	1.18 (1.16–1.21)	1.50 (1.45–1.54)
Alzheimer's disease/dementia	1.18 (1.14–1.22)	1.24 (1.19–1.30)
Osteoporosis	1.10 (1.05–1.15)	1.02 (0.96–1.08)
Thyroid disorders	1.05 (1.02–1.08)	0.99 (0.95–1.03)
Osteoarthritis	1.03 (1.00–1.05)	0.98 (0.94–1.01)
Chronic back disorders†	1.01 (0.97–1.05)	1.01 (0.96–1.07)
Ocular disorders	0.95 (0.92–0.97)	0.96 (0.93–0.99)
Prostatic hyperplasia	0.94 (0.90–0.98)	0.93 (0.88–0.99)
Hypercholesterolemia	0.80 (0.78–0.82)	1.09 (1.06–1.13)

*Adjusted for same variables as in Table 3. †Includes intravertebral injury, spondylosis or other chronic back disorders. Abbreviations as in Table 2.

patients with greater comorbidity may experience more adverse events that lead to preventable hospitalizations. These include underutilization of effective CHF therapies in the presence of other conditions because of safety concerns (for example, use of beta-blockers in asthma or angiotensin-converting enzyme inhibitors in renal insufficiency), patient nonadherence to or inability to recall complex dietary or medication regimens, inadequate postdischarge care, failed social support, and failure to promptly seek medical attention during symptom recurrence (21–25). Psychological stress from chronically poor health may also predispose to bad outcomes. Emotional stress can induce left ventricular

Table 5. Association of Noncardiac Comorbidity With Death Among Medicare Beneficiaries With CHF

	Risk Ratio (95% CI) (n = 122,630)	
Condition	**Unadjusted**	**Adjusted***
Lower respiratory disease, failure or insufficiency	2.56 (2.48–2.63)	2.34 (2.27–2.41)
Acute and unspecified renal failure	2.06 (1.96–2.16)	1.46 (1.38–1.54)
Chronic renal failure	1.92 (1.84–1.99)	1.65 (1.58–1.73)
Alzheimer's disease/dementia	1.64 (1.58–1.70)	1.24 (1.20–1.29)
Cerebrovascular disease, late effects	1.41 (1.32–1.51)	1.23 (1.15–1.31)
COPD/bronchiectasis	1.31 (1.27–1.34)	1.12 (1.09–1.16)
Depression/affective disorders	1.12 (1.07–1.18)	1.07 (1.02–1.13)
Peripheral or visceral atherosclerosis	1.03 (0.99–1.07)	0.95 (0.92–0.99)
Hypertension—with complications or secondary	0.97 (0.93–1.02)	0.94 (0.90–0.98)
Diabetes mellitus	0.94 (0.91–0.97)	1.11 (1.07–1.14)
Anxiety, somatoform disorders and personality disorders	0.89 (0.82–0.96)	0.89 (0.83–0.97)
Asthma	0.78 (0.73–0.83)	0.81 (0.75–0.86)
Osteoporosis	0.78 (0.73–0.83)	0.84 (0.79–0.90)
Thyroid disorder	0.73 (0.70–0.76)	0.81 (0.78–0.85)
Essential hypertension	0.61 (0.59–0.63)	0.70 (0.68–0.72)
Chronic back disorders†	0.60 (0.56–0.64)	0.78 (0.73–0.83)
Prostatic hyperplasia	0.59 (0.55–0.63)	0.63 (0.58–0.67)
Osteoarthritis	0.56 (0.54–0.59)	0.65 (0.62–0.68)
Ocular disorders	0.40 (0.39–0.42)	0.46 (0.44–0.48)
Hypercholesterolemia	0.33 (0.31–0.35)	0.47 (0.44–0.49)

*Adjusted for same variables as in Table 3; †Includes intravertebral injury, spondylosis, or other chronic back disorders. Abbreviations as in Table 2.

dysfunction in patients with idiopathic cardiomyopathy (26), and in one study preceded CHF hospitalization in 49% of patients (27). Elderly patients with multiple comorbidities and polypharmacy are also susceptible to poor coordination of care (19) and at increased risk for experiencing adverse drug reactions from drug-drug interactions (28). Finally, it may be that greater chronic disease burden results in diminished physiologic reserve and hence more acute events.

In this study, we found that renal disease, hypertension, COPD/bronchiectasis, anxiety/somatoform/and personality disorders, and DM associate with the highest risks of ACSC hospitalizations. The association of these comorbidities with potentially preventable hospitalizations is clinically relevant because these conditions are all typically responsive to effective outpatient management, and possibly, to care coordination with non-cardiologists. Although it remains unproven that improving outpatient access and care integration necessarily improves outcomes among older CHF patients with these comorbidities, these strategies clearly target two important indicators of healthcare quality (14).

Some of our results might seem unexpected without further discussion. Alzheimer's disease/dementia conferred a lower preventable CHF hospitalization risk, but higher overall preventable hospitalization and mortality risk. Sloan and Taylor (29) also observed Medicare patients with Alzheimer's disease to have high rates of mortality and hospitalization for conditions like pneumonia and hip fracture, but low rates of hospitalization for CHF; it may be that caregivers or chronic care institutions have high thresholds for hospitalizing near-terminal patients with dementia for CHF exacerbations. Hypertension also associated with unexpected outcomes, conferring a higher preventable hospitalization risk but lower overall mortality risk. Although uncontrolled hypertension can frequently precipitate CHF hospitalizations (21,22), uncomplicated hypertension may be "protective" in the CHF setting (30,31). This may relate to differences in prognosis between CHF due to diastolic dysfunction with blood pressures in the "hypertensive" range and CHF due to systolic dysfunction with blood pressures in the low-output failure range (30). Finally, hypercholesterolemia appeared protective in the setting of CHF by conferring a 53% lower mortality risk than those without hypercholesterolemia. Several other studies have correlated high lipoprotein levels with improved survival rates among individuals with CHF (32,33). One proposed mechanism is the capacity for lipoproteins to bind lipopolysaccharide, and curtail proinflammatory cytokine production and cytokine-induced catabolism (34). An additional explanation is a coding artifact. Healthier patients may more likely have hypercholesterolemia coded on an administrative billing form than do patients with serious conditions requiring frequent medical attention (35).

Study limitations. This study has several noteworthy limitations. First, we used administrative claims data to draw inferences about care outcomes. This precluded assessments of heart failure etiology, ejection fraction, disease severity, medication usage and several sociodemographic factors. Thus, we cannot ignore the potential impact of unmeasured confounders on our results. Because we were unable to distinguish diastolic from systolic dysfunction, we are also unable to conclude whether the impact of chronic disease comorbidity on outcomes is the same for these two forms of CHF. The lack of significant age and gender interactions with the comorbidities we studied on outcomes provides some suggestion that these differences are unlikely substantial, given that the predominant forms of CHF for elderly females and younger males are diastolic and systolic dysfunction, respectively.

A second limitation is that we used ICD-9 codes to define chronic conditions. Whereas ICD-9 codings for chronic conditions can have variable sensitivity, the specificity of this method to identify a condition is typically exceptional, with levels exceeding 96% (36). In addition to coding practices varying by providers and institutions, several studies, including those that evaluated coding in patients with heart failure, suggest that severe, acute complications take coding precedence over chronic conditions, particularly during hospitalizations (31,35). The reason for underreporting chronic diseases may also relate to influences of reimbursement incentives on ICD-9 coding. Although claims-based selection and misclassification bias likely biased the prevalence rates of our chronic conditions downward, we do not believe such biases invalidate the major implications of our analysis.

Because we focused on patients age $\geq$65 years and excluded beneficiaries enrolled in managed care, our results may not be generalizable to the entire Medicare CHF population. Also, because we used two CHF-coded claims rather than one to increase the specificity of our defined sample, we may have favorably or adversely selected a population by excluding incident CHF cases with just one claim. We performed a sensitivity analysis to estimate the impact of this potential selection bias. As this resulted in little change to probabilities of outcomes, selection bias on these grounds appears minimal. A final study limitation is that we did not account for time-dependent variables in our multivariable regression models. Beneficiaries who developed incident CHF beyond year onset or who died before year-end would have had shortened periods of risk exposure to the outcomes we measured compared to those with CHF for the entire 1999 study period.

Conclusions. Noncardiac comorbidity clearly complicates CHF care and is prevalent in one form or another for over 95% of elderly individuals with CHF. These data suggest that the health system's current "cardiologic" approach for managing elderly patients with CHF needs strong consideration of change. Parmley (37) recently recognized this need and outlined the growing importance for cardiologists to better recognize the frailty of the primary population they increasingly treat. Optimal approaches to managing elderly patients with CHF also need clearer definition. The stringent entry criteria of most randomized-controlled CHF

treatment trials typically exclude elderly patients and those with one or more significant comorbidities (38,39). Underrepresentation of these individuals makes it difficult to generalize findings to patients with CHF more likely to be encountered in routine clinical practice.

In conclusion, this study highlights how noncardiac comorbidities negatively influence individuals with CHF. Responses from cardiologists might include increased vigilance to conditions that complicate care, reorganized practices to reduce access barriers and improved communications with other providers when quality of comprehensive care seems suboptimal. Medicare responses might include multidisciplinary disease management teams, explicit payment for care coordination and new case-mix-adjusted reimbursement strategies that reward cardiologists for recognizing and referring, when necessary, patients with inappropriately treated noncardiac conditions. Given the steady rise in CHF incidence and prevalence in an aging population, optimizing outcomes for this high-risk population is a public health imperative.

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