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ORIGINAL RESEARCH

Impact of Frailty and Delirium Among Older Adults Admitted With Acute Decompensated Heart Failure

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ABSTRACT

BACKGROUND The presence of frailty or delirium among patients hospitalized for acute decompensated heart failure (ADHF) is associated with increased mortality and prolonged hospital stay.

OBJECTIVES The purpose of this study was to assess the combined effect of frailty and delirium on in-hospital mortality and disposition at discharge among older adults hospitalized with ADHF.

METHODS We conducted a retrospective observational study using Nationwide Inpatient Sample data from the Agency for Healthcare Research and Quality from 2016 to 2018. Patients aged 65 years or older with a diagnosis of ADHF (both with preserved and reduced left ventricular ejection fraction) were included. For analysis, we conducted a multivariable logistic regression analysis to determine OR for in-hospital mortality or nonhome discharge from delirium and frailty.

RESULTS A total of 3,577,433 weighted number of hospitalizations with ADHF were included. Delirium, moderate frailty risk, and high frailty risk increased the OR for in-hospital mortality (3.74; 95% CI: 3.70-3.78, 4.02; 95% CI: 3.96-4.09, and 8.63; 95% CI: 8.47-8.78, respectively) and nonhome discharge (4.21; 95% CI: 4.18-4.25, 2.95; 95% CI: 2.94-2.97, and 8.86; 95% CI: 8.78-8.94, respectively). When the combination of delirium and frailty was assessed, compared to those without delirium and with low frailty risk, the OR of mortality among those with delirium and high frailty risk was the highest at 12.18 (95% CI: 11.89-12.48). For nonhome discharge, the OR was the highest among those with delirium and high frailty risk at 14.01 (95% CI: 13.77-14.26).

CONCLUSIONS Frailty and delirium, independently and in combination, led to higher odds of in-hospital mortality and nonhome disposition at discharge among patients hospitalized with ADHF. (JACC Adv. 2024;3:101274) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

ADHF = acute decompensated heart failure

HF = heart failure

HFpEF = heart failure with preserved ejection fraction

HFrEF = heart failure with reduced ejection fraction

ICD = International Classification of Diseases

NIS = Nationwide Inpatient Sample

Heart failure (HF) is a major public health problem that affects more than 6 million people in the United States.[1] The lifetime risk for developing HF increases with age and ranges between 20% and 45% among adults aged 45 to 95 years.[2] HF is the leading cause of morbidity, mortality, and hospitalizations among older patients.[3] HF alone leads to an estimated 1 million hospitalizations annually.[1] Hospitalizations related to decompensated HF significantly increase after 65 years of age,[4] with 1 in 7 hospitalizations occurring in patients aged 80 years or older.[5] In-hospital mortality among patients admitted to the hospital for HF has been reported to be higher among those aged ≥65 years than among those aged <65 years.[6] Furthermore, a study found that older age (≥65 years) is a factor that significantly predicts patient prognosis after a HF hospitalization.[7] As a result, HF inflicts a significant societal burden in terms of morbidity, mortality, disability, and financial cost in the older population.

HF in older adults is complicated because of coexisting geriatric syndromes that have significant impact on clinical outcomes, such as frailty or delirium. Frailty represents a state of reduced physiological reserve that makes older adults vulnerable to external stressors, whereas delirium is a neuropsychiatric syndrome characterized by behavioral changes more often seen during hospitalization.[8,9] These syndromes are highly prevalent among older adults with frailty ranging between 12% and 24% and delirium ranging between 15% and 75%, depending on the clinical setting and definition used.[9,10] Both frailty and delirium are associated with adverse clinical outcomes including functional loss, prolonged length of stay in the hospital, and mortality.[11-13]

Previous studies have shown that older patients hospitalized for acute decompensated heart failure (ADHF) are at increased risk of developing delirium and having higher rates of frailty.[14,15] Furthermore, delirium has been shown to increase in-hospital mortality as well as hospital cost and length of stay among older adults hospitalized for ADHF.[14] A Japanese cohort study found that frail patients admitted to the hospital for ADHF also had longer length of stay and worsening walking ability when compared to prefrail and nonfrail patients.[16,17] The combined influence of frailty and delirium on clinical outcomes among hospitalized older patients for ADHF are not known. Therefore, the purpose of this study is to assess the association of frailty and delirium, in combination, with in-hospital mortality and nonhome disposition at discharge of older patients admitted for ADHF.

METHODS

STUDY DESIGN AND PATIENT POPULATION. This is a retrospective observational study using Nationwide Inpatient Sample (NIS) data from the Agency for Healthcare Research and Quality from the year 2016 to 2018. The NIS data is a large nationally representative publicly available all-payer inpatient database in the United States.[18] We identified patients aged 65 years or older who had a primary diagnosis of ADHF based on the following International Classification of Diseases-10th Revision (ICD-10) codes: I50.21, I50.23, I50.31, I50.33, I50.41, I50.43, I50.811, or I50.813. Before weighting, patients younger than 65 years (n = 13,585,284) and without a diagnosis of HF (n = 6,448,606) were excluded from the study. Patients with missing values in outcomes and demographic factors were also excluded (**Figure 1**).

We also included data on patients' demographics such as age (stratified in increments of 5 years), sex, race (White, Black, Hispanic, Asian or Pacific Islander, Native American, other), hospital bed size, hospital region, type of health insurance (Medicare, Medicaid, private insurance, self-pay, other), Elixhauser comorbidity mortality index, clinical relevant medical comorbidities (hypertension, diabetes mellitus, peripheral vascular disease, valvular heart disease, hypothyroidism, chronic lung disease, cancer, kidney disease, obesity, dementia, and depression), type of HF (heart failure with preserved ejection fraction [HFpEF] or heart failure with reduced ejection fraction [HFrEF]) (Supplemental Table 1), cardiac procedures (coronary artery bypass graft [CABG], percutaneous coronary artery intervention, open heart valvular surgery, and percutaneous valvular procedure) (Supplemental Table 1), presence of delirium and frailty risk, and nonhome disposition at discharge. The missing values were less than 3%, and we removed these data from the analyses. This study received exempt status from the institutional review board of the University of Texas Health Science Center at Houston.

FRAILTY RISK AND DELIRIUM ASSESSMENT. Frailty risk was assessed using the Hospital Frailty Risk Score (HFRS) developed by Gilbert et al.[19] The HFRS ranging from 0 to 99 was given to patients: low risk (score of

<5), intermediate risk (score between 5 and 15), and high risk (score higher than 15).[19] This score has been validated in many studies.[20,21] Delirium was identified based on ICD-10 criteria.[22]

STATISTICAL ANALYSIS. Descriptive statistics were used for patients' demographics and clinical characteristics. We also conducted multivariable logistic regressions, expressed as OR and 95% confidence interval (95% CI), for in-hospital mortality and nonhome discharge. The included explanatory variables were delirium, frailty, interaction between delirium and frailty, sex, age group, race, insurance, and hospital bed size. These variables were chosen based on clinical judgement. All explanatory variables are categorical. Observations with missing values were dropped from analysis. A *P*-value less than 0.05 was considered statistically significant. Statistical software SAS, version 9.4, was used for data manipulation and statistical analysis. Since NIS dataset is a sample survey, in order to obtain the national estimates, the Healthcare Cost and Utilization Project requires all analyses to be conducted using weighting with the variable. This variable adjusts the data to ensure the results can represent the national estimates and was developed to account for the complex sampling design of the NIS, incorporating hospital characteristics, patient demographics, and clinical conditions. The weighting methods were developed by the Healthcare Cost and Utilization Project and described elsewhere.[18] Therefore, we presented the weighted number rounded at the first decimal place in the results.

SENSITIVITY ANALYSIS. We conducted 2 sensitivity analyses. First, since the population with different types of HF may be different, we conducted a sensitivity analysis to assess the OR of each outcome in 3 separate groups: HFrEF, HFpEF, and combined type. Second, since HFRS is not yet thoroughly validated in patients younger than 75 years, we conducted a sensitivity analysis using another tool to identify frailty, the Claims-Based Frailty Index (CFI). The CFI is one of the most widely used frailty identification tools and has been mainly validated in claims data such as Medicare data[23]

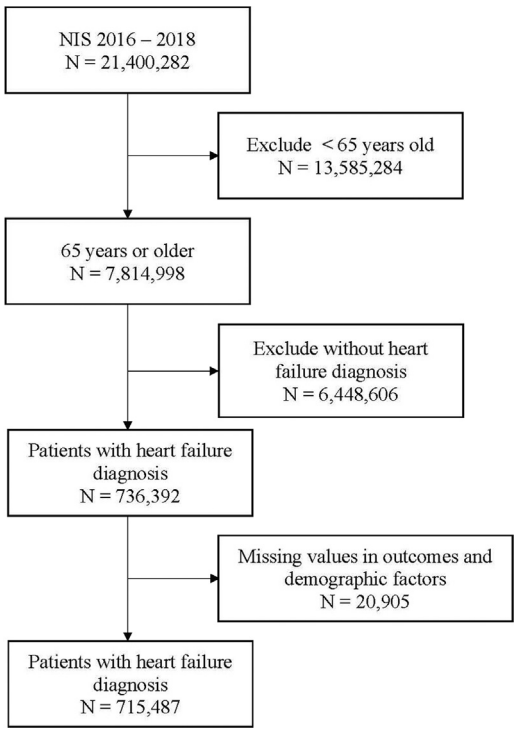
RESULTS

BASELINE CHARACTERISTICS. A total of 3,577,433 weighted number of hospitalizations with ADHF were included in the study (736,392 unweighted number). Delirium was present in 8.49% (n = 303,830) of patients. The mean number of medical comorbidities in these patients was 2.88 ± 1.4, and the most common reported comorbidities were hypertension (72.9%, n = 221,510), chronic lung disease (39.6%, n = 120,195), diabetes mellitus (35%, n = 106,340), dementia (27.4%, n = 83,400), hypothyroidism (20.8%, n = 63,100), and obesity (20.5%, n = 62,400) (**Table 1**, **Central Illustration**).

Out of the total number of patients included in the study, 55.6% (n = 1,989,259) had a moderate frailty risk, and 8.4% (n = 298,805) had a high frailty risk. Similar to patients with delirium, the mean number of medical comorbidities in patients with moderate frailty risk was 2.69 ± 1.4 and 3.09 ± 1.4 in the high-frailty-risk group. The most common reported comorbidity was hypertension (62.9% in moderate-risk group and 74.1% in high-risk group) (**Table 2**, **Central Illustration**).

IN-HOSPITAL MORTALITY. Among patients hospitalized for ADHF, mortality was higher in males (OR: 1.14; 95% CI: 1.13-1.15), those aged 90 years or older (OR: 1.54; 95% CI: 1.51-1.57), and those of Native

FIGURE 1 Flowchart With Sample Exclusion



The numbers included in this flowchart are not weighted. NIS = Nationwide Inpatient Sample.

TABLE 1 Demographic and Clinical Characteristics of Older Adults With and Without Delirium Hospitalized With ADHF

	Total (N = 3,577,433)	Delirium (n = 303,830)	No Delirium (n = 3,273,603)
Age, y			
65-69	554,405 (15.5)	43,010 (14.2)	511,395 (15.6)
70-74	619,860 (17.3)	48,800 (16.1)	571,060 (17.4)
75-79	650,925 (18.2)	55,090 (18.1)	595,835 (18.2)
80-84	653,200 (18.3)	55,360 (18.2)	597,840 (18.3)
85-89	602,385 (16.8)	53,975 (17.8)	548,410 (16.8)
90 or older	496,660 (13.9)	47,595 (15.7)	449,065 (13.7)
Sex			
Female	1,857,379 (51.9)	159,185 (52.4)	1,698,194 (51.9)
Male	1,720,054 (48.1)	144,645 (47.6)	1,575,409 (48.1)
Race			
White	2,726,504 (76.2)	231,905 (76.3)	2,494,599 (76.2)
Black	417,805 (11.7)	35,430 (11.7)	382,375 (11.7)
Hispanic	258,345 (7.2)	21,250 (7.0)	237,095 (7.2)
Asian or Pacific Islander	80,789 (2.3)	7,225 (2.4)	73,554 (2.3)
Native American	14,550 (0.4)	1,250 (0.4)	13,330 (0.4)
Other	79,450 (2.2)	6,770 (2.2)	72,680 (2.2)
Hospital bed size			
Small	731,854 (20.5)	55,915 (18.4)	675,939 (20.7)
Medium	1,109,489 (31.0)	93,285 (30.7)	1,016,204 (31.0)
Large	1,736,091 (48.5)	154,630 (50.9)	1,581,461 (48.3)
Hospital region			
Northeast	723,154 (20.2)	51,710 (17.0)	671,444 (20.5)
Midwest or North Central	759,155 (21.2)	63,515 (20.9)	695,640 (21.3)
South	1,456,855 (40.7)	125,825 (41.4)	1,331,030 (40.7)
West	638,269 (17.8)	62,780 (20.7)	575,489 (17.6)
Insurance			
Medicare	3,250,968 (90.9)	277,430 (91.3)	2,973,538 (90.8)
Medicaid	47,505 (1.3)	3,635 (1.2)	43,870 (1.3)
Private insurance	210,560 (5.9)	16,955 (5.6)	193,605 (5.9)
Self-pay	17,485 (0.5)	1,235 (0.4)	16,250 (0.5)
No charge	1,085 (0.03)	45 (0.01)	1,040 (0.03)
Other	49,830 (1.39)	4,530 (1.5)	45,300 (1.4)
Frailty risk			
Low	1,289,369 (36.0)	24,855 (8.2)	1,264,514 (38.6)
Moderate	1,989,259 (55.6)	198,540 (65.4)	1,790,719 (54.7)
High	298,805 (8.4)	80,435 (26.5)	218,370 (6.7)
Cardiac procedure			
CABG	46,185 (1.3)	4,040 (1.3)	42,145 (1.3)
PCI	118,990 (3.3)	6,020 (2.0)	112,970 (3.5)
Valve surgery (open)	29,435 (0.8)	2,450 (0.8)	26,985 (0.8)
Valve surgery (percutaneous)	49,695 (1.4)	1,560 (0.5)	48,135 (1.5)

Continued on the next page

American race (OR: 1.13; 95% CI: 1.05-1.22). When compared to Medicare beneficiaries, those with private insurance, self-pay, or other type of insurance had higher odds of inpatient mortality (OR: 1.44; 95% CI: 1.41-1.47, OR: 1.65; 95% CI: 1.55-1.75, OR: 2.34; 95% CI: 2.27-2.40, respectively). Patients who underwent CABG, percutaneous coronary artery intervention, or open valve surgery also had higher odds of inpatient mortality (OR: 1.10; 95% CI: 1.05-1.15, OR: 1.43; 95% CI: 1.39-1.46, OR: 1.34; 95% CI: 1.27-1.42, respectively) than patients who did not undergo these cardiac procedures. Delirium increased the odds of mortality compared to patients without delirium (OR: 3.74; 95% CI: 3.70-3.78). Moderate and high frailty risk increased the odds of mortality compared to low frailty risk (OR: 4.02; 95% CI: 3.96-4.09, OR: 8.63; 95% CI: 8.47-8.78, respectively). When interaction terms between delirium and frailty were introduced, compared to those without delirium and with low frailty risk, the OR of mortality was 6.09 (95% CI: 5.81-6.39) among those with delirium and low frailty risk, 10.49 (95% CI: 10.29-10.70) among those with delirium and moderate frailty risk, and 12.18 (95% CI: 11.89-12.48) among those with delirium and high frailty risk. The OR of mortality was 3.67 (95% CI: 3.61-3.73) among those without delirium and with moderate frailty risk and 7.84 (95% CI: 7.69-8.00) among those without delirium and with high frailty risk (**Table 3**, **Central Illustration**).

From the sensitivity analysis, when stratified by type of HF (HFpEF, HFrEF, and combined HF), delirium increased the odds of mortality among patients with low, moderate, and high frailty risk when compared to patients with no frailty risk. Similarly, among those with and without delirium, moderate and high frailty risk also increased the odds of mortality when compared to low risk of frailty (Supplemental Table 3). When CFI was applied to identify frailty, CFI captured more pre-frail and frail population than HFRS (Supplemental Table 5). Regarding the association between delirium and frailty, the CFI scoring system showed that patients with delirium and no frailty had increased odds of mortality compared to those without delirium. In addition, patients with delirium who were pre-frail or frail had increased odds of mortality compared to patients with no frailty. As observed with the HFRS system, pre-frail and frail patients without delirium also had increased odds of mortality compared to patients without delirium and without frailty. Interestingly, using the CFI scoring system, frail patients with delirium had lower odds of mortality than patients with delirium but without frailty or patients with delirium and with pre-frailty (Supplemental Table 6).

NONHOME DISPOSITION AT DISCHARGE. Patient disposition to nonhome facilities after hospitalization for ADHF was more prevalent among patients aged 90 years or older (OR: 2.27; 95% CI: 2.25-2.29) than among patients between the ages of 65 and 69 years. Patients who underwent CABG or open valve surgery had higher odds of nonhome disposition (OR: 2.22; 95% CI: 2.17-2.26, OR: 1.57; 95% CI: 1.53-1.61) than

patients who did not undergo these cardiac procedures. The presence of delirium increased the odds of nonhome discharge compared to patients without delirium (OR: 4.21; 95% CI: 4.18-4.25). Moderate and high frailty risk increased the odds of nonhome discharge compared to low frailty risk (OR: 2.95; 95% CI: 2.94-2.97, OR: 8.86; 95% CI: 8.78-8.94, respectively). When interaction terms between delirium and frailty were introduced, compared to those without delirium and with low frailty risk, the OR of nonhome discharge was 4.51 (95% CI: 4.40-4.63) among those with delirium and low frailty risk, 8.51 (95% CI: 8.42-8.60) among those with delirium and moderate frailty risk, and 14.01 (95% CI: 13.77-14.26) among those with delirium and high frailty risk. The OR of nonhome discharge was 2.73 (95% CI: 2.71-2.74) among those without delirium and with moderate frailty risk and 7.96 (95% CI: 7.88-8.04) among those without delirium and with high frailty risk. Sex, race, hospital bed size, region of hospitalization, or type of insurance did not lead to higher odds of disposition to nonhome facilities at discharge (**Table 4**, **Central Illustration**).

From the sensitivity analysis, when stratified by type of HF (HFpEF, HFrEF, and combined HF), delirium increased the odds of nonhome disposition at discharge among patients with low, moderate, and high frailty risk when compared to patients with no frailty risk. Similarly, among those with and without delirium, moderate and high frailty risk also increased the odds of nonhome disposition at discharge when compared to those patients at low risk of frailty (Supplemental Table 4). The CFI scoring system showed that patients with delirium and no frailty had increased odds of nonhome disposition compared to patients with no delirium. Similarly, patients with delirium who were pre-frail or frail had increased odds of nonhome disposition at discharge when compared to patients with no frailty. As observed with the HFRS system, pre-frail and frail patients without delirium also had increased odds of nonhome disposition at discharge compared to patients with no frailty. Furthermore, pre-frail and frail patients with delirium had increased odds of nonhome disposition at discharge compared to patients without frailty (Supplemental Table 7).

TABLE 1 Continued

	Total (N = 3,577,433)	Delirium (n = 303,830)	No Delirium (n = 3,273,603)
Number of medical comorbidities[a]	2.53 ± 1.4	2.88 ± 1.4	2.50 ± 1.35
Hypertension	2,206,993 (61.7)	221,510 (72.9)	1,985,483 (60.7)
Diabetes mellitus	1,120,865 (31.3)	106,340 (35.0)	1,014,525 (31.0)
Peripheral vascular disease	481,829 (13.5)	37,075 (12.2)	444,754 (13.6)
Valvular heart disease	197,080 (5.5)	12,070 (4.0)	185,010 (5.7)
Hypothyroidism	751,589 (21.0)	63,100 (20.8)	688,489 (21.0)
Chronic lung disease	1,398,659 (39.1)	120,195 (39.6)	1,278,464 (39.1)
Cancer	246,299 (6.9)	22,630 (7.4)	223,669 (6.8)
Kidney disease	130,700 (3.7)	13,270 (4.4)	117,430 (3.6)
Obesity	701,539 (19.6)	62,400 (20.5)	639,139 (19.5)
Dementia	440,065 (12.3)	83,400 (27.5)	356,665 (10.9)
Depression	394,815 (11.0)	39,085 (12.9)	355,730 (10.9)

Values are n (%) or mean ± SD. [a]The number of comorbidities is calculated based on Elixhauser comorbidities (range from 0 to 38). The percentage is column percentage. The numbers in the table are weighted numbers rounded up at the first decimal place. The table only shows the number and the percentage of 11 comorbidities.

ADHF = acute decompensated heart failure; CABG = coronary artery bypass graft; PCI = percutaneous coronary intervention.

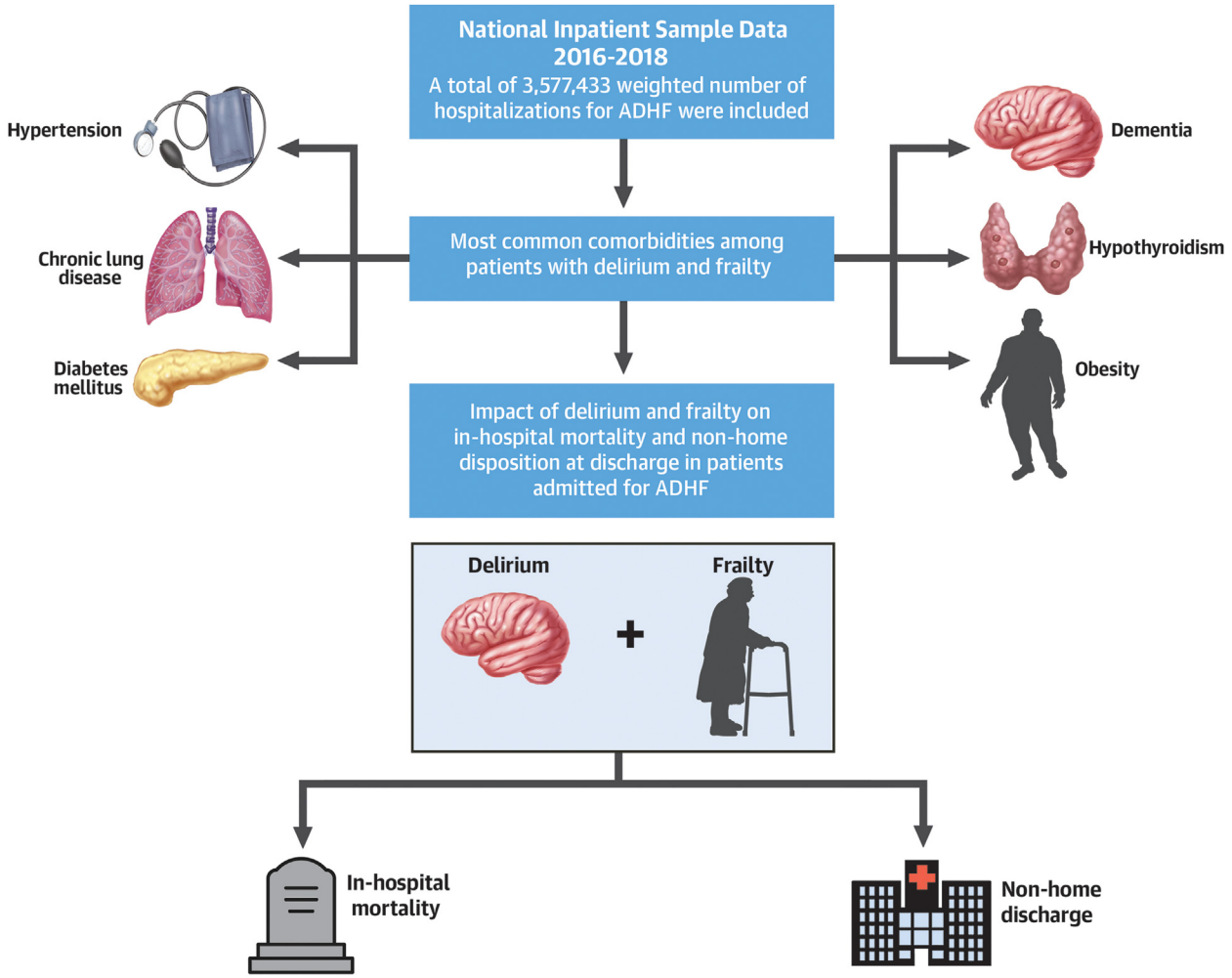
DISCUSSION

The results of our study demonstrated an increase in in-hospital mortality as well as nonhome disposition at discharge among patients with frailty and delirium admitted to the hospital for ADHF. Moreover, the rates of in-hospital mortality increased as the severity of frailty increased irrespective of the presence or absence of delirium. The highest in-patient mortality rates were seen in patients with delirium and higher risk of frailty.

Very few studies have assessed the impact of the coexistence of delirium and frailty on patient outcomes.[8,24-26] In the current study, we demonstrated for the first time that delirium together with frailty can increase the odds of in-hospital mortality and lead to nonhome disposition at discharge in patients admitted for ADHF. Older patients have some baseline degree of frailty and are at risk of developing delirium in the hospital. Frailty in HF may be explained by factors such as chronological age, subtype of HF (HFpEF vs HFrEF), severity of HF, and presence of comorbidities feeding into the condition of HF.[27] Some factors that predispose patients to develop delirium in the hospital setting include pre-existing congestive HF, visual or hearing impairment, polypharmacy, and history of cognitive impairment.[28]

The exact mechanism by which frailty and delirium lead to adverse clinical outcomes remains unknown.[8] Both syndromes are known independently to increase the risk of adverse clinical outcomes among older patients. Due to overlapping characteristics between frailty and delirium, it has been proposed that frailty

CENTRAL ILLUSTRATION **Morbidity and Mortality Associated With Frailty and Delirium Among Older Adults Admitted for ADHF**



Odds Ratio (95% CI)		Odds Ratio (95% CI)
Reference	No delirium with low frailty risk	Reference
6.09 (5.81-6.39)	Delirium with low frailty risk	4.51 (4.40-4.63)
10.49 (10.29-10.70)	Delirium with moderate frailty risk	8.51 (8.42-8.60)
12.18 (11.89-12.48)	Delirium with high frailty risk	14.01 (13.77-14.26)
3.67 (3.61-3.73)	No delirium with moderate frailty risk	2.73 (2.71-2.74)
7.84 (7.69-8.00)	No delirium with high frailty risk	7.96 (7.88-8.04)

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Frailty and delirium, in combination or independently, led to an increased odds in mortality and nonhome disposition at discharge compared to patients with no delirium and low frailty risk. Multivariable logistic regressions, expressed as OR and 95% CI, were used for the analysis. Icons made by ADHF = acute decompensated heart failure.

TABLE 2 Demographic and Clinical Characteristics of Older Adults at Risk of Frailty Hospitalized With ADHF

	Total (N = 3,577,433)	Low Frailty Risk (n = 1,289,369)	Moderate Frailty Risk (n = 1,989,259)	High Frailty Risk (n = 298,805)
Age, y				
65-69	554,405 (15.5)	228,245 (17.7)	290,705 (14.6)	35,455 (11.9)
70-74	619,860 (17.3)	239,765 (18.6)	335,485 (16.9)	44,610 (14.9)
75-79	650,925 (18.2)	237,120 (18.9)	362,250 (18.2)	51,555 (17.3)
80-84	653,200 (18.3)	228,390 (17.7)	368,300 (18.5)	56,510 (18.9)
85-89	602,385 (16.8)	200,340 (15.5)	343,015 (17.2)	59,030 (19.8)
90 or older	496,660 (13.9)	155,510 (12.1)	289,505 (14.6)	51,645 (17.3)
Sex				
Female	1,857,379 (51.9)	647,510 (50.2)	1,041,780 (52.4)	168,090 (56.3)
Male	1,720,054 (48.1)	641,859 (49.8)	947,479 (47.6)	130,715 (43.8)
Race				
White	2,726,504 (76.2)	974,844 (75.6)	1,525,584 (76.7)	226,075 (75.7)
Black	417,805 (11.7)	155,950 (12.1)	227,365 (11.4)	34,490 (11.5)
Hispanic	258,345 (7.2)	95,535 (7.4)	140,650 (7.1)	22,160 (7.4)
Asian or Pacific Islander	80,789 (2.3)	27,845 (2.2)	44,855 (2.3)	8,080 (2.7)
Native American	14,550 (0.4)	5,270 (0.4)	8,250 (0.4)	1,030 (0.3)
Other	79,450 (2.2)	29,925 (2.3)	42,555 (2.1)	6,970 (2.3)
Hospital bed size				
Small	731,854 (20.5)	273,975 (21.3)	401,119 (20.2)	56,760 (19.0)
Medium	1,109,489 (31.0)	399,234 (31.0)	615,960 (31.0)	94,295 (31.6)
Large	1,736,091 (48.5)	616,160 (47.8)	972,180 (48.9)	147,750 (49.5)
Hospital region				
Northeast	723,154 (20.2)	287,170 (22.3)	387,710 (19.5)	48,275 (16.2)
Midwest or North Central	759,155 (21.2)	257,695 (20.0)	426,665 (21.5)	74,795 (25.0)
South	1,456,855 (40.7)	529,845 (41.1)	810,365 (40.8)	116,645 (39.0)
West	638,269 (17.8)	214,659 (16.7)	364,519 (18.3)	59,090 (19.8)
Insurance				
Medicare	3,250,968 (90.9)	1,161,129 (90.1)	1,814,659 (91.2)	275,180 (92.1)
Medicaid	47,505 (1.3)	18,885 (1.5)	24,595 (1.2)	4,025 (1.4)
Private insurance	210,560 (5.9)	82,370 (6.4)	113,190 (5.7)	15,000 (5.0)
Self-pay	17,485 (0.5)	7,360 (0.6)	8,920 (0.5)	1,205 (0.4)
No charge	1,085 (0.03)	510 (0.04)	520 (0.03)	55 (0.02)
Other	49,830 (1.4)	19,115 (1.5)	27,375 (1.4)	3,340 (1.1)
Delirium				
Yes	303,830 (8.5)	24,855 (1.9)	198,540 (10.0)	80,435 (26.9)
No	3,273,603 (91.5)	1,264,514 (98.1)	1,790,719 (90.0)	218,370 (73.1)
Cardiac procedure				
CABG	46,185 (1.3)	19,025 (1.5)	24,925 (1.3)	2,235 (0.8)
PCI	118,990 (3.3)	57,360 (4.5)	56,140 (2.8)	5,490 (1.8)
Valve surgery (open)	29,435 (0.8)	12,840 (1.0)	15,200 (0.8)	1,395 (0.5)
Valve surgery (percutaneous)	49,695 (1.4)	29,325 (2.3)	19,015 (1.0)	1,355 (0.5)
Number of medical comorbidities[a]	2.53 ± 1.4	2.20 ± 1.3	2.69 ± 1.4	3.09 ± 1.4
Hypertension	2,206,994 (61.7)	735,094 (57.0)	1,250,330 (62.9)	221,570 (74.1)
Diabetes mellitus	1,120,865 (31.3)	312,965 (24.3)	699,090 (35.1)	108,810 (36.4)
Peripheral vascular disease	481,830 (13.5)	154,825 (12.0)	285,780 (14.4)	41,225 (13.8)
Valvular heart disease	197,080 (5.5)	79,835 (6.2)	106,095 (5.3)	11,150 (3.7)
Hypothyroidism	751,590 (21.0)	248,855 (19.3)	436,880 (22.0)	65,855 (22.0)
Chronic lung disease	1,398,659 (39.1)	440,780 (34.2)	838,459 (42.1)	119,420 (40.0)
Cancer	241,890 (6.8)	78,055 (6.1)	147,400 (7.4)	16,435 (5.5)
Kidney disease	130,700 (3.7)	30,720 (2.4)	90,655 (4.6)	9,325 (3.1)
Obesity	701,540 (19.6)	233,115 (18.1)	406,570 (20.4)	61,855 (20.7)
Dementia	440,065 (12.3)	43,075 (3.3)	301,080 (15.1)	95,910 (32.1)
Depression	394,815 (11.0)	99,845 (7.7)	250,475 (12.6)	44,495 (14.9)

Values are n (%) or mean ± SD. [a]The number of comorbidities is calculated based on Elixhauser comorbidities (range from 0 to 38). The percentage is column percentage. The numbers in the table are weighted numbers rounded up at the first decimal place. The table only shows the number and the percentage of 11 comorbidities.

ADHF = acute decompensated heart failure; CABG = coronary artery bypass graft; PCI = percutaneous coronary intervention.

TABLE 3 In-Hospital Mortality Attributable to the Interaction Between Delirium and Frailty Risk in Older Adults Hospitalized With ADHF

	OR	95% CI
Age, y		
65-69	Reference	
70-74	1.09	1.07-1.11
75-79	1.21	1.19-1.24
80-84	1.29	1.26-1.31
85-89	1.42	1.39-1.45
90 or older	1.54	1.51-1.57
Sex		
Female	Reference	
Male	1.14	1.13-1.15
Race		
White	Reference	
Black	0.75	0.73-0.76
Hispanic	0.83	0.81-0.85
Asian or Pacific Islander	0.97	0.94-1.01
Native American	1.13	1.05-1.22
Other	0.93	0.90-0.96
Hospital bed size		
Small	Reference	
Medium	1.07	1.05-1.08
Large	1.15	1.14-1.17
Hospital region		
Northeast	Reference	
Midwest or North Central	0.82	0.80-0.83
South	0.89	0.87-0.89
West	0.98	0.96-0.99
Health insurance		
Medicare	Reference	
Medicaid	0.91	0.87-0.95
Private insurance	1.44	1.41-1.47
Self-pay	1.65	1.55-1.75
No charge	1.32	0.90-1.76
Other	2.34	2.27-2.4
Elixhauser Comorbidity Mortality Index	1.03	1.028-1.030
Cardiac procedure		
CABG	1.10	1.05-1.15
PCI	1.43	1.39-1.46
Valve surgery (open)	1.34	1.27-1.42
Valve surgery (percutaneous)	0.86	0.82-0.90
Presence of delirium		
No	Reference	
Yes	3.74	3.70-3.78
Presence of frailty based on HFRS		
Low frailty risk	Reference	
Moderate frailty risk	4.02	3.96-4.09
High frailty risk	8.63	8.47-8.78
Interactions between delirium and frailty		
No delirium with low frailty risk	Reference	
Delirium with low frailty risk	6.09	5.81-6.39
Delirium with moderate frailty risk	10.49	10.29-10.70
Delirium with high frailty risk	12.18	11.89-12.48
No delirium with moderate frailty risk	3.67	3.61-3.73
No delirium with high frailty risk	7.84	7.69-8.00

ADHF = acute decompensated heart failure; CABG = coronary artery bypass graft; HFRS = Hospital Frailty Risk Score; PCI = percutaneous coronary intervention.

may act as a cofounder in the association between the presence of delirium and clinical outcomes.[8] This hypothesis has been supported by various studies that have shown inconsistent results. A previous prospective study of 273 patients aged ≥75 years found that patients with delirium had significantly higher frailty index scores than those without delirium and that frail patients had greater long-term mortality among those with delirium than those without frailty.[24] However, another study that investigated the impact of delirium on mortality in a cohort of patients (aged ≥70) also being evaluated for frailty found that the overall impact of delirium on acute medical admissions appeared to be greater at lower levels of frailty.[29] These discrepancies highlight the complex interactions between both conditions and the importance of early diagnosis to improve the prognosis of patients with these geriatric syndromes.

As previously reported in the literature, we found that frailty, in the presence or absence of delirium, is associated with an increased odds of in-hospital mortality among patients hospitalized with ADHF.[30,31] The 2022 American Heart Association/American College of Cardiology/Heart Failure Society of America guidelines for the management of HF recognize frailty as a potential barrier to effective self-care among patients with HF and as an important comorbidity when considering mechanical circulatory support and cardiac transplant among those with advanced HF.[32] Previous studies on frailty among patients with HF have mostly focused on physical function,[31] but additional data have emerged with regard to the role that other prevalent factors, such as cognitive dysfunction[33] and social isolation,[34] have on the prognosis of frail older patients with HF. In fact, a prospective cohort study of older adults (>65 years of age) hospitalized for HF found that patients who are frail (defined by weak hand grip) and have cognitive dysfunction (defined by score of <2 on a Mini-Cog test) have higher rates of readmissions and all-cause death.[35]

Although frailty has significant impact on clinical outcomes in HF patients, it has been challenging to accurately identify frailty. We chose the HFRS scoring system as it has been validated in hospitalized patients. However, it has not yet been validated among patients aged 75 years or older. Therefore, we performed a sensitivity analysis using the CFI scoring system, which is one of the other widely used frailty identification tools and has been validated using Medicare data for patients in the inpatient and outpatient settings. The result of these sensitivity analyses showed that the identification of frailty using both tools was different. The main difference was

the prevalence of frailty using the 2 different tools. And one of the interesting findings was that frail patients with delirium had decreased odds of mortality compared to patients without frailty, but pre-frail patients with delirium had increased odds of mortality compared to patients without frailty. We speculate that the categorization of the frailty may be different using these 2 different tools since HFRS was developed to be used in inpatient data, but the CFI was developed to be used in longitudinal claims data that contain both diagnosis codes and procedural codes. However, given that the findings of the results from using the CFI somewhat contradict current knowledge that frail patients are associated with higher mortality, we believe that the results from using HRFS could be more reliable. However, identifying the different stratification between the 2 tools and developing more accurate cutoff values in those 2 tools to identify frailty will be a necessary step in future studies to develop an appropriate frailty index to be used in NIS data.

Older patients with HF are at risk of developing delirium due to chronic cerebral hypoperfusion from a low cardiac output state and loss of normal autoregulation of cerebral perfusion pressures.[36] In our study, we found that delirium increases the odds of in-hospital mortality among patients hospitalized with ADHF. These findings are consistent with previous studies showing that delirium leads to increased morbidity and mortality in patients admitted with ADHF.[14,37-39] Delirium not only leads to higher odds of in-hospital mortality among patients hospitalized with ADHF, but it is also associated with increased total hospital cost ($4262 more) and increased length of stay (1.73 more days) compared to those of patients admitted for ADHF who did not develop delirium, creating a substantial economic burden.[14]

After a hospitalization for ADHF, most patients return home, but about 20% of these patients are discharged to a skilled nursing facility to continue working on their functional recovery.[40] In our study, we found that delirium and frailty increased the odds of nonhome disposition at discharge among patients hospitalized for ADHF. Moreover, a study carried out among veterans who were discharged to an skilled nursing facility following hospitalization for HF found that those with delirium were less likely to have improvement in their functional status and more likely to experience functional regression than those without delirium.[41]

When the interaction terms were tested, compared to those without delirium and without frailty, those with delirium and high frailty risk showed the highest

TABLE 4 Nonhome Discharge Attributable to the Interaction Between Delirium and Frailty Risk in Older Adults Hospitalized With ADHF

	OR	95% CI
Age, y		
65-69	Reference	
70-74	1.13	1.12-1.14
75-79	1.28	1.27-1.29
80-84	1.51	1.50-1.53
85-89	1.83	1.82-1.85
90 or older	2.27	2.25-2.29
Sex		
Female	Reference	
Male	0.87	0.87-0.88
Race		
White	Reference	
Black	0.76	0.76-0.77
Hispanic	0.69	0.68-0.70
Asian or Pacific Islander	0.69	0.68-0.70
Native American	0.83	0.80-0.86
Other	0.81	0.80-0.83
Hospital bed size		
Small	Reference	
Medium	0.97	0.97-0.98
Large	0.89	0.89-0.90
Hospital region		
Northeast	Reference	
Midwest or North Central	0.88	0.87-0.89
South	0.83	0.83-0.84
West	0.73	0.72-0.73
Health insurance		
Medicare	Reference	
Medicaid	0.678	0.663-0.694
Private insurance	0.897	0.888-0.906
Self-pay	0.659	0.636-0.684
No charge	0.606	0.519-0.708
Other	1.096	1.075-1.118
Elixhauser Comorbidity Mortality Index	1.007	1.006-1.008
Cardiac procedure		
CABG	2.22	2.17-2.26
PCI	0.87	0.85-0.88
Valve surgery (open)	1.57	1.53-1.61
Valve surgery (percutaneous)	0.72	0.70-0.73
Presence of delirium		
No	Reference	
Yes	4.21	4.18-4.25
Presence of frailty based on HFRS		
Low frailty risk	Reference	
Moderate frailty risk	2.95	2.94-2.97
High frailty risk	8.86	8.78-8.94
Interaction between delirium and frailty		
No delirium with low frailty risk	Reference	
Delirium with low frailty risk	4.51	4.40-4.63
Delirium with moderate frailty risk	8.51	8.42-8.60
Delirium with high frailty risk	14.01	13.77-14.26
No delirium with moderate frailty risk	2.73	2.71-2.74
No delirium with high frailty risk	7.96	7.88-8.04

ADHF = acute decompensated heart failure; CABG = coronary artery bypass graft; PCI = percutaneous coronary intervention.

OR for morality and nonhome discharge. These findings highlight the importance of recognizing delirium earlier, even for those patients with low frailty risk, as it can lead to worse clinical outcomes. Early detection of delirium and mobilizing hospital resources to prevent and manage delirium through multicomponent patient-centered care, such as Hospital Elder Life Program, can be one of the ways to prevent this geriatric syndrome.[42,43]

Even though our study provides important findings with regards to the interaction between delirium and frailty in the clinical outcomes of patients hospitalized with ADHF, there are several limitations. First, as previously mentioned in our study on delirium and HF,[14] the ICD-10 code for delirium in this large national dataset could have been underreported. In fact, compared to previously reported incidence of delirium of 17% to 23%,[39,44] our study had a relatively low incidence of 8.5%, pointing to the possible limitation of not reporting the presence of delirium in patients that likely met the criteria. Similarly, the currently available frailty scales, including the one used in this study, provide fair to moderate frailty ratings.[19] Thus, even though 64% of our cohort was classified as having moderate to high frailty, the incidence could have varied if we had used another frailty scale, indicating the need for further research into the development of universally acceptable frailty-assessment scores. Second, the NIS does not provide information of admission source. The lack of additional data on admission source could have resulted in overestimation of patients that were discharged to nonhome facilities for the first time. Third, this is a retrospective study with an inherent risk of selection bias and confounding, which could have led, for example, to an inability to identify those patients with ADHF who required intensive care unit level of care and whether this had an effect in the reported incidence of delirium and frailty.[14]

Despite its limitations, our study provides findings of significant clinical value that shed light on the gaps regarding care of older patients with HF. Furthermore, this study highlights the importance of early recognition of frailty and delirium as the presence of these syndromes is associated with adverse cardiovascular outcomes and higher risk of overall mortality.

CONCLUSIONS

In this retrospective cohort analysis, we demonstrated for the first time in the literature that both delirium and moderate-to-high frailty risk, combined or independently, led to an increased odd of mortality and nonhome disposition at discharge among older patients hospitalized for ADHF.

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PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE: Among older adults hospitalized for ADHF, frailty and delirium, in combination or independently, are associated with an increased odd of mortality and nonhome disposition at discharge. Furthermore, the rates of in-hospital mortality increased as the severity of frailty increased irrespective of the presence or absence of delirium.

TRANSLATIONAL OUTLOOK: Additional studies are needed to better characterize the mechanisms by which frailty and delirium lead to adverse clinical outcomes. Likewise, further efforts are required to implement strategies that will lead to identification and treatment of patients who are at a higher risk of developing frailty and delirium.

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APPENDIX For supplemental tables, please see the online version of this paper.