Hospital readmission and mortality: associations to a hospital frailty risk score in a national sample of US older adults with pre-existing coronary heart disease, an observational study.

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Research article

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Abstract

Background

Coronary heart disease (CHD) is the most common form of heart disease and a leading cause of death in cardiovascular disease (CVD). Although frailty has been studied in CVD, a condition encompassing heart disease and stroke, frailty in hospitalized elders with CHD is under researched. The study aimed to examine how a Hospital Frailty Risk Score (HFRS) influenced readmission and in-hospital mortality rates in older patients with CHD.

Methods

Adults > 65 years with pre-existing CHD identified by ICD-10-CM codes from the 2016 Nationwide Readmissions Database (NRD) were included in the study. Frailty risk was determined using a validated Hospital Frailty Risk Score (HFRS) based on ICD-10-CM codes. Readmission was defined as a) any subsequent inpatient readmission and b) 30-day readmission after an index event. In-hospital mortality was measured as death during index event, any readmission death, and death during a 30-day readmission.

Results

Frailty risk was identified in 92.4% of the 1.09 million eligible adults with CHD. Readmission and in-hospital mortality rates were higher in frail patients. Compared to the non-frail, patients with low, intermediate, and high frailty risk showed 27% vs 28%, 47% vs 49%, and 42% vs 49% greater risk for readmission and 30-day readmission, respectively. Patients with intermediate and high frailty risk were 2.31 and 3.44 times more likely to die during the index events, 2.15 and 2.44 times more likely to die during readmission, and 2.26 and 2.68 times more likely to die during 30-day readmission.

Conclusion

Readmission and mortality rates increased proportionally to the level of frailty risk in older adults with CHD. CHD, frailty, and older age together profoundly impact patients' health outcomes in negative ways and places patients at a higher risk of mortality and readmission rate than non-frail patients. Further research should investigate interventions to improve frailty risk in CHD.

Background

In frail older adults, physiological changes speed up physical deterioration and functional decline that increase the risk of poor health outcomes [1, 2, 3]. The prevalence of frailty increases as people age and is associated with increased mortality, morbidity, disability, health care utilization and costs, and is a predictor of poor surgical and interventional outcomes [4, 5]. Frailty also independently predicts hospital readmission including less than 30 day readmission after complex cardiovascular surgery, as well as after a general admission to a medical ward [6, 7].

More than half of all cardiovascular disease (CVD) patients are 65 years or older [8], with 90% of adults over the age of 80 diagnosed with CVD [9]. CVD includes broad diagnostic categories for coronary heart disease (CHD) and stroke, with CHD the main cause of mortality (43.8%), followed by stroke (16.8%) [10]. CHD, the most common form of heart disease, results in an estimated 370,000 deaths and 735,000 heart attacks annually in the US. There is a developing literature about the associations between frailty and CVD. The proportion of older adults with CVD identified with frailty ranges from 25–50%, and among those the prevalence of frailty is nearly 3 times greater than in the general population of community-dwelling older adults [11, 12]. The negative impacts of frailty on the physical ability of older adults with CVD can further compromise their quality of life [10, 13] and increase the risk for subsequent cardiovascular events [14] and the 5-year mortality rate after the onset of CVD [15, 16]. The correlation between frailty and the risk of CVD is stronger in women than men [16].

Although research shows that there are associations between frailty and CVD, few studies examine the associations between CHD diagnoses and frailty, particularly in older adults [17]. Little is known about the relationship between frailty and in-hospital mortality and readmission rates in hospitalized older patients with CHD. The American College of Cardiology and American Geriatric Society state there is a critical need for research in the clinical management and care for older adults with CVD to improve health care outcomes [18]. To respond to this critical need, this study aimed to investigate the impact of frailty on mortality and readmission rates in older patients with CHD using a nationally representative data set, the 2016 US Nationwide Readmissions Database (NRD). Given that individual frailty is not assessed in the NRD, this study used a new methodology developed and validated by Gilbert et al. (2018) [19] that allows researchers to assess the risk of frailty in claims, retrospective survey, or electronic health record data using ICD-10-CM codes to create a Hospital Frailty Risk Score (HFRS) for each separate discharge record. The Gilbert et al. study showed that the HFRS performed as well or better than existing tools to measure frailty risk. Our study is the first to use this method to explore and investigate the impacts of frailty on hospitalized CHD patients in nationally representative data.

Methods

Data source

This retrospective observational study used the 2016 US NRD drawn from the Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases (SID). The SID tracks patients within and across hospitals from 49 participating US states, covering approximately 97% of all US community hospital discharges. The sampling frame for NRD contains patient data on discharges from community hospitals as defined by the American Hospital Association (AHA) Annual Survey of Hospitals [20], excluding rehabilitation and long-term acute care facilities. The introduction to the NRD documentation gives a lengthy description of the definition of community hospital [21]. Since the NRD is structured to represent a larger universe of discharges than is included in the study sample, post-stratification by hospital and patient characteristics was conducted by HCUP-NRD to create discharge-level weights that can be applied to produce national estimates [22].

Study sample

Participants included in this study experienced an index event of a first hospitalization associated with CHD during 2016. The study included those ≥ 65 years of age with CHD identified by ICD-10-CM diagnosis codes for coronary atherosclerosis and other heat disease, angina pectoris, unstable angina, other acute and subacute forms of ischemic heart disease, coronary atherosclerosis and other forms of chronic heart disease. Patients admitted between January and November of 2016 were included in the study sample to allow at least 30 days to identify readmission events. Participants were excluded if they experienced a discharge involving transfer to another care facility and same-day stays, and those with cancer were excluded due to the high risk of readmission. Finally, participants with missing or invalid data of study variables, representing less than 1% of the study sample, were excluded. Patients meeting these inclusion and exclusion criteria were included in study sample one to examine the association between frailty and in-hospitalization mortality. After excluding those who died during the index event from the first study sample, study sample two was created to examine the association between frailty and readmission (See Fig. 1: Consort chart).

Outcomes measures

The primary outcomes were readmission and in-hospital mortality. Two types of readmission events were measured. The overall readmission was defined as a subsequent inpatient admission with any condition after the index event. The 30-day readmission was defined as a subsequent inpatient admission with any condition within one month after the index event. Three types of in-hospital mortality were measured, including death during the index event defined as index in-hospital mortality, death during any readmission event defined as overall readmission in-hospital mortality, and death during 30-day readmission event defined as 30-day readmission in-hospital mortality. All patients were followed for at least 30 days and up to 365 days after the index event.

Independent variables

Frailty, the primary independent variable, was measured by calculating a HFRS developed and validated by Gilbert et al. [19] for older patients in the acute care setting. In brief, the diseases associated with frailty were identified by using ICD-10-CM codes and assigned points to reflect the risk of frailty (See the appendix to Gilbert et al., article for a full listing of the ICD-10-CM codes and their risk categories for the HFRS). The total HFRS was then categorized into 0, < 5, 5–15, and > 15 to represent no frailty, low risk, intermediate risk, and high risk of frailty. The characteristics of the study sample included patient demographics (age, gender, location, and income level), health insurance, and loss of function. To differentiate the older population, older patients were categorized in two age groups: 65–74 years and 75 years and older. The patient location was measured by NRD using the National Center for Health Statistics urban-rural classification scheme for US counties and categorized into metropolitan and non-metropolitan. NRD used 2016 median income quartiles to define four income levels. The loss of function was measured based on diagnosis-related group (DRG) as estimated by HCUP NRD using the 3M Health Information System to reflect the severity of illness.

Data analysis

Chi-square tests were used to compare characteristics in patients with no, low, intermediate, and high risks of frailty. Log-rank tests were used to compare readmission rates and in-hospital mortality rates in patients with different risks for frailty. In addition, Cox-regression models were used to examine the effects of frailty risk on overall readmission, 30-day readmission, and in-hospital mortality during overall readmission and 30-day readmission events. The proportional hazard assumption was assessed and found to be satisfied [23]. Logistic regression was used to examine the association between frailty risk and in-hospital mortality during index event. The statistical significance was set at $p < 0.05$. The discharge weights were applied in the analysis and provide justification for national estimated of the measured outcomes [22]. All analyses were conducted using SAS 9.4.

Results

For the study sample 1, a total of 1.13 million older patients were included to examine in-hospital mortality during the index event, representing 2.14 million patients in the US (Fig. 1). After excluding those who died during the index events (n = 37,557), a total of 1.09 million patients were included in study sample 2 to examine the outcomes associated with readmission, representing a total of 1.9 million patients in the US (Fig. 1). We found 92.4% were at risk of frailty; of those 44.5% were at low risk and 50.5% at intermediate risk. Overall, patients with a higher risk of frailty showed were proportionately of older age (≥ 75 years), female gender, with a household income higher than the 75th percentile, and had major or extreme loss of function (Table 1).

Table 1

Characteristics of the study sample for readmission outcomes by a Hospital Frailty Risk Score range (n = 1,090,329)

	Frailty risk score range				
Characteristics	No frailty (0) n = 84,254	Low risk (< 5) n = 448,499	Intermediate (5–15) n = 508,546	High risk (> 15) n = 48,784	p
	n (weighted %)	n (weighted %)	n (weighted %)	n (weighted %)	
Age (years)					< 0.001
65–74	45,176 (53.9)	194,118 (43.5)	160,201 (31.9)	10,721 (22.5)	
75+	39,078 (46.1)	254,381 (56.5)	348,345 (68.1)	38,063 (77.5)	
Gender female	32,310 (38.1)	180,929 (40.4)	236,323 (46.6)	25,847 (53.1)	< 0.001
Primary payer					< 0.001
Medicare/Medicaid	75,476 (89.9)	411,198 (92.0)	476,070 (93.8)	46,307 (95.2)	
Private and other	8,778 (10.1)	37,301 (8.0)	32,476 (6.2)	2,477 (4.8)	
Median household Income quartile ($)					< 0.001
1–42,999	22,436 (27.3)	120,023 (27.6)	135,105 (27.8)	12,264 (26.6)	
43,000–53,999	22,762 (28.0)	118,759 (27.4)	130,506 (26.5)	11,953 (25.4)	
54,000–70,999	21,612 (25.7)	114,501 (25.5)	130,619 (25.5)	12,434 (25.2)	
71,000+	17,444 (18.9)	95,216(19.5)	112,316 (20.2)	12,133 (22.7)	
Metropolitan location	69,482 (78.1)	375,086 (79.8)	434,501 (81.9)	43,127 (85.2)	< 0.001
Loss of function					< 0.001

	Frailty risk score range			
Minor	34,505 (40.4)	84,953 (18.8)	24,431 (4.8)	455 (0.9)
Moderate	41,487 (49.6)	23,5971 (52.7)	171,018 (33.7)	7,420 (15.6)
Major - extreme	8,262 (10.0)	127,575 (28.5)	313,097 (61.5)	40,909 (83.5)

Ascending trends of readmission rates and in-hospital mortality rates were observed as the frailty risk increased (Fig. 2). As the frailty risk increased from no risk to high risk, the overall readmission rate rose from 23.9–41.7% and 30-day readmission rate rose from 11.2–23.5% (Fig. 2A). Comparing patients with no frailty risk vs. those with high frailty risk, the in-hospital mortality rates during the index event changed from 0.5–9.3%, from 1.1–5.2% during an overall readmission event, and from 0.5–3.1% during 30-day readmission event. After adjusting for patient demographic and health characteristics, patients with low, intermediate, and high frailty risk showed 27%, 47%, and 42% higher risk for overall readmission and 28%, 49%, and 49% higher risk for 30-day readmission than those with no frailty risk (Table 2). Compared with those with no frailty risk, patients with intermediate and high frailty risk were 2.31 and 3.44 times more likely to die during the index events, 2.15 and 2.44 times more likely to die during readmission events, and 2.26 and 2.68 times more likely to die during 30-day readmission events (Table 3). The full regression results are shown in Appendices 1 and 2.

Table 2
Adjusted risk for readmission associated with frailty

Frailty risk score range	Overall readmission, HR (95% CI)	30-day readmission, HR (95% CI)
No frailty (0)	1.00	1.00
Low (< 5)	1.27 (1.25, 1.29)	1.28 (1.25, 1.31)
Intermediate (5–15)	1.47 (1.44, 1.49)	1.49 (1.45, 1.52)
High (> 15)	1.42 (1.39, 1.48)	1.49 (1.44, 1.53)
CI: confidence interval; HR: hazard ratio		

Table 3

Adjusted risk for in-hospitalization mortality and readmission associated with frailty

	In-hospital mortality		
Frailty risk score range	Index, OR (95% CI)	Overall readmission, HR (95% CI)	30-day readmission, HR (95% CI)
No frailty (0)	1.00	1.00	1.00
Low (< 5)	1.02 (0.91, 1.15)	1.59 (1.48, 1.71)	1.65 (1.50, 1.82)
Intermediate (5–15)	2.31 (2.06, 2.58)	2.15 (2.01, 2.30)	2.26 (2.05, 2.49)
High (> 15)	3.44 (3.06, 3.87)	2.44 (2.25, 2.63)	2.68 (2.41, 2.98)
CI: confidence interval; HR: hazard ratio; OR: odds ratio			
Figure 1 Consort chart			

Discussion

This nationally representative study examined frailty in terms of a HFRS in association with any and 30-day readmission and mortality in older adults with CHD, and found that an increasing HFRS increases the rate of and risk for an index event mortality, 30-day mortality, and any readmission and 30-day readmission. The increased rates and risks were most pronounced between those with low and intermediate HFRSs, and less so between those with intermediate and high HFRSs. The risk for index, any and 30-day mortality ranged from 2.15–3.44 times more likely to die. These results are distinct for CHD, and are among the few to isolate CHD from the overarching category of CVD, a diagnostic category that also includes vascular conditions and stroke.

Several frailty tools exist to assess a clinical frailty phenotype, or symptoms, comorbidities or disabilities associated with frailty [24, 25]. Few instruments use information that could be gleaned from the EMR or found in claims databases. To our knowledge only one other study by Kundi et al., uses the HFRS to assess acute myocardial infarction AMI, heart failure (HF) and pneumonia [26, 27]. The Kundi study used Medicare fee-for-service data, while this study is the first known to use HCUP's NRD with the validated HFRS developed by Gilbert et al., to use ICD-10-CM codes to identify those with gradations of frailty risk (no frailty, low, intermediate, or high risk of frailty). Similar to the Kundi study our findings showed increased risk of readmission and mortality among frail vs the non-frail in those with CHD (e.g., AMI, HF). Other factors such as the amount and type of treatment received for events of AMI may influence the prevalence of a treatment risk gap that may influence AMI mortality outcomes, and explain some of the difference between all-cause and cardiac related mortality [28].

Frailty is identified in 92.4% of older adults with CHD, which is considerably higher than the 25–50% previously reported in CVD patients [12]. Our demographic findings reflect similar gender differences as reported in prior research, e.g., more women than men were frail. However, in a meta-analysis assessing gender differences among frail elders, although women were proportionately more frail, males showed higher mortality rates [29]. The gender differences in mortality among frail elders reported that meta-analysis may be equivocal. Other research suggests that frail elderly women with acute coronary syndrome have greater mortality than frail men of similar age [30].

As expected, in our sample of older adults with pre-existing CHD our findings showed increased mortality as the rates and risk of frailty increase. These results are similar to those in CVD [12, 16, 25], acute coronary syndrome [31–33], and myocardial infarction [34], as well as after CVD interventions [35–37]. This lends credence to using the HFRS for observational research, or for applications with electronic medical records (EMR) to identify frailty using ICD-10-CM codes to determine who may be at greater risk for readmission or death. Using the HFRS in conjunction with the EMR may be a proactive approach to help identify older adults who may benefit from interventions that reduce the risks associated with frailty, such as interventions that increase physical activity ([7, 38]. Our study adds the dimension of further delineating frailty by level of frailty (none, low, intermediate, and high) in relation to mortality and in-patient readmissions instead of a commonly used overarching dichotomous yes frail vs no frailty. Further research could compare our results to dichotomous claims based frailty indicators to determine the finer gradations of no frailty, low, intermediate, and high risk of frailty [39].

Implications for Clinical Practice

It is vital to identify frail patients and intervene early to stem further declines in reserve and function. Using a HFRS amenable for use with the electronic medical record (EMR) could alert health care providers about frailty status in hospitalized patients. Evidence-based interventions, such as nutritional supplementation [40] or exercise that improves muscle strength and gait speed [41, 42], could then be implemented once a patient's risk score was elevated. The EMR embedded HFRS could monitor frailty status over time to alert providers about functional status declines. Further, an EMR embedded HFRS could monitor those engaging in long-term interventions to improve frailty status. Long-term engagement in exercise is beneficial to cardio and renal function of older patients [43]. The anaerobic threshold, left ventricular ejection fraction, and the average estimated glomerular filtration rate were maintained over the duration of 5-year exercise program [43]. Better use of physical therapy, group exercise programs, and specific exercise modalities shown to be feasible with no significant adverse events in older adults (e.g., Qigong exercise) should be considered [44].

Limitations

This study did not compare the HFRSs between those with and without CHD, or compare subgroups of CVD, such as CHD to other vascular disease or stroke. We would expect to show findings similar to those in CVD where those with vs without CVD show greater frailty, and greater mortality. Further research is needed to determine if there are differences in the associations between frailty, readmission, and

mortality between heart disease and stroke. In addition, the NRD has several limitations. This study could not track a patient through discharges over several years. Although the NRD includes a patient linkage number, this number only applies to one year of data and does not follow a patient across several years. Each year of the NRD is considered a unique separate sample which limits the research to assessing just one year of data. This study chose the most recently available data for year 2016. However, the patient linkage number provides the means to follow a patient longitudinally during the respective data set year. The NRD does not include qualitative measures of frailty, quality of life, or pre-admission or post-discharge measures of functional or health status. The study is limited to a hospitalization measure of frailty as categorized by the HFRS. As with any retrospective research using administrative data, the results show associations and do not imply causation.

Conclusion

An increasing HFRS is associated with increased any and 30-day readmission and index event and 30-day mortality in older adults with CHD. Using a frailty score calculated from ICD-10-CM codes may help health care providers and health systems identify those at risk for higher levels of frailty who may benefit from interventions designed to reduce or stabilize frailty. Further research is needed to determine if frailty indexes using ICD-10-CM codes have wide applicability.

Abbreviations

CHD coronary heart disease

CVD cardiovascular disease

DRG diagnostic related groupings

EMR electronic medical record

HCUP Healthcare Cost and Utilization Project

HF heart failure

HFRS Hospital Frailty Risk Score

ICD-10-CM International Classification of Diseases, 10th Revision, Clinical Modification

NRD Nationwide Readmissions Database

SID State Inpatient Database

US United States

Declarations

Ethics approval and consent to participate: Consent to participate was not applicable for this study.

Consent for publication: Not applicable

Availability of data and material: The datasets used and analyzed during the current study are available and accessible through the NRD Overview. Healthcare Cost and Utilization Project (HCUP). September 2019. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/nrdoverview.jsp.

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Figures

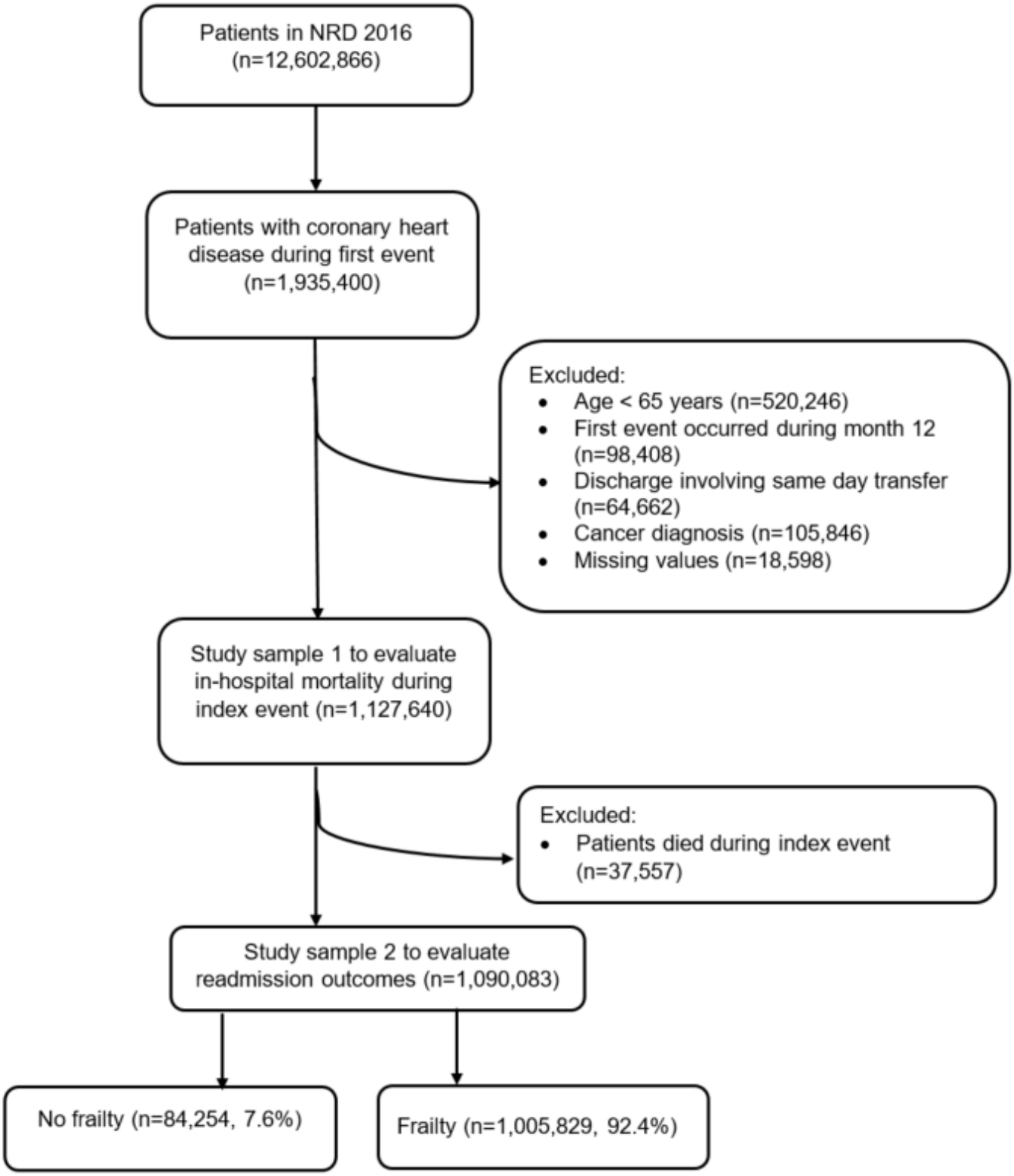

Figure 1

Consort chart

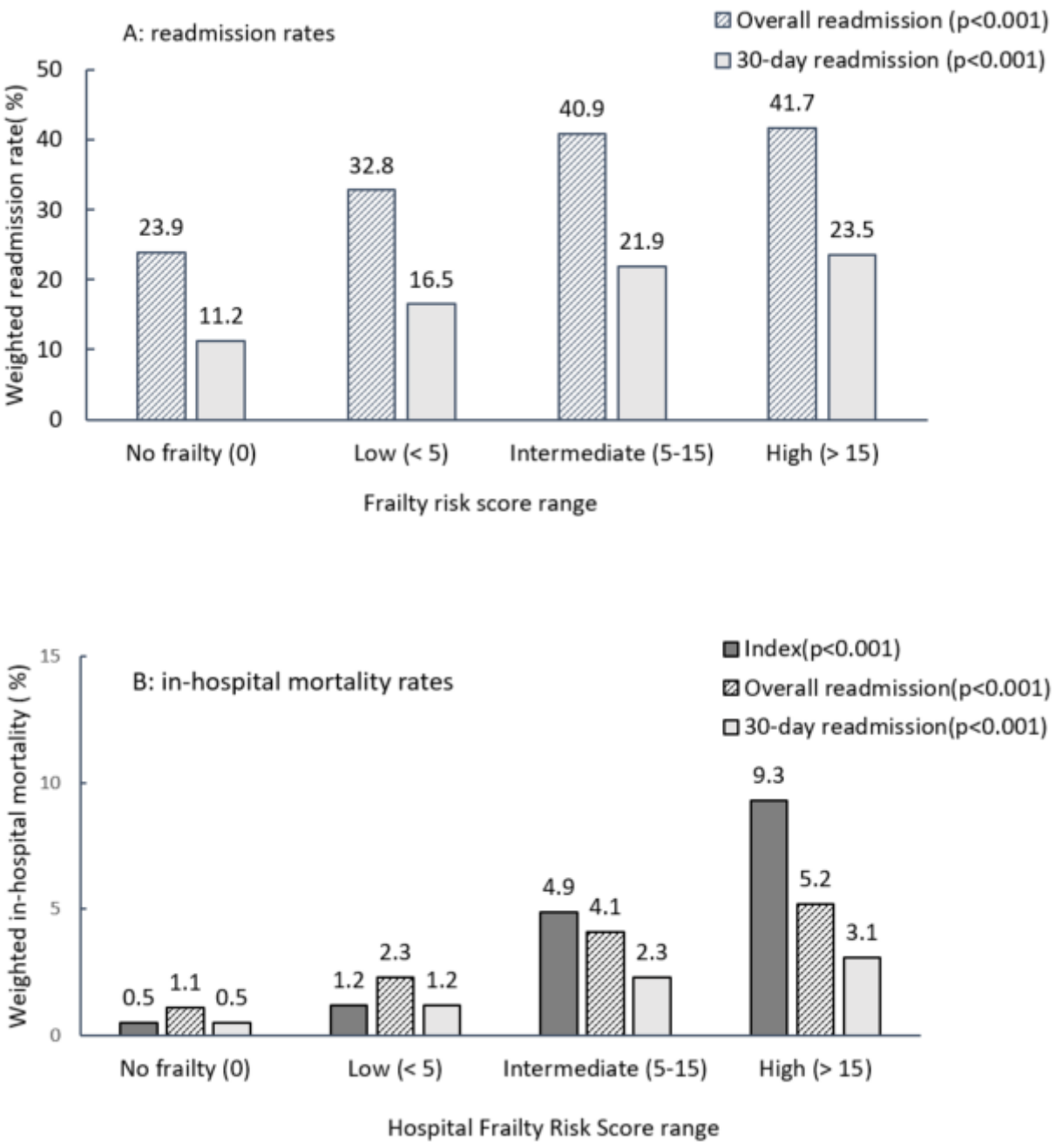

Figure 2

Readmission rates and in-hospital mortalities by frailty risk score range

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