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Frailty and Function in Heart Failure: Predictors of 30-Day Hospital Readmission?

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Structured Abstract

Background and Purpose: Although there have been decreases noted in 30-day readmission rates for persons with heart failure since enactment of the Hospital Readmissions Reduction Program, costs related to heart failure readmissions remain high. Consequently, there is a need to better identify persons with heart failure who are at risk for 30-day hospital readmission. Therefore, this study aimed to compare the ability of measures of function and frailty to predict 30-day hospital readmissions for adults aged 65 and older with heart failure.

Methods: Secondary data analysis using the 2011 National Health and Aging Trends Study (NHATS) merged with Medicare claims data. Logistic regression modelling was used to compare the ability of function and frailty to predict 30-day readmission. ROC curves were constructed to examine the ability of function and frailty to identify those who were readmitted.

Results and Discussion: Frailty and function demonstrated comparable ability to predict 30-day readmissions (R^2=.0873 and R^2=.0870, respectively). Neither measure identified persons at risk for readmission (AUC_{SPPB}=.6083; AUC_{PFP}=.5866).

Conclusions: Functional assessment demonstrated comparable ability to predict 30-day readmissions in persons with heart failure, compared to frailty. However, neither measure was able to identify persons at high risk for readmission. Although frailty status is emphasized in research for older adults with heart failure, functional status is an important patient level factor associated with readmission.

Keywords

heart failure; patient readmission; frailty; geriatric assessment

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INTRODUCTION

Medical advances have increased life expectancy in recent decades, particularly for persons with cardiovascular diseases (CVD).[1] As a result, individuals are living longer lives with chronic cardiovascular conditions, which increases CVD prevalence in older adults. However, CVD prevalence also increases with aging, which will further inflate CVD prevalence in older adults and double the total cost for cardiovascular care to an estimated $918 billion by 2030.[1] Increased CVD prevalence and cost of care will present considerable challenges for society.

One such challenge relates to heart failure, a common CVD seen in older adults.[2] Heart failure is one of four conditions responsible for the highest number of hospital readmissions within 30 days of hospital discharge among Medicare beneficiaries.[3] In 2013, 30-day readmissions for individuals with heart failure cost $2.7 billion.[3,4] To reduce the costs associated with 30-day hospital readmissions, the Hospital Readmission Reduction Program (HRRP) was created.[5] Under the HRRP, hospitals with readmission rates that exceed the national average for four conditions (including heart failure) are penalized by a reduction in payments across all Medicare admissions.[5] Therefore, to reduce readmissions, a clinical tool that can detect individuals with heart failure who are at increased risk for 30-day hospital readmission is needed.

Factors contributing to hospital readmissions are multidimensional and difficult to fully define. For individuals with CVD, patient level factors have been explored by using administrative data to create risk prediction models[6,7] or by emphasizing the role of frailty status on readmission risk.[8,9] Frailty status is commonly assessed using the framework established by Fried and colleagues.[10] In brief, frailty occurs when normal physiologic changes associated with aging are exacerbated by disease (e.g., CVD). Individuals who are frail are at increased risk for adverse events, such as morbidity and mortality.[10]

Frailty assessment is complicated by the multidimensional nature of frailty itself. The Fried Frailty Phenotype includes functional limitations; yet, there are physiologic mechanisms at play that are not well understood or easily measured. As a result, the five items used to measure frailty via the Phenotype (exhaustion, weight loss, grip strength, walking speed, and amount of physical activity),[11] may be reflective of additional symptoms that either precede or result from being frail, such as functional decline. Additionally, scoring of the phenotype (e.g., robust, pre-frail, and frail) decreases a clinician's ability to identify gradations of frailty, resulting in decreased sensitivity of the measure to detect change over time.[13,14] In response to these issues, we propose that the use of conceptually grounded, psychometrically validated functional assessments may improve clinicians' ability to identify individuals who are at risk of readmission. Previous work has demonstrated that for persons 65 and older, function is predictive of 30-day hospital readmission following post-acute rehabilitation[15] and self-reported function better predicts poor post-operative outcomes when compared to frailty status.[16] Thus, function may be predictive in other patient populations, such as older adults with heart failure.

The Short Physical Performance Battery (SPPB) is a measure of function used widely in the study of aging individuals, and is reliable and valid for measuring function in community-dwelling persons aged 65 years and older.[17] The SPPB is comprised of 3 elements: balance, gait speed, and muscle strength. When used in community-dwelling older adults without disability, the SPPB is predictive of subsequent hospitalization and overall mortality.[18] The SPPB also predicts mortality and rehospitalization for older individuals with a variety of conditions.[19]

Although SPPB score and frailty status are predictive of rehospitalization for older adults with a variety of conditions, the ability of the SPPB and frailty status to predict 30-day readmission for persons with heart failure is not clear. Therefore, the primary focus of this investigation is to compare the ability of measures of frailty and function to predict risk of 30-day readmission in persons with heart failure. We hypothesized that lower function and being classified as frail will be associated with increased risk of 30-day acute hospital readmission. Additionally, we sought to identify score cut points that could identify persons at high risk for 30-day readmission for the measures of frailty and function.

METHODS

Data Source

Data came from the initial round of the National Health and Aging Trends Study (NHATS), conducted in 2011.[20] National Health and Aging Trends Study (NHATS) is sponsored by the National Institute on Aging (grant number NIA U01AG32947) and was conducted by the Johns Hopkins University. The NHATS sample was drawn from the Medicare enrollment file in 2011 and is nationally representative of adults aged 65 and older in the United States. [21] The NHATS data include validated self-reported and performance based measures of function, and are collected annually by in-person interview.[22] Data from the 2011 NHATS were merged with Medicare claims data from 2011 and 2012 (to provide a 12-month period of claims data starting from the administration of the NHATS in 2011) to investigate 30-day hospital readmissions for NHATS participants.

Inclusion/Exclusion Criteria

NHATS participants were included if they were community-dwelling and identified as having heart failure using chronic condition codes present in the claims data. Participants were excluded if they were missing data for frailty and/or function measures.

Measures: Fried Frailty Phenotype[10,23]

Frailty was assessed using the physical frailty phenotype (PFP) via the technique described by Bandeen-Roche et al in 2015.[23] Five criteria (exhaustion, low physical activity, weakness, slowness, and shrinking[10]) were operationalized from NHATS interview and performance assessments (Table 1).[23] For each “yes” answer to the five criteria, respondents received 1 point.

The PFP is used as a categorical measure, defining persons as “robust”, “pre-frail”, and “frail”.[10] However, the categorized measure has been criticized for inability to identify

differences present between those who are pre-frail vs. frail.[14] This study separately analyzed the PFP as an ordinal measure (scored 0 to 5 points) and as a categorical measure to examine potential differences in the ability of the PFP to predict 30-day readmission based on scoring. NHATS participants were categorized as robust (0 points), pre-frail (1-2 points), and frail (3 or more points).[10,23]

Measures: Short Physical Performance Battery

Function was assessed using the SPPB which has been validated in the NHATS sample.[24,25] Individuals were screened for ability to safety complete the SPPB by research staff.[24] There are three items on the SPPB: gait speed, five time sit to stand test, and balance assessment.[25] Individual items are scored from 0 to 4 and summed to identify the total score, in which 12 indicates the highest function and 0 indicates lowest function.[25] Participants who cannot complete the tasks due to dependency or safety reasons received a score of 0.

Measures: 30-Day Hospital Readmissions

Thirty-day readmission was identified using Medicare claims data. Chronic condition codes identified persons with heart failure.[26] Inpatient claims were used to identify all-cause 30-day hospital readmissions to acute care hospitals and critical access hospitals for persons with heart failure. A claim was determined to be a 30-day acute hospital readmission if it occurred within 30 days of an index hospitalization and was not a transfer to another facility (e.g., inpatient rehabilitation facility, skilled nursing facility, etc.). The 30-day readmission claims data was then merged with the NHATS tracker file, to ensure that the readmission occurred within 12 months after the date that the NHATS was administered in 2011. All-cause readmission within 30-days were operationalized as a dichotomous (yes/no) variable for analysis.

Measures: Demographic Characteristics

The following demographic characteristics have been shown to both increase risk and have no impact on the risk of 30-day hospital readmissions for individuals with heart failure: age, sex, race, geographic location, and comorbidity.[27] Due to the ambiguous relationship between these factors and risk of readmission, the association between demographic factors and readmission were examined to identify factors to control for in final regression modeling in this sample. Age, sex, race, and geographic location were self-reported by NHATS participants. Age is categorized: 65-69, 70-74, 75-79, 80-84, 85-89, and 90+. Sex is reported as “male” or “female”. Race is self-identified as “White, non-Hispanic”, “Black, non-Hispanic”, “Hispanic”, and “Other”. Geographic location is categorized based on U.S. Census listing. Comorbidity was classified as a count of chronic conditions, which were identified using data from the Chronic Conditions Warehouse (CCW). The CCW contains codes that identify 26 chronic conditions.[26] Participants with each disorder were given a ‘1’ for each condition, and all conditions were summed together.[28] We then dichotomized chronic conditions into “0 to 7” and “8 or more”, consistent with previous work.[28]

Analysis

For all statistical analyses, survey weights were used to account for the shared variance of the sample to maintain national representativeness. We implemented these analyses using the PROC SURVEY-suite of procedures in SAS, version 9.4.

Descriptive statistics were computed to describe the demographic characteristics of the 2011 NHATS sample for persons with heart failure who experienced a 30-day readmission vs. no readmission. Rao-Scott Chi Square analyses were used to examine significant demographic associations between those who experienced a 30-day readmission vs. no readmission.

Scores on the SPPB were calculated using means/standard deviations and median/interquartile range while PFP ordinal and categorical and scores were described using proportions. Rao-Scott Chi Square testing was used to evaluate significant differences between groups for the PFP ordinal and categorical scores. SPPB score differences between groups were assessed by examining adjusted means using PROC SURVEYREG in SAS.

To compare the ability of the SPPB and PFP (ordinal and categorical) to predict 30-day hospital readmission, a series of logistic regressions were used. The SPPB and PFP are collinear (Spearman's rho=0.43, p=<.0001). Therefore, three separate, one predictor models were used to estimate the ability of the SPPB, PFP ordinal measure, and PFP categorical measure to predict 30-day readmission. Additionally, separate one predictor models were run to examine the relationship between 30-day readmission and each of the demographic characteristics (age, sex, race, geographic location, and chronic conditions). Demographic characteristics that significantly predicted 30-day readmission were then included in the adjusted models for each measure: SPPB, PFP ordinal, and PFP categorical. The max rescaled R^2 was used to determine which model contributed the most variance in 30-day hospital readmission, thereby identifying the most predictive model. Standardized beta coefficients were estimated to examine the relative contribution of the SPPB and PFP (ordinal and categorical measures) to predict 30-day hospital readmission when adjusted for significant demographic factors.

Receiver operating characteristic (ROC) curves were constructed to determine the discriminative ability of the SPPB and PFP ordinal measure to predict 30-day hospital readmission for participants with heart failure. The areas under the curve (AUC) were examined for each instrument to determine if either measure was clinically useful in the prediction of 30-day hospital readmission. Specificity/sensitivity of cut point scores were then examined to identify a score associated with optimal prediction of 30-day hospital readmission.

This study received approval from the Johns Hopkins Bloomberg School of Public Health (NHATS) Institutional Review Board and the Partners Healthcare Institutional Review Board.

RESULTS

In the 2011 NHATS, 16.6% of community dwelling participants had heart failure (n=1,313). Of those, 1,053 participants had complete SPPB and frailty data and were included in analyses. We examined differences in demographic characteristics between NHATS participants included in our analyses and NHATS participants who were excluded due to incomplete data. One difference was found in race, with a significantly higher proportion of persons categorized as “Other” (10.5% were not analyzed vs. 2.0% that were analyzed). Overall, approximately 9.6% of persons with heart failure in this sample experienced a 30-day hospital readmission. Compared to those who were not readmitted, a higher proportion of persons who were readmitted had 8 or more chronic conditions (47.9% vs. 20.3%; Table 2).

Persons not readmitted had a significantly higher mean SPPB score compared to those who were readmitted (Table 3). More persons who were readmitted scored 2, 3, 4, or 5 on the PFP ordinal scale compared to those who were not readmitted. A higher proportion of individuals who were readmitted were categorized as “frail” when compared to individuals who were not readmitted (44.0% vs. 27.9%).

Regression modeling revealed that the SPPB, PFP ordinal measure, and PFP categorical measure significantly predicted 30-day readmissions for persons with heart failure (Table 4). The SPPB demonstrated comparable predictive ability (R^2=.0395), when compared to the PFP ordinal measure (R^2=.0387) and the PFP categorical measure (R^2=.0312). Number of chronic conditions was the only demographic characteristic significant for predicting 30-day readmission in the sample (R^2=.0669). Accounting for chronic conditions, the SPPB, PFP ordinal measure, and PFP categorical measure continued to demonstrate comparable predictive ability (R^2=0.0870 vs. 0.0873 vs. 0.0823, respectively). When examining the association between ordinal and categorical scoring of the PFP with readmission, we found that a score of 3 on the ordinal measure and being classified as “frail” on the categorical measure were significantly associated with readmission. Conversely, each 1 unit increase in SPPB score contributed to a decrease in the odds of readmission (Standardized β=−12.96).

Neither the SPPB nor the PFP continuous measure demonstrated adequate ability to discriminate between those who experienced 30-day readmission and those who did not (Figure 1). The AUC associated with the SPPB was 0.61 (95% CI: 0.55, 0.67) and the AUC associated with PFP was 0.59 (95% CI: 0.53, 0.64). Each AUC value was below the threshold of 0.7 where a measure is considered to be diagnostically “acceptable”.[29] As the average number of days that passed between NHATS administration and 30-day hospital readmission was 190.2 days, separate ROC curves were analyzed with persons readmitted within 180 days (n=48), 90 days (n=27), and 60 days (n=16) of NHATS administration. Results for these subsets were similar to those for the entire sample.

DISCUSSION

This is the first nationally representative study to compare the ability of function and frailty to predict 30-day hospital readmissions for community-dwelling Americans aged 65 and

older with heart failure. Compared to persons with heart failure who were not readmitted, those readmitted in the year following the NHATS survey had a higher number of chronic conditions, lower function, and higher frailty.

Comparisons of regression model fit for predicting 30-day hospital readmissions were similar for the SPPB and the PFP measures. This demonstrates that measures of frailty and function are comparable in their ability to predict 30-day hospital readmissions for persons aging with heart failure. These findings persisted when accounting for chronic conditions. Our findings that age, sex, race, and geographic location were not significant in predicting 30-day readmission for this sample are consistent with previous literature.[27] However, this study may have been underpowered to examine full associations between demographic characteristics and 30-day readmission due to small sample sizes for certain categories (e.g. race and geographic location). It may be that other individual and social factors not measured in this study contribute to increased risk of 30-day readmissions, such as cognition, depression, and social supports.[27,28] As frailty and function accounted for approximately 8% of the variance in 30-day hospital readmissions, further investigation is needed to identify factors that explain the remaining variance in risk for readmission.

When examining differences in model fit for the PFP based on scoring, the PFP ordinal measure contributed slightly more to the variance in 30-day readmission compared to the PFP categorical measure (8.73% vs. 8.23%). However, a score of 3 was the only score significantly associated with readmission on the PFP ordinal measure, which corresponds to a “frail” score on the PFP categorical measure. Therefore, there was no difference in the ability of the PFP to predict readmission based on ordinal vs. categorical scoring.

Although function and frailty were predictive of 30-day hospital readmissions for persons with heart failure, examination of ROC curves did not reveal evidence for the ability of either measure to clinically discriminate between those who were readmitted vs. not readmitted based on a given score cut point. This may be due to the timing of administration of measures of function and frailty, as they were recorded at the beginning of the study period in the home setting, as part of NHATS protocol. Consequently, the measures of function and frailty in this study may better identify persons at risk of readmission when they are administered at different time points (e.g., at the time of hospitalization or directly after discharge from acute care or post-acute care).

Our finding that function demonstrated comparable ability to predict 30-day readmission when compared to frailty provides further evidence that functional status is associated with 30-day readmission.[15,16] Despite the growing empirical support for functional status as a predictor of readmissions and other outcomes, there is a lack of rehabilitation focused research being conducted in the area. Therefore, future studies should continue to examine the relationship between functional status, frailty, and readmission and should focus on timing of and setting of administration. As rehabilitation services are rendered with the primary goal of restoring or maintaining function, physical therapists are uniquely positioned to further investigate how function relates to risk of readmission. In fact, numerous measures of function exist that span a broad array of functional ability, are psychometrically validated, and are efficient to administer. These functional assessments

discriminate between lower and higher levels of function using item banks that contain hundreds of items to assess a range of functional ability. Test administration is simple—a computer uses the items banks to deliver a small number of items to each person, based on their previous response. These measures of function have demonstrated high reliability and validity in various patient populations.[30] A recent study demonstrated superiority of one such measure over frailty status in predicting readmissions for older adults undergoing surgery.[16] Therefore, physical therapists should consider how contemporary measures of function may be used clinically to identify persons with heart failure who are at risk for 30-day hospital readmissions.

LIMITATIONS

There are several limitations that warrant attention. We were unable to account for severity or etiology of heart failure in this sample, which may have important implications for function and frailty. While Medicare claims data provided important information regarding 30-day readmissions, we were unable to examine frailty and function immediately preceding the dates of hospitalization. Therefore, there may have been differences in frailty and function at the point of hospitalization or readmission that this study was unable to capture. Because of this, there may be important differences in how PFP and SPPB scores impact 30-day readmission at different points in the healthcare system. This study employed an observational design and is unable to identify causal links between frailty status, functional status, and 30-day readmission. Lastly, there were several cases (n=214) with missing data for the PFP or SPPB that could not be analyzed. Therefore, this study could have been underpowered to detect the true magnitude of effect sizes related to function and frailty.

CONCLUSIONS

In a nationally representative sample of Americans aged 65 and older with heart failure, measures of function and frailty were comparable in their ability to predict 30-day hospital readmission. However, no score on either measure identified persons at high risk for 30-day readmission in the following year. Physical therapists are uniquely positioned to further investigate the ability of measures of function to identify older adults at risk for 30-day readmission and to establish appropriate timing of administration of measures for optimal prediction.

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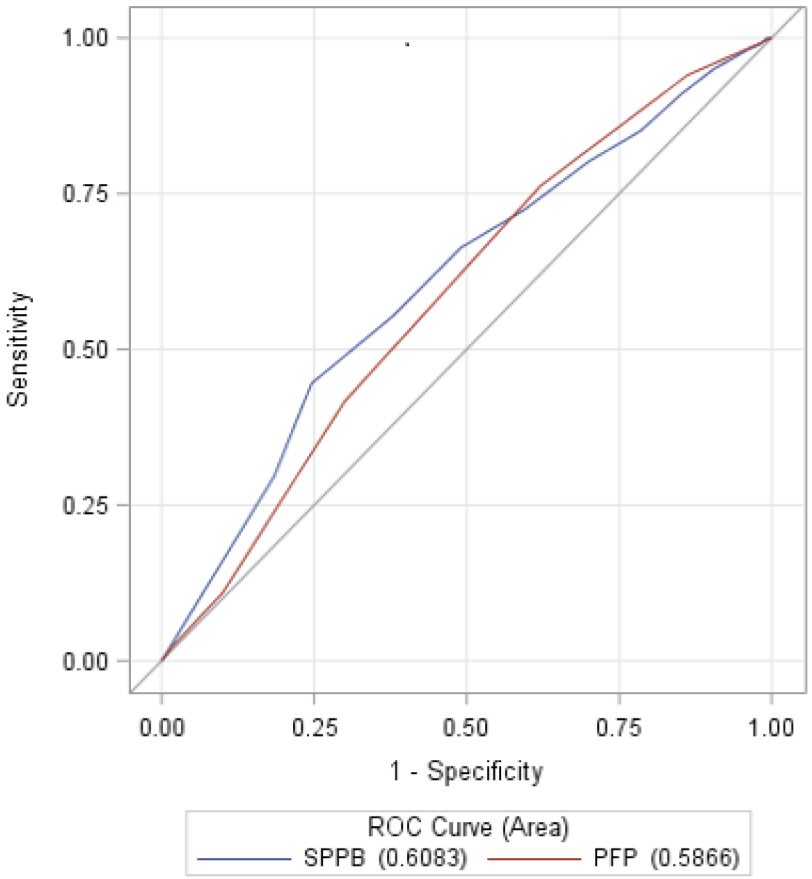

Figure 1.
ROC Curve Comparisons for the SPPB and PFP in Predicting 30-Day Readmissions

Table 1.

Criteria for Frailty Definition in NHATS *

PFP Criteria	NHATS Operationalization
Exhaustion	Reported recently having low energy or being easily exhausted; enough to limit activities
Low Physical Activity	Reported recently that they never walked for exercise or engaged in vigorous activities
Weakness	Maximum dominant hand grip strength over 2 trials; score at or below 20th percentile of weighted population distribution within 4 categories (arranged by sex and BMI)
Slowness	Utilized 1st of 2 usual walking pace trials; score at or below the 20th percentile of the weighted population distribution (arranged by sex and height)
Shrinking	BMI < 18.5 kg/m^2 based on self-reported height and weight or unintentional weight loss of 10 pounds in the last year

* adapted from Bandeen-Roche et al., 2015

Table 2.

Characteristics of the 2011 NHATS Sample with Heart Failure by 30-Day Readmission

	No Readmission n=952		Readmission n=101	
	n	%	n	%
Sex				
Male	392	43.0	44	38.6
Female	560	57.0	57	61.4
Age				
65-69	95	15.3	**	**
70-74	131	18.5	17	20.5
75-79	153	17.8	13	12.0
80-84	222	20.7	25	24.6
85-89	197	17.7	22	23.3
90+	154	9.9	17	9.9
Race				
White	658	82.3	69	79.3
Black	221	9.0	25	11.1
Hispanic	48	5.7	**	**
Other	25	3.0	**	**
Geographic Location				
New England	51	6.1	**	**
Middle Atlantic	134	14.5	15	15.7
East North Central	144	14.7	12	11.4
West North Central	81	8.7	**	**
South Atlantic	201	20.2	18	22.3
East South Central	77	7.0	**	**
West South Central	121	13.8	16	14.0
Mountain	21	2.0	**	**
Pacific	122	13.0	21	18.2
# of Chronic Conditions*				
0 to 7	765	79.7	56	52.1
8+	187	20.3	45	47.9

* p <.0001;

** Indicates cell size < 11 persons. Cannot report due to small sample size.

Table 3.

Frailty and Function in Persons with Heart Failure by 30-Day Readmission

	No Readmission n=952	Readmission n=101
Short Physical Performance Battery Score*		
mean (SD)	4.44 (0.12)	3.02 (0.30)
median [IQR]	3.81 [1.44, 6.24]	1.89 [0, 4.60]
Fried Frailty Phenotype (ordinal)†		
n (%)		
0	131 (16.8)	**
1	230 (24.9)	18 (18.1)
2	306 (30.4)	35 (31.5)
3	190 (18.3)	31 (33.1)
4	81 (8.1)	**
5	14 (1.4)	**
Fried Frailty Phenotype (categorical)‡		
n (%)		
Robust (0)	131 (16.8)	**
Pre-Frail (1-2)	536 (55.3)	53 (49.7)
Frail (3+)	285 (27.9)	42 (44.0)

* p < .0001;

† p .0221;

‡ p .0155;

** Indicates cell size < 11 persons. Cannot report due to small sample size.

Table 4.

Comparisons of Models Using Frailty vs. Function to Predict Readmission

Model	Model Estimates		Parameter Estimates	
	R^2	Max Rescaled R^2	Standardized β	p-value
1. Short Physical Performance Battery				
(Score 0 to 12)	0.0182	0.0395	−17.16	0.0012
2. SPPB adjusted for Chronic Conditions	0.0401	0.087		
SPPB			−12.96	0.0114
Chronic Conditions (8+ vs. 0 to 7)			−16.05	<.0001
3. Fried Frailty Phenotype				
(Categorized 0 to 5, ref=0)	0.0179	0.0387		
1			−6.96	0.3042
2			0.69	0.9122
3			11.92	0.0154
4			−0.26	0.9694
5			9.55	0.3005
4. Fried Frailty Phenotype (0 to 5) adjusted for Chronic Conditions	0.0403	0.0873		
Fried Frailty (ref=0)				
1			−4.63	0.4999
2			1.21	0.8538
3			10.44	0.0441
4			−0.74	0.9158
5			5.36	0.6012
Chronic Conditions (8+ vs. 0 to 7)			16.24	<.0001
5. Fried Frailty Phenotype				
(Robust, Pre-Frail, Frail)	0.0144	0.0312		
pre-frail vs. robust			2.6	0.6684
frail vs. robust			15.07	0.0079
6. Fried Frailty Phenotype (categ.) adjusted for Chronic Conditions	0.0379	0.0823		
pre-frail vs. robust			1.84	0.759
frail vs. robust			11.3	0.0424
Chronic Conditions (8+ vs. 0 to 7)			16.52	<.0001