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Frailty in people with COPD, using the National Health and Nutrition Evaluation Survey dataset (2003–2006)

Soo Kyung Park, PhD, RN^{a,*}, Caroline R. Richardson, MD^{b,c}, Robert G. Holleman, MPH^{b,c}, and Janet L. Larson, PhD, RN^d

^aSchool of Nursing, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, Republic of Korea

^bDepartment of Family Medicine, University of Michigan Medical School, Ann Arbor, MI, USA

^cCenter for Clinical Management Research, Health Services Research and Development Center of Excellence, Veterans Affairs Ann Arbor Healthcare System, Ann Arbor, MI, USA

^dSchool of Nursing, University of Michigan, Ann Arbor, USA

Abstract

Background—Little is known about frailty in people with chronic obstructive pulmonary disease (COPD). The purposes of this study were to describe frailty, to identify, which demographic and clinical characteristics contributed to frailty, and to examine the relationship between frailty and health-related outcomes in people with COPD.

Methods—This was a secondary cross-sectional study, using data from the National Health and Nutrition Evaluation Survey. The frailty index and outcome measures were derived primarily from survey responses.

Results—The prevalence of frailty was 57.8%. Multivariate logistic regression showed that individuals with COPD who had self-reported shortness of breath and comorbid diabetes were more likely to be frail than those who did not. Frail people tended to have a greater number of disabilities.

Conclusions—The findings support the importance of frailty in the COPD population. Further study is needed to understand frailty in people with COPD, using objective measures for criteria of frailty.

Keywords

Accelerometer; Chronic obstructive pulmonary disease; Frailty; NHANES; Older people

Introduction

Frailty is associated with the decline of physiologic reserves in multiple systems and the inability to respond to stressful insults.¹ Evidence suggests that frailty contributes to falls,

disability, and mortality in the general population of older adults.² Less is known about frailty in people with chronic diseases such as chronic obstructive pulmonary disease (COPD). People with COPD experience marked deficits in muscle strength and mass³ and impaired functional status,⁴ which places them at risk for frailty. No studies to date have described frailty in detail from the viewpoint of people who are living with COPD, although frailty has been shown to have a strong association with COPD as a comorbidity.⁵⁻⁷

Absent a precise definition or measure of frailty, the condition has been generally viewed in two ways.⁸ One view focuses on frailty's physical aspect, such as the phenotype of frailty introduced by Fried.² The other view defines frailty as a condition that is characterized by multidimensional deficits over time.⁹ For example, Gobbens et al¹⁰ define frailty as "a dynamic state affecting an individual who experiences losses in one or more domains of human functioning (physical, psychological, and social)" (p. 176). It is caused by a range of variables, and increases the risk of adverse outcome. Their definition emphasizes the dynamic nature and multifactorial aspects of frailty. Based on the several analyses of frailty that have been conducted,¹¹ most researchers now agree that the concept of frailty should be multidimensional; it should account for the interrelationship of individual factors (i.e., physical and psychological); and it should acknowledge a person's individual context. Gobbens et al's definition incorporates these dimensions. Although several conceptual frameworks for frailty have been advanced,¹² we used Gobbens et al's⁹ frailty model to guide our research (Fig. 1), because it is consistent with our understanding of the phenomenon. In addition to describing a distinct relationship between frailty and adverse outcomes, this model illustrates how frailty and adverse outcomes can be affected by multiple personal characteristics.

Factors and health-related outcomes associated with frailty in older people

Studies have described the factors that contribute to frailty in older people.¹³ Although most studies have used different conceptual frameworks and definitions of frailty, several factors have emerged as significant contributors to the condition. Older age,^{2,5,6,14-16} particularly in people aged 85 and older¹⁶; female gender; and race, being an African American, have been related to frailty.^{2,6,16,17} A lower level of education,^{2,5,15,17} lower income,^{2,6,18} and poorer health perception have also been associated with frailty.^{2,14,15,19} Chronic diseases, such as COPD, diabetes, peripheral vascular disease, heart failure, and osteoarthritis, and multimorbidity have been significantly associated with frailty.^{2,14,15,17-19} Strawbridge et al¹⁹ and Rome-Ortuno et al¹⁵ found that frail people tended to have more symptoms.

Frailty in the general population has been associated with health-related outcomes. Frail individuals had higher rates of disability than those who were not frail.^{2,16,20} Frailty was significantly associated with impairment in activities of daily living (ADL) and instrumental activities of daily living (IADL) disability.^{2,14,15,20} Furthermore, one cohort study²¹ found that frail people had a significantly higher risk of developing new-onset dependency for ADL than non-frail people. Frail people were more likely to have visits to the emergency department, admission to the hospital, and more contact with physicians.^{14,15} The age-adjusted odds ratio for mortality has been shown to be 4.8 for women and 6.9 for men in a frail group compared with non-frail group.¹⁵

Frailty in people with chronic disease

The relationship between frailty and chronic disease is complicated. Research has described frailty from the perspective of people with advanced chronic disease.^{7,22,23} The odds of frailty were substantially higher in people with chronic kidney disease than in those without and frailty was related to the severity of chronic kidney disease.⁷ Cardiovascular disease, particularly congestive heart failure, has been associated with an increased likelihood of frailty.²² In addition, it has been suggested that insulin resistance is associated with frailty.²⁴

Researchers have also reported that one frailty marker, decreased strength, significantly predicted toxicity from cancer treatments, including chemotherapy and radiotherapy, in older people with cancer²⁵ and that preoperative frailty was associated with an increased risk of postoperative complications and length of hospital stay in older patients.²⁶ Death was found to be progressively more prevalent in frail patients with congestive heart disease than in frail people without the disease.²⁷

Chronic obstructive pulmonary disease is an irreversible and progressive disease, and people with COPD will experience intermittent exacerbation, characterized by acute deterioration in chronic dyspnea and functional limitation. As with people who have other advanced chronic diseases, people with COPD are more likely to be frail.^{5–7} The current study attempts to better understand frailty in the COPD population, including its contributing factors and outcomes. Its findings will aid the development of a more tailored and effective intervention to delay frailty, thereby improving function and minimizing disability in this population.

Purpose

The purposes of this study were: (1) to describe frailty, (2) to examine the relative contribution of demographic and clinical characteristics to frailty, and (3) to examine the relationship between frailty and health-related outcomes (e.g., ADL/IADL disability and health care utilization) in people with COPD.

Methods

Design

Data from the National Health and Nutrition Evaluation Survey (NHANES) were used for this cross-sectional study. NHANES is a nationally representative, ongoing survey of the health status of persons residing in the United States.²⁸ The NHANES data were collected using a multistage, stratified, clustered probability design to obtain a representative sample of non-institutionalized civilians in the United States. In the NHANES, certain populations were oversampled, including low income persons, Mexican Americans, African Americans, and those aged 12–19 and 60 years or older.

Sample, settings, and procedure

We identified 20,470 participants who completed an NHANES interview between 2003 and 2006. We then selected participants who were aged 55 and older and were told by a physician that they had emphysema, chronic bronchitis, or both. People with no history of smoking were excluded from our data analysis.

The NHANES survey consists of an interview that collects sociodemographic information and a physical examination that identifies biological markers. The Center for Disease Control and Prevention's institutional review board approved the NHANES, and all participants provided written informed consent. This study was exempted from IRB approval.

Instruments

All information on demographic and clinical characteristics, the criterion for frailty, disability, and health care utilization were based on answers from self-reported questions, except physical activity, which was measured by actigraph.

Demographic and clinical characteristics

Data for age, gender, ethnicity, level of education, number in household, household income, marital status, number of comorbidities, number of respiratory symptoms (e.g., cough, phlegm, shortness of breath, or wheezing), smoking history (pack years), medication use (e.g., respiratory inhalant products), and duration of disease were used to describe sample characteristics.

Frailty

Our operational definition of frailty is based on previously validated criteria²⁹ and a framework of frailty.¹⁸ It reflects the physical, psychological and social domains of frailty (Table 1). Some criteria (e.g., endurance and balance for physical frailty domain, mood and coping for psychological frailty domain) were not measured in the NHANES survey (2003–2006). Therefore, we measured frailty using nine criteria (Table 1). Each criterion yielded a dichotomous score of “0” or “1” (Table 1). If more than one item was available for a given criterion, the criterion was considered positive (“1”) for a deficit if any item was scored “1.” A frailty total score was then calculated by adding the scores from all criteria. The potential range for the total frailty score was 0–9. Internal consistency for the frailty total score for our sample was Kuder–Richardson 20 = .66.

Physical activity—Physical activity was measured by an ActiGraph (ActiGraph Model 7164 accelerometer, LLC; Ft. Walton Beach, FL), which was worn over the right hip on an elasticized belt for 7 days during waking hours. Upon completion of wearing an ActiGraph, participants were asked to mail the device back to the NHANES' warehouse. After downloading the data, the warehouse staff cleaned and calibrated each ActiGraph. Standardized, data-collection methods were used in the NHANES (2003–2006) to minimize site-specific error and interexaminer bias. Details of the accelerometer protocol are available.³⁰ The uniaxial ActiGraph measures and records vertical acceleration as “counts per min,” which indicates the intensity of physical activity. Data were recorded in 1 min epochs. A valid day was defined as >10 h of wear. We included participants who wore the ActiGraph for at least 4 valid days of monitoring. Zero activity counts for more than 60 min were considered as “non-wear time.” The NHANES used standardized, data quality procedures to assess the validity and reliability of the actigraphic data.³⁰

We used a cut-point of 85.35 counts/min for low physical activity; it was one standard deviation below the mean for the general population without COPD, aged 55 and above in the NHANES dataset (2003–2006). There is no well-established cut-point for low level of physical activity, but the cut-point of 85.35 counts/min is consistent with the work of others who have defined sedentary activity as <100 counts/min^{31,32} and <50 counts/min,³³ using an Actigraph uniaxial accelerometer. Previous researchers have used the lowest 20% of k cal/week² or <270 k cal of physical expenditure⁵ as a cut-point for physical activity. In past studies, investigators have used subjective measures to assess physical activity, and their populations did not comprise chronically ill patients. Because chronically ill patients were the focus of our study and people with COPD have been reported to have lower levels of physical activity than healthy subjects, we chose one standard deviation below the mean of activity count for the general population. Participants whose total physical activity was less than 85.35 counts/min were assigned a “1” for this criterion. Participants whose total physical activity was more than 85.35 counts/min were assigned a “0” for this criterion.

Primary outcome measures

Disability (ADL/IADL)—Disability, a distinct entity that differs from frailty,¹ is defined as limitations in performing daily activities that are essential in independent lives,³⁴ specifically difficulty in ADL and IADL. IADL are recognized to be the more complicated levels of function that are required for independent living in a community, for example, shopping, cooking, and handling one’s own finances.³⁵ Disability was evaluated by asking participants about their difficulty in managing money (e.g., keeping track of expenses or paying bills), doing chores, preparing meals, eating, and dressing themselves. Participants were asked to select one of the following: 1 (no difficulty), 2 (some difficulty), 3 (much difficulty), 4 (unable to do), and 5 (do not do this activity). The internal consistency for ADL/IADL was Kuder–Richardson 20 = .77. Participants were also asked to report the actual number of missed days due to poor physical or mental health.

Health care utilization—Health care utilization was evaluated by questioning participants on the number of visits to a physician’s office, a clinic, or a hospital emergency department; physician visits at home; visits to see a physician or other health care professionals during the past 12 months; or an overnight stay in the hospital during the past 12 months. Participants were asked to select one of the following: none, 1, 2–3, 4–9, 10–12, or more than 13 for the number of visits to the offices of different health care professionals. They were asked to answer “Yes” or “No” to a question about an overnight stay in the hospital.

Data analysis

Stata version 11.0 was used to analyze the NHANES data. All analyses used the sampling weight and stratification variables. Weight is assigned to each participant in survey data and this value indicates how much each participant will count in a statistical procedure.³⁶ The purpose of weighting is to enable unbiased estimation of population statistics from survey data.³⁶ Distributions for all continuous variables were approximately normal and distributions are described as mean and standard deviations. Categorical variables were presented with percentage, frequency, or standard error.

The receiver operating curve (ROC) was used to establish a cut-point in the frailty score to categorize participants as frail, pre-frail, or non-frail. This analysis was performed without considering sample weight. Sensitivity and specificity were estimated for each item of ADL/IADL disability (e.g., difficulty in managing money, doing chores, preparing own meals, eating, and dressing, and number of disabilities) at each cut-point of the frailty score, ranging from “0” to “9”; the area under the curve (AUC) was reported with a 95% confidence interval.

Logistic regression was used to examine univariate and multivariate associations between frailty and sociodemographic-clinical characteristics. The dependent variable in this logistic regression was frailty. In this logistic regression, non-frail (frailty score = 0) and pre-frail (frailty score = 1) participants were combined and then were compared with frail participants (frailty score = 2) due to small sample size. All variables were entered together into the multivariate logistics regression model.

Logistic regression was also used to examine the association of frailty with the number of ADL/IADL disabilities and health care utilization. The dependent variables in this logistic regression were ADL/IADL disability and health care utilization. Responses from questions on disability were all dichotomized for the logistic regression (i.e., “No difficulty vs. Some difficulty”, “Much difficulty”, and “Unable to do”). Responses from questions on health care utilization were also dichotomized for the logistic regression. The number of disabilities was calculated by adding the number of difficulties (e.g., difficulty in managing money, doing chores, preparing one’s own meals, eating, and dressing) that participants answered “Some, Much difficulty, and Unable to do.” We dichotomized the number of disabilities (0 vs. >0). Poisson regression, a regression analysis used to model count data, was used to examine the association of each criterion of frailty with the number of disabilities. A *p* value of less than .05 was considered statistically significant.

Results

The final analytic sample comprised 211 persons (Fig. 2). Of those, 98 people had chronic bronchitis, 70 had COPD, and 43 had both diseases. The mean age of the total sample ($n = 211$) was 70.65 years. The sample was predominantly non-Hispanic Whites and evenly split between men and women (Table 2). Twenty-eight percent ($n = 60$) were still smoking.

Frailty

The unweighted mean (SD) frailty score was 1.97 (SD = 1.53) (range: 0–6). The frequency distribution for and proportion of the sample with each criterion of frailty are presented in Table 3. Difficulty in mobility was the mostly commonly reported criterion of frailty. Data from the larger NHANES sample age >55, excluding people with COPD, are presented to facilitate interpretation of results from people with COPD (Table 3). Accelerometers were worn for a mean of 6.41 (SD = .89) days and a mean of 15.57 (SD = 2.65) hours a day. The total count per day was a mean of 131,723.20 (SD = 85,843.86). The mean total counts/min was 142.36 (SD = 92.11).

We chose a frailty index score of “2” as the cut-point for frailty, based on good sensitivity and acceptable specificity. The ROC analyses showed that this cut-point yielded a sensitivity and specificity of 92.9% and 49.4% for predicting difficulty in managing money (AUC .78, 95% CI: .70–86). It yielded a sensitivity and specificity of 90.1 % and 63.6% for predicting difficulty in doing chores around the house (AUC .83, 95% CI: .78–89) and a sensitivity and specificity of 97.5% and 53.5% for predicting difficulty in preparing one’s own meals (AUC .84, 95% CI: .79–90). Using this cut-point, 43 (20.4%) of the 211 participants were not frail, 46 (21.8%) were pre-frail, and 122 (57.8%) were frail.

Factors related to frailty

Univariate logistic regression showed that COPD participants who had respiratory symptoms, particularly shortness of breath and wheezing, and co-morbid arthritis, liver disease, diabetes, and hypertension were more likely to be frail (Table 2). Participants who were White and had more education and income were less likely to be frail (Table 2). The multivariate logistic regression showed that the overall model was significant ($F_{9,22} = 5.78$, $p = .0004$) and that the strongest predictor for frailty was shortness of breath (Table 4).

Frailty and health-related outcomes

Frail people tended to have more difficulty managing money, doing household chores, preparing their own meals, feeding themselves, and dressing themselves, even after adjusting for other covariates (Table 5). The covariates included were age, gender, race, shortness of breath, number of comorbidities, and pack years of smoking. Frail participants also tended to have a higher total number of disabilities. The nine criteria of frailty were examined in a Poisson regression, using the number of disabilities as the dependent variable (Table 6). The overall model was significant ($F_{9,22} = 25.68$, $p = .00001$) and the most significant predictor was mobility. A significant relationship was found between frailty and the number of inactive days due to health in the last month, even after adjusting for other covariates (Table 5). A significant relationship was also found between frailty and health care utilization in the univariate logistic regression.

Discussion

To our knowledge, this is the first study to describe frailty in people with COPD and to use objectively measured physical activity as a component of frailty. In this study, the prevalence of frailty was high and the strongest predictor of frailty was self-reported shortness of breath. Frailty was significantly associated with ADL and IADL disability.

The prevalence of frailty was higher than in the general population of older adults¹⁸ and people with chronic kidney disease.⁷ However the differences in definitions of frailty, the number of criteria for frailty, and mean age make it difficult to compare across studies. Although the underlying mechanisms of frailty are not fully understood, it has been suggested that sarcopenia, the steady and involuntary loss of skeletal muscle mass and muscle strength during aging, is an integral component of frailty.^{37–39} Similar characteristics are found in COPD.^{3,40–42} It is not surprising that a high prevalence of frailty exists in the COPD population, as the clinical picture of COPD includes many of the criteria for frailty.

One could think of frailty in COPD as a cascade of events, consistent with the downward spiral of COPD.^{43,44} Increasing disease severity and shortness of breath lead to inactivity,^{45–47} which in turn leads to a loss of muscle strength,^{3,48,49} problems with mobility,^{50,51} and ultimately frailty. People with COPD experience a loss of muscle strength, primarily in lower limb muscles.^{48,52} It has also been reported that people with COPD experienced marked deficits in mobility,^{3,50,51} gait speed impairments,⁵¹ and gait instability.⁵³ All of the above contributes to the high prevalence of frailty in COPD.

We found that arthritis, diabetes, hypertension, and liver disease were significant predictors of frailty in univariate logistic regression. Of these comorbidities, diabetes was the strongest predictor for frailty in multivariate logistic regression. We also observed a significant relationship between the number of comorbidities and frailty, which is consistent with other findings.^{2,6,19} A clear distinction between frailty and comorbidity has been described in the literature.¹ Frailty and comorbidity may cause or aggravate each other and there can be synergistic effects on health-related outcomes, when frailty and comorbidity coexist.¹ Furthermore, one study confirmed that synergistic interaction between specific inflammatory diseases increased the risk of frailty.¹⁷

Shortness of breath was also a strong predictor of frailty. The prevalence of shortness of breath in people with severe COPD has been estimated to be 94%.⁵⁴ Shortness of breath is the most disabling and main symptom experienced by people with COPD and may affect physical activity and social relations.^{45,46,55} This symptom eventually affects their activities of daily living and causes psychological distress.⁵⁴

We found that frailty was significantly associated with ADL/IADL disability. Four of the nine frailty criteria were significant predictors of the number of disabilities. Each of these could result from a direct effect of COPD severity and symptoms, a side effect of drug therapy, or an interaction effect of COPD with one or more comorbid conditions. However, the level of physical activity was not a significant predictor of the number of disabilities. This is not consistent with theoretical expectations and could reflect the fact that we dichotomized each frailty criterion including physical activity. Alternatively the decline in physical activity could occur early enough in the process that it is not a direct predictor of adverse outcome. Physical activity could be a mediating variable with indirect effects through decreased strength and difficulty in mobility.

We also observed a significant association between frailty and health care utilization in univariate logistic regression, although this association was not found in multivariate model. Conflicting findings have been reported in past studies on the relationship of frailty to health care utilization.^{14,15,56} These studies used different frailty measures and different methods to assess health care utilization and this makes it difficult to compare across studies. Further study with more detailed information about the specific nature of health care visits and hospitalizations may be needed.

This study's strength is that it is based on a nationally representative survey. This study has limitations. First, no measure for pulmonary function testing was available, so we could not describe the severity of disease in this sample. However, we included only people with a

history of COPD and smoking, which provides some confidence in the diagnosis. Second, because most items in the frailty index were derived from self-reported data in the NHANES questions, our findings may not be comparable with findings from objective measures. Third, using a dichotomous method to define each criterion of frailty may have obscured potentially relevant distinctions. Fourth, because we used secondary data for our analysis, the validity of the questions that we used for each criterion of frailty and the outcome measures could be limited. However, the questions that we selected for the criterion and outcome measures were based on those used in previous studies.^{8,29} Fifth, the Kuder-Richardson 20 for the frailty total score was low, which may be due to the fact that we included only nine criteria. Finally, because the NHANES did not measure balance, endurance, and depression in 2003 and 2006, we were unable to fully describe all dimensions of the Gobbens et al's frailty model.

Our findings confirmed that frailty is prevalent in people with COPD and particularly in those with shortness of breath. The findings also showed that frailty is significantly associated with ADL/IADL disability in this population. Further study is needed to better understand frailty in people with COPD, using objective measures for criteria of frailty. Interventions to delay the onset of frailty are also warranted to enhance function and minimize disability in this population.

Once health care providers recognize the high prevalence of and adverse outcomes caused by frailty in patients with COPD, they should be strongly motivated to assess frailty in this population. Enhanced knowledge of frailty's determinants and predictors of adverse outcomes can help health care providers to identify patients with COPD who are at risk of ADL/IADL disability and require evaluation for physical therapy or pulmonary rehabilitation before they become frail.

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Fig. 1.

Framework for this study (Adapted from 'a working framework in development'⁹).

Fig. 2.
Flow chart for study sample.

Table 1

NHANES questions and actigraphic data used for frailty.

Questions	Responses to questions	Responses required to be frail (scored "1") in each criterion	Score for each criterion
<i>Physical frailty</i>			
Nutrition (weight history)			
1) How much do you weigh without clothes or shoes?	Number	More than 10 pounds of unintentional weight loss over 1 year	1
2) How much did you weigh a year ago?	Number		
3) Was the change between your current weight and your weight a year ago because you tried to lose weight?	Yes/No		
Mobility			
1) Do you have difficulty walking without using any special equipment?	Yes/No	Yes to the first question OR some or much difficulty or unable to do to the second question	1
2) By yourself and without using any special equipment, how much difficulty do you have.....walking up 10 steps without resting	No difficulty, some, much, unable to do, do not do this activity		
Physical activity		Less than 85.35 counts/min	1
Strength			
By yourself and without using any special equipment, how much difficulty do you have lifting or carrying something as heavy as 10 pounds (like a sack of potatoes or rice)	No difficulty, some, much, unable to do, do not do this activity	Some or much difficulty or unable to do	1
Sensory functions (vision)			
1) At the present time, would you say your eyesight, with glasses or contact lenses if you wear them, is...	Excellent, good, fair, poor, very poor	Poor or very poor to the first question OR moderate, extreme difficulty, or unable to do to the rest of questions	1
2) How much difficulty do you have...	No difficulty, a little, moderate, extreme, unable to do because of eyesight..., does not do this for other reasons		
a. Reading ordinary print in newspapers?			
b. Doing work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house, or using hand tools			
c. Going down steps, stairs or curbs in dim light walking?			
d. Noticing objects off to the side while you are walking?			
Sensory functions (hearing)			
Which statement best describes your hearing (without hearing aid)? Would you say your hearing is excellent, good, that you have a little trouble, moderate trouble, a lot of trouble, or are you deaf?	Excellent, good, a little trouble, moderate trouble, a lot of trouble, are you deaf	Moderate trouble, a lot of trouble, or are you deaf	1
<i>Psychological frailty</i>			
Cognition			
Are you limited in any way because of difficulty remembering or because you experience periods of confusion?	Yes/No	Yes	1
<i>Social frailty</i>			

Questions	Responses to questions	Responses required to be frail (scored "1") in each criterion	Score for each criterion
Social support			
Can you count on anyone to provide you with emotional support such as talking over problems or helping you make a difficult decision?	Yes/No	No	1
Social relation			
In general, how many close friends do you have?	Number	None	1
Possible frailty total score			9

Table 2

Sample characteristics & odds ratios for association of sample characteristics with frailty from univariate logistic regression in people with COPD.

	Unweighted mean $\pm$ SD & frequency (%) (N = 211)	Odds ratios for frailty ^a (95% CI)
Age	70.65 $\pm$ 8.43	
55–75	135 (64.0)	1
75–	76 (36.0)	1.65 (.82–3.33)
Gender		
Male	108 (51.2)	1
Female	103 (48.8)	.84 (.50–1.42)
Race		
Others, including Hispanic, Mexican-American, Non-Hispanic Black	57 (27.0)	1
Non-Hispanic White	154 (73.0)	.31* (.14–.67)
Education		
High school or less	125 (59.2)	1
More than high school	86 (40.8)	.46* (.25–.84)
Income		
<\$25,000	108 (53.2)	1
\$25,000–\$55,000	65 (32.0)	.54 (.25–1.16)
>\$55,000	30 (14.8)	.32* (.11–.90)
Marital status		
Living with someone, married	111 (52.6)	1
Separated, widowed, divorced	100 (47.4)	1.03 (.46–2.31)
Number of people in household		
1	62 (29.4)	1
2–7	149 (70.6)	1.34 (.60–2.99)
Current smoker	60 (28.4)	
Past smoker	141 (66.8)	
Pack years	58.19 $\pm$ 45.00	1.00 (1.00–1.01)
Number of respiratory symptoms	1.95 $\pm$ 1.29	
0	29 (13.7)	1
>0	182 (86.3)	3.00* (1.19–7.54)
Shortness of breath on stairs/inclines	160 (75.8)	3.94* (2.03–7.62)
Cough	74 (35.1)	1.21 (.58–2.51)
Sputum	70 (33.3)	1.65 (.83–3.28)
Wheezing	109 (51.7)	1.71* (1.03–2.84)
Use of bronchodilators or respiratory inhalant products	61 (28.9)	1.67 (.96–2.93)
Number of co-morbidities	3.34 $\pm$ 2.08	
1	43 (20.4)	1
>1	168 (79.6)	3.98* (1.80–8.81)

	Unweighted mean $\pm$ SD & frequency (%) (N = 211)	Odds ratios for frailty ^a (95% CI)
Asthma	74 (35.1)	1.78 (.83–3.85)
Arthritis	131 (62.1)	2.34* (1.19–4.62)
Heart diseases	76 (36.0)	1.69 (.93–3.09)
Stroke	23 (11.0)	.88 (.22–3.49)
Liver diseases	15 (7.1)	4.21* (1.57–11.3)
Thyroid problem	47 (22.3)	1.00 (.52–1.95)
Cancers	57 (27.0)	.84 (.41–1.76)
Diabetes	52 (24.6)	4.86* (2.10–11.25)
Kidney disease	20 (9.5)	3.32 (.83–13.29)
Hypertension	131 (62.1)	2.73* (1.14–6.51)

*
p < .05.

^aFrail group (frailty score = 2) was compared with non-frail (frailty score = 0) and pre-frail (frailty score = 1), using logistic regression; Reference was non-frail and pre-frail group combined.

Table 3

Frequency and proportion of each criterion of frailty in people with COPD and people without COPD.

	Unweighted frequency (%) <i>N</i> = 211 (COPD)	Weighted percentage (SE) <i>N</i> = 3,786,415 (COPD) ^a	Unweighted frequency (%) <i>N</i> = 2621 (without COPD) ^b
Physical frailty domain			
Unintentional weight loss	21 (10.0)	11.0 (.03)	277 (10.8)
Difficulty in mobility	103 (48.8)	45.5 (.04)	704 (26.9)
Decreased physical activity	57 (27.0)	22.9 (.03)	387 (14.8)
Decreased strength	80 (37.9)	35.4 (.04)	518 (21.8)
Poor vision	53 (25.1)	23.6 (.03)	494 (18.9)
Poor hearing	40 (19.0)	19.1 (.03)	347 (13.2)
Psychological frailty domain			
Impaired cognition	42 (19.9)	17.7 (.02)	338 (12.9)
Social frailty domain			
Poor social relations	8 (3.8)	3.4 (.01)	83 (3.2)
Poor social support	11 (5.2)	5.3 (.02)	172 (6.6)

^aData were weighted using population size of 288,793,657.^bData from the larger NHANES sample of people age 55 and older, excluding people with COPD, are presented here to facilitate interpretation of data from the sample with COPD.

Table 4

Odds ratios for association of sample characteristics with frailty from multivariate logistic regression in people with COPD.

	Odds ratio for frailty (95% CI)
Age	1.02 (.98–1.07)
Gender	.84 (–.42–1.70)
Race	.55 (.22–1.41)
Marital status	.89 (.35–2.25)
Education	.56 (.28–1.12)
Income level	.63 (.32–1.22)
Shortness of breath	3.98* (1.79–8.88)
Liver disease	2.64 (.64–10.80)
Diabetes	3.88* (1.29–11.67)

* $p < .05$.

Table 5
Odds ratios for association of frailty with health-related outcomes in people with COPD from unadjusted and covariate adjusted logistic regressions (dependent variables were health-related outcomes).

Health-related outcomes	Difficulty in managing money ^a	Difficulty in doing chores around the house ^a	Difficulty in preparing own meals ^a	Difficulty in eating, like holding a fork ^a	Difficulty in dressing yourself ^a	Number of disabilities [0 (reference) vs. >0]	Inactive days due to health [0 (reference) vs. >0]	Times receive health care over past year [2 (reference) vs. >3]	Staying in hospital overnight in last year [No (reference) vs. Yes]
Frailty ^b									
Unadjusted									
Odds ratios (95% CI)	1.94* (1.36–2.78)	2.41* (1.68–3.46)	2.70* (1.95–3.72)	1.98* (1.45–2.71)	1.82* (1.36–2.43)	3.60* (2.09–6.20)	1.50* (1.26–1.79)	1.27* (1.04–1.55)	1.45* (1.13–1.87)
Covariate adjusted model									
Odds ratios ^c (95% CI)	2.21* (1.56–3.13)	2.29* (1.52–3.47)	2.64* (1.96–3.56)	2.08* (1.54–2.82)	1.76* (1.30–2.39)	3.43* (1.94–6.07)	1.43* (1.18–1.73)	1.17 (.94–1.45)	1.27 (.95–1.70)

*p-value < .05.

^aAnswers from these questions were dichotomized into no difficulty (reference) vs. some, much difficulty, and unable to do.

^bFrailty total score (0–9) was used for this analysis.

^cCovariates include age, gender, race, shortness of breath, number of co-morbidity, and pack years of smoking.

Table 6

Relationship between number of disabilities and nine criteria of frailty from Poisson regression (dependent variable was number of disabilities).

	Regression coefficient (β)
Unintentional weight loss	-.24
Mobility	1.26*
Decreased physical activity	-.01
Decreased strength	.26*
Poor vision	.52*
Poor hearing	.29
Impaired cognition	.50*
Poor social relations	-.01
Poor social support	-.18

*
 $p < .05$.