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Long Sleep Duration Is Associated with Increased Frailty Risk In Older Community-Dwelling Adults

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Abstract

Objective: To examine whether sleep duration is correlated with increased frailty risk and investigate the determinants of frailty status. **Methods:** Data on 3632 participants from the 2011 to 2014 National Health and Nutrition Examination Survey (NHANES, community-dwelling > 60 years, 52.1% pre-frail, 13.6% frail, 55% women) were used. Frailty status was categorized by Fried Phenotype (robust, pre-frail, and frail) with customized criteria for the NHANES data set. Hours of self-reported sleep duration were categorized as short (< 6), normal (7-9), and long (≥ 10). Multinomial regression analysis identified risk factors for each frailty state.

Results: Only long sleep duration was associated with increased odds (2.86 [1.09–7.50]) of being characterized as frail but not pre-frail. Frail and pre-frail states had shared risk factors but also had many distinct to each state.

Discussion: Sleep duration is a potential, modifiable therapeutic target for frailty management. Multicomponent interventions should be tailored for frailty status.

Keywords

Frailty; Risk Factors; Sleep Duration; NHANES

Introduction

Frailty is a state of accelerated physical decline and increased vulnerability to adverse health outcomes including disability, falls, institutionalization, and mortality compared to individuals of similar age who are not frail (Endeshaw, Unruh, Kutner, Newman, & Bliwise, 2009; Ensrud et al., 2009; Fried et al., 2001; Gill, Gahbauer, Han, & Allore, 2010; Morley, 2016; Robinson et al., 2015). The etiology of frailty is multifactorial; therefore, the

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Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

interventions used to reduce frailty include a combination of physical exercise, nutrition, and cognitive training (Ng et al., 2015; Peterson et al., 2009; Puts et al., 2016). The Fried Phenotype, the most extensively used index of frailty severity, has five criteria: unintentional weight loss, weakness, slow walking speed, exhaustion, and low activity levels (Fried et al., 2001). Persons are categorized according to the Fried Phenotype into one of three frailty severity states: the absence of all criteria (robust), the presence of one or two criteria (pre-frail), and the presence of three or more criteria (frail).

Although age is not independently predictive of frailty, there is an increased prevalence of frailty with older age (Collard, Boter, Schoevers, & Oude Voshaar, 2012; Ensrud et al., 2009; Fried et al., 2001). The prevalence of frailty and pre-frailty has been reported as high as 10.7% and 41.6%, respectively, in adults 65 years and older (Collard et al., 2012). By 2030, a projected 70 million people in the United States will be over the age of 65, placing a large portion of the population at risk for frailty (United States Census Bureau, 2014). With the growing public health burden of frailty (Buckinx et al., 2015; Robinson et al., 2015) combined with an aging population, there is a demonstrated need for better understanding factors associated with increased risk for frailty so that new strategies can be developed to prevent and to better manage frailty.

Impaired sleep and sleep disturbances are progressively more common with increased age and frailty severity (Collard et al., 2012; Ensrud et al., 2012; Fried et al., 2001; Young et al., 2002). Prior studies report a greater prevalence of frailty among older adults with poor self-reported sleep quality, excessive daytime sleepiness, poor sleep efficiency, prolonged sleep latency, and sleep disorders. (Ensrud et al., 2009; Nóbrega, Maciel, Holanda, Guerra, & Araújo, 2014). Deviations from the recommended 7 to 8 hours of sleep per night, both short and long sleep durations, have been associated with adverse health effects in older adults (Itani, Jike, Watanabe, & Kaneita, 2017; Jike, Itani, Watanabe, Buysse, & Kaneita, 2017). Recent systematic reviews reported significant associations between nighttime sleep duration (shorter and longer) and higher mortality with increasing age (Cappuccio, D'Elia, Strazzullo, & Miller, 2010; Yin et al., 2017). Two longitudinal studies found long nighttime sleep duration (> 10 hours) as well as frailty, measured by the Fried Phenotype, to be independently associated with an increased 5-year mortality (Lee et al., 2014; Lee, Peng, Liang, Chiou, & Chen, 2017).

However, data on the contribution of sleep duration to the development of frailty in older adults is limited. Studies that evaluated the relationship between sleep duration and frailty included samples that were exclusively male (Ensrud et al., 2009, 2012), disease specific (Endeshaw et al., 2009), sample populations recruited from Taiwan and Hong Kong (Lee et al., 2014; Lee et al., 2017), or focused on the independent associations of sleep duration and frailty to mortality (Lee et al., 2014; Silva et al., 2016). A previous study of very old adults ages 75 years and older using National Health and Nutrition Examination Survey (NHANES) data found that longer sleep duration was predictive of decreased health (Chasens, Yang, Baniak, Choi, & Imes, 2017). However, the association between sleep duration and frailty remains unclear. The identification of distinct risk factors for pre-frail and frail older adults is important to determine the most appropriate interventions that will effectively address each frailty state. The purpose of this study was twofold: 1) to assess

whether sleep duration is independently associated with an increased risk for frailty in a United States representative community-based population of adults 60 years of age and, 2) to identify the potential differences and/or similarities among risk factors between frailty groups (i.e., pre-frail and frail).

Methods

Design and Sample

The sample consisted of participants evaluated in the 2011–2012 and the 2013–2014 NHANES. The study protocol was approved by the National Center for Health Statistics Research Ethics Review Board. The NHANES used a stratified, multistage probability sampling design to recruit non-institutional, community-dwelling individuals in the United States. The 2011–2012 and 2013–2014 NHANES cohorts were unique in that during those years there was a planned over-sampling of persons from non-white races, Hispanic ethnicity, lower social-economic status, and older than 80 years. The NHANES collected data using interviews and clinical examinations conducted in a mobile assessment unit that included physical measurement and laboratory testing. We included 3,632 respondents ages 60 years and older for this study who had data on all the components of the primary outcome measure, frailty status.

Measures

Primary Outcome and Predictor: Frailty Status

Frailty status was categorized according to parameters based on the Fried Phenotype in which three or more of the following criteria are present: unintentional weight loss, slow walking speed, weakness, exhaustion, and low physical activity (Fried et al., 2001). Pre-frailty is indicated by the presence of one or two criteria and robust is the absence of all criteria. Our definition adheres to the five frailty domains established in the Fried Phenotype but customized the criteria for application to NHANES data.

1. Unintentional weight loss.—Defined as having low body weight for height (body mass index [BMI] ≤ 22.5 kg/m²) or at least 5% unintentional weight loss over the past year, calculated using three questions: “How much do you weigh without clothes or shoes,” “how much did you weigh a year ago,” and “was the change between your current weight and weight a year ago intentional?” Participants were coded as having “unintentional weight loss if they had 1) a BMI ≤ 22.5 kg/m² or 2) a weight loss of at least 5% and answered “no” to the weight loss being intentional. It was necessary to modulate the definition of this domain to include adults with a low body weight (using geriatric categories) because a low body weight in older adults is associated with an increased risk of frailty and due to missing data on the unintentional weight loss NHANES question. This definition is similar to the one used by other NHANES studies (Wilhelm-Leen, Hall, Tamura, & Chertow, 2009; Kamil, Li, & Lin, 2014).

2. Slow walking speed.—As walking speed was not assessed, we used a surrogate measure for slow walking speed. If a participant answered “with some difficulty” or “with

much difficulty” or “unable to do” to the question “by yourself and without using any special equipment, how much difficulty to you have walking from one room to another on the same level,” this was coded as slow walking speed.

3. Weakness.—Defined as present if the participants answered “with some difficulty,” “much difficulty,” or “unable to do” to the question “by yourself and without using any special equipment, how much difficulty do you have lifting or carrying something as heavy as 10 pounds?”

4. Exhaustion.—Defined as present if the participants answered “with some difficulty,” “much difficulty,” or “unable to do” to the questions “by yourself and without using any special equipment, how much difficulty do you have walking for a quarter of a mile.”

5. Low physical activity.—Calculated using the World Health Organization (WHO) endorsed Global Physical Activity Questionnaire (GPAQ)(Department of Chronic Diseases and Health Promotion/Surveillance and Population-Based Prevention/World Health: Geneva, Switzerland, n.d.). Participants report in minutes their average amount of vigorous and moderate-intensity activity during three domains: work, travel to and from places, and recreation. Metabolic equivalent (MET) minutes are then calculated. Total MET scores were dichotomized into “Meets Physical Activity Guidelines – Yes (≥ 600 MET-minutes per week)” and “Meets Physical Activity Guidelines – No (< 600 MET-minutes per week)” based on the WHO’s recommended weekly level of physical activity for adults.

Sleep Duration

Sleep duration was measured by a single question, “How much sleep do you usually get at night on weekdays or workdays?” with allowable responses between 1 and 24 hours. Sleep duration was analyzed as categorical variables of short sleep duration (six hours or less/night), normal sleep duration (seven to nine hours/night), and long sleep duration (10 or more hours/night).

Demographic variables

Gender was dichotomized by NHANES as either male or female. Age was defined as self-reported years at the time of screening; participants who were 80 years or older were reported as “80” to reduce the risk of identification. Respondents were asked their race and Hispanic or Non-Hispanic background with possible options of “Non-Hispanic White,” “Non-Hispanic Black,” “Mexican American/other Hispanic,” and “Asian.” Participants who selected “Other/Multiple Races” were excluded from the current study because of the small number of participants who selected this option. Educational level was evaluated by asking the respondents what is the highest grade they completed or degree they received. Financial status was determined by asking the family gross income and the family size and then using the information to determine what percentage it is of the U.S. Poverty Index. Low income in this study was considered anyone with less than 200% of the U.S. Poverty Index. Changes in health status was evaluated by asking whether the respondent’s health was “better,” “worse,” or “the same” compared to one year ago. Respondents were queried whether they had been

hospitalized during the last 12 months and, if so, how many occasions, not days, were they hospitalized during this time.

Clinical variables

Trained research staff obtained all physical and laboratory measurements in the NHANES mobile examination centers using standardized examination methods and calibrated equipment. Standing height and weight measurements were collected in the Mobile Examination Center according to protocol.

Body mass index (BMI kg/m²) was calculated according to a standardized protocol using height and weight and then categorized based on geriatric groups with “underweight” a BMI < 22.5 kg/m², “normal” a BMI 22.5–24.9 kg/m², and “overweight/obese” a BMI ≥ 25.0 kg/m² (Winter, MacInnis, Wattanapenpaiboon, & Nowson, 2014).

Hemoglobin level (g/dL) was obtained through a blood sample that was drawn from the participant’s arm.

Memory/confusion difficulty was assessed by the question “Are you limited in any way because of difficulty remembering or because you experience periods of confusion?” Participants responded either “Yes” or “No.”

Comorbidity index was assessed by 7 yes/no questions “Ever told you had” 1) congestive heart failure, 2) coronary heart disease, 3) heart attack, 4) stroke, 5) emphysema, 6) thyroid problem, 7) liver condition, 8) cancer or malignancy, and/or 9) diabetes. All “yes” responses were added up and categorized as 0 = “no diseases,” 1 = “few diseases,” and 2 = “many diseases.”

Diet was measured by asking the global question, “In general, how healthy is your overall diet (“Excellent” to “Poor” on a 5-point Likert scale)?” For the present analysis, we recoded this question into three categories of “excellent to very good”, “good to fair”, or “poor”.

Depressive symptoms were measured by responds to nine questions from the Patient Health Questionnaire (PHQ-9) (Kroenke, Spitzer, & Williams, 2001). Participants were asked to rate the frequency of each symptom (e.g., “little interest or pleasure in doing things”) over the past 2 weeks by choosing one of the following options: 0 (“not at all”), 1 (“several days”), 2 (“more than half of the days”) and 3 (“nearly every day”). Total score ranges from 0 to 27 and scores of 5–9, 10–14, 15–19 and ≥ 20 are used to represent mild, moderate, moderately severe and severe depression, respectively (Kroenke et al., 2001). For the present analysis, we dichotomized PHQ-9 total score into “none or minimal (PHQ-9 total score < 5)” and “mild to severe” (PHQ-9 total score ≥ 5).

The number of prescription medications by questions that asked about use of prescription medication (including prescribed dietary supplements) during the past 30 days. For the analyses, number of medications was placed into three categories: few (0–2 prescription medications), moderate (3–5 prescription medications), and large (≥ 6 prescription medications).

Statistical Analysis

To estimate sampling errors based on the complex sampling design of NHANES, data analyses were conducted with the SAS statistical software (version 9.4, SAS Institute, Cary, NC). The data was weighted to adjust the unequal probabilities of selection, nonresponse adjustments, and post-stratification using the 4-year weight. The SAS SURVEY procedures were used to account for stratification, clustering and weights. For example, demographic and clinical information were presented using Surveyfreq with Wald chi-square test (weighted % and comparisons by frailty status), Surveymeans (mean and standard error for continuous variables), and Surveyreg with LSMEANS statement (for comparisons of continuous variables by frailty status). The Surveylogistic Procedure was conducted to identify potential risk factors selected a priori per the literature between frailty severity groups (pre-frail vs. robust and frail vs. robust).

Results

Description of the sample

The present analysis included all participants 60 years and older with data from both in-home interviews and in-person clinical evaluations. To represent population level parameters, demographic (Table 1) and frailty related risk factors (Table 2) have been weighted with a 4-year weight. Table 1 presents the demographic and health characteristics for the total sample and for each frailty state. According to the weighted sample (N= 3,632), participants were primarily female (54.9%), Non-Hispanic White (79%), mostly overweight or obese (73.1%), living above the poverty level (64.8%), and with post high school education (59.0%). Overall, 34.3% of the sample was robust, 52.1% was pre-frail, and 13.6% was frail.

Characteristics of frail and pre-frail participants

According to Table 1, both the pre-frail and frail groups were characterized by persons who are more likely to be female, Non-Hispanic White, have 4 or more hospitalizations during the past year, and report the same level of health over the past 12 months (all p -values < .001). The pre-frail group was also more likely to have a higher income, a higher education level, and no or few comorbid diseases while the frail group was more likely to be older, have a lower income, a lower education level, and many comorbidities (all p -values < .001). Both the pre-frail and the frail groups were characterized by persons who are more likely to have a BMI ≥ 25 kg/m² (69.4% and 70.5% respectively); however, the robust group had an even higher percentage of overweight and obese persons at 79.6%.

Figure 1 represents the percentage of the sample with normal, short, and long sleep duration according to frailty status. The robust and pre-frail groups were mostly characterized by persons with normal sleep (72.0% and 67.0%, respectively). The frail group had a higher percentage of individuals with both short and long (32.7% and 12.0%) sleep duration (Figure 1) compared to both the pre-frail (29.2% and 3.8%) and robust groups (25.7% and 2.3%). Table 2 displays additional modifiable risk factors by frailty status. The robust and pre-frail groups were characterized by persons that had no or minimal depressive symptoms, no confusion or memory problems, and with an adequate diet. The robust group typically

was prescribed less than 3 medications daily. The frail group had a significantly higher percentage of individuals with mild to severe depressive symptoms, confusion, a poor diet, and who take 6 or more medications daily compared to the pre-frail and robust groups (all p -values $< .001$).

Correlates by Frailty Status

Multinomial logistic regression analysis (Table 3) revealed that self-reported long sleep duration was associated with a frail state after controlling for sociodemographics, BMI, change in health status, number of hospitalizations, hemoglobin level, medication use, comorbidity index, depressive symptoms, diet, and confusion (p -value $< .001$). Short sleep duration was not associated with either a frail or pre-frail state. Specifically, those individuals who slept 10 or more hours per night had increased risk (OR 2.86 [1.09 – 7.50]) of being in the frail group. In addition to long sleep duration, other unique risk factors related to a frail state included (Figure 2): poverty, being hospitalized 4 or more times during the past year, worse health over the past year, and having a poor diet. Risk factors that were unique to a pre-frail state included being Non-Hispanic Black and Asian. Shared correlates among both frail and pre-frail states included older age, female sex, lower education, mild or severe depressive symptoms, confusion, and taking 6 or more medications. To explore a potential gender bias regarding the relationship between frailty and sleep duration, we performed a subgroup or domain analysis (using Surveylogistic Procedure with the DOMAIN statement) to test separate logistic models for each gender. When stratifying by gender, the relationship between long sleep duration and frailty was non-significant in both frail males (OR 2.6 [0.78 – 8.48]) and females (OR 2.94 [0.91 – 9.54]).

Discussion

In this large, nationally representative sample of community-dwelling older adults, participants who sleep an average of 10 hours were almost three times more likely to be characterized as frail. This association was still significant after adjusting for known frailty risk factors. In addition, although frailty and pre-frailty have some common risk factors, there were risk factors distinct to each state that may provide relevant targets for individual and population-level detection and preventative strategies to reduce the risk of frailty.

The study identified an association between long sleep duration and frailty in both men and women. Older adults who reported sleeping 10 hours or more per night were almost three times (2.86) more likely to be characterized as frail even after adjustments for potential confounding risk factors. Short duration was not significant in increasing the odds for being characterized as pre-frail or frail. Similar to our results, cohort studies from the Osteoporotic Fractures in Men (MrOS) trial did not find a significant cross-sectional (Ensrud et al., 2009) or longitudinal (Ensrud et al., 2012) (approximately 3.4 years) association between actigraphy assessed short sleep duration (< 5 hours) and greater frailty status. In both of these studies, sleep duration was expressed as a dichotomous variable (< 5 hours vs. ≥ 5 hours), thus a potential U-shaped relationship was not explored. A study of 8100 women aged 69 and older (The Study of Osteoporotic Fractures [SOF]) found self-reported long sleep (≥ 10 hours) to be significantly associated with an increased risk of falls and fractures;

sleep duration included daytime napping hours unlike the current study (Stone et al., 2006). Long sleep duration of 9 hours or longer, has been independently associated with sarcopenia (a major cause of physical frailty and a defining component of the Fried Phenotype) among Korean community-dwelling adults (Kwon et al., 2017). Although, long sleep duration has long been considered a consequence of disease severity (Jike et al., 2017), results of the current study are significant in that they corroborate long sleep duration as an antecedent to frailty, thus, a potential modifiable marker of risk.

The inconsistent conclusions between studies regarding the association between frailty and sleep duration may be due to differences in how sleep duration was assessed (i.e., self-report vs. actigraphy), categorized (i.e., short sleep duration defined as <5 hours, <6 hours or <7 hours), or may be the result of a gender disparity. Frailty is typically more common in women than in men (Song, Mitnitski, & Rockwood, 2010) and gender-related differences in how men and woman answer sleep-related questions have been observed (Lin, Davidson, & Ancoli-israel, 2009; Valipour et al., 2007). In the current study, the prevalence of frailty among the females was 65.9% versus 34.1% among the men. However, our results from separate logistic models that were performed for men and women do not support a potential gender disparity in regards to the effect of sleep duration on frailty status. Further testing is needed to confirm these results.

The relationships between frailty and known risk factors (i.e., older age, income, education, female sex, depression, cognitive impairment, poor nutrition, comorbidity, poor self-related health, and polypharmacy) (Buttery, Busch, Gaertner, Scheidt-Nave, & Fuchs, 2015; Collard et al., 2012; Feng et al., 2017; Huohvanainen et al., 2016; Lorenzo-López et al., 2017; Vaughan, Corbin, & Goveas, 2015; Veronese et al., 2017) have been described in the literature and are similar to the results found in the current study. However, our results extend the findings of previous studies by providing a novel insight into which factors are associated with each frail state. In the current study, inadequate diet, a modifiable behavior, was found to be a risk factor for only frail individuals in addition to long sleep duration, lower education, and having multiple hospitalizations and worse health over the past year. Race (Non-Hispanic Black and Asian) was a distinct risk factor for the pre-frail state indicating high-risk populations who are more vulnerable to developing frailty. In our sample, Non-Hispanic Black and Asian groups had a higher percentage of pre-frail persons (58.1% and 57.8%, respectively) compared to the percentage of pre-frail persons in the Non-Hispanic White group (49.5%). Risk factors for both pre-frailty and frailty include older age, female sex, lower education, depressive symptoms, confusion, and polypharmacy. These findings support managing frailty on a continuum rather than as discrete entities and treating each frail state with a comprehensive and personalized approach, especially in those high-risk populations.

Until now, research in frailty has been focused primarily on improving physical function in older adults using exercise only or exercise in combination with a nutrition, cognitive, or physical therapy intervention (Ng et al., 2015; Peterson et al., 2009; Puts et al., 2016). These multicomponent interventions are typically standardized and are not personalized to reflect the potential individual phenotypes. Likewise, clinical trials using these interventions have historically focused on reducing frailty and disability in older adults who already

experienced a frailty-related adverse health outcome. The management of frailty could benefit from a similar approach that is used in many medical conditions, including diabetes and heart failure, where focus is on disease prevention through early detection and health promotion using personalized interventions that are based on disease severity.

Prevalence rates of frailty and pre-frailty vary among studies primarily because the proportion of frail persons in a population is dependent on the definition of frailty and on the characteristics of the population. The prevalence of frailty (13.6%) and pre-frailty (52.1%) in the NHANES sample was higher than in other studies (Collard et al., 2012; Liljas et al., 2017). Results from a systematic review that included 21 studies for a total of 61,500 community-dwelling adults 65 years and older found an overall weighted frailty prevalence of 10.7% (95% CI, 10.5–10.9), and pre-frailty prevalence of 41.6% (95% CI, 41.2–42.2) (Collard et al., 2012). The higher prevalence observed in our study could be explained by the intentional oversampling by NHANES of persons over the age of 80 years (19.7%). Since the prevalence of frailty increases with age and the age range in the current study was truncated with persons over 80, it is unknown how much beyond the age of 80 persons in this group actually were.

Strengths of this study are its large representative sample of older adults living in the United States and the use of weighted percentages to represent population level parameters that permit unbiased estimates and minimizes sampling error. Limitations are the cross-sectional design that precludes the inference of causal relationships and the use of self-report measures for frailty and sleep duration. In addition, the findings could not be adjusted for hypnotic drugs use or for coexisting sleep disorders (e.g. sleep apnea and insomnia), both possible significant clinical confounders in the correlation between long sleep duration and frailty status. Finally, sleep duration is only one factor of sleep health (Buysse, 2014) and a more expansive examination of the effect of impaired sleep on frailty is warranted.

Conclusions

Long sleep duration was associated with increased risk of frailty even after for controlling for multiple risk factors associated with decreased health status. Results from this study suggest that long sleep may not just be the byproduct of impaired health and resultant frailty but that there may be deleterious effects of the prolonged inactivity with long sleep duration. It is important not to equate long sleep duration with restorative sleep or good sleep quality. Future research needs to evaluate persons at risk for frailty for sleep disorders (e.g., insomnia) and explore if normalizing sleep duration to 7 – 8 hours per night, possibly through treatment of a sleep disorder, is an effective approach to improve the management of frailty. In addition, targeted interventions to improve sleep quality may be most effective when coupled with early detection of individuals and/or populations at high-risk for frailty and concurrent attention to modifiable risk factors such as insufficient physical activity, inadequate diet, impaired cognitive status, and depression.

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Figure 1.
Percentage of sample with normal, short, or long sleep duration by frailty status.

Figure 2.
Risk Factors According to Frailty Status

Table 1.

Characteristics of the Total Sample by Category of Frailty Status (N = 3632)

		All	Robust	Pre-Frail	Frail	p-value
		N (%) [*]	n (%) [*]	n (%) [*]	n (%) [*]	
		3632 (100%)	1556 (34.3%)	1654 (52.1%)	422 (13.6%)	
Gender	Female	54.9	43.4	60.1	65.9	<.001
	Male	45.1	56.6	39.9	34.1	
Age (years)	60–69	53.4	61.9	51.5	37.5	<.001
	70 or older	46.6	38.1	48.5	62.5	
Race/Ethnicity	NH White	78.7	83.3	76.2	76.5	.004
	NH Black	9.2	6.8	10.5	10.9	
	Hispanic	7.9	6.5	8.7	8.6	
	Asian	4.2	3.5	4.7	4.0	
Poverty Level	> 200%	64.8	75.0	63.5	42.0	<.001
	200%	35.2	25.0	36.6	58.0	
Education	high school graduate	41.0	32.2	41.7	62.1	<.001
	Post high school	59.0	67.8	58.3	37.9	
Geriatric BMI Categories	Normal (22.5–24.9 kg/m ²)	15.7	20.4	14.1	9.6	N/A [†]
	Underweight (< 22.5 kg/m ²)	11.2	0	16.6	20.0	
	Overweight/Obese (≥ 25.0 kg/m ²)	73.1	79.6	69.4	70.5	
General Health versus 1 year ago	Better	16.0	16.3	15.8	16.3	<.001
	Same	70.6	75.8	70.8	55.3	
	Worse	13.4	8.0	13.4	28.4	
Number of hospitalizations in the past year	0–1	17.9	22.6	17.1	6.7	<.001
	2–3	31.9	37.1	29.5	25.5	
	4	50.2	40.3	53.4	67.8	
Comorbidity Index	No diseases	39.3	48.3	37.7	20.4	<.001
	Few (1–2)	33.2	31.0	34.0	35.7	
	Many (≥ 3)	27.5	20.7	28.3	43.8	

Note: Age range truncated with persons ≥ 80 coded as “80.” Frailty status is categorized by the Fried Phenotype (robust, pre-frail, and frail) with customized criteria for application to NHANES data.

^{*}Weighted column percentages are reported.

[†]Wald Chi square tests were not computed because at least one table cell has 0 frequency.

Table 2.

Modifiable Frailty Risk Factors

		All	Robust	Pre-Frail	Frail	<i>p</i> -value
		% [*]	% [*]	% [*]	% [*]	
Hemoglobin [†]	Value (g/dL)	14.0 ±0.05	14.4±0.06	13.8±0.08	13.8±0.1	<.001
Sleep Duration	Normal (7–9 hours)	67.3	72.1	67.0	55.3	.0004
	Short (≤ 6 hours)	28.4	25.7	29.2	32.7	
	Long (≥ 10 hours)	4.3	2.3	3.8	12.0	
Depressive Symptoms	None or minimal (PHQ-9 < 5)	78.3	88.1	76.7	56.0	<.001
	Mild to Severe (PHQ-9 ≥ 5)	21.7	11.9	23.3	44.0	
Confusion /Memory Problems	Yes	11.7	3.3	12.1	33.0	<.001
	No	88.3	96.7	87.9	67.0	
Self-Reported Diet Habits	Excellent/very good	13.8	16.3	13.1	9.6	.0001
	Good/fair	72.1	73.2	72.4	67.2	
	Poor	14.1	10.5	14.5	23.2	
Number of Rx. Medications	Few (0–2)	38.6	49.9	36.7	15.5	<.001
	Moderate (3–5)	34.4	38.0	32.8	31.2	
	Large (≥ 6)	26.9	12.2	30.5	53.3	

Note: Frailty status is categorized by the Fried Phenotype (robust, pre-frail, and frail) with customized criteria for application to NHANES data.

^{*} Weighted column percentages are reported.

[†] Values are reported as mean ± standard error.

Table 3.

Results of the Multinomial Logistic Regression Analysis for Variables Predicting Frailty Status

Variable	Pre-Frail Versus Robust	Frail Versus Robust
Age (y)		
60–69	1.00	1.00
70+	1.50 (1.17 – 1.91) *	1.79 (1.12 – 2.88) *
Female	1.75 (1.35 – 2.26) *	1.93 (1.25–2.97) *
Race		
NH White	1.00	1.00
Asian	2.01 (1.25–3.22) *	1.20 (0.50 – 2.89)
Hispanic	1.29 (0.99 – 1.69)	0.53 (0.33 – 0.86)
NH Black	1.46 (1.13 – 1.89) *	1.22 (0.81 – 1.83)
Education		
high school graduate	1.24 (1.02 – 1.51) *	2.26 (1.66 – 3.08) *
Post high school graduate	1.00	1.00
Poverty		
200%	1.28 (0.93 – 1.76)	2.36 (1.39 – 4.03) *
> 200%	1.00	1.00
Health vs 1 yr ago		
Better	1.00	1.00
About the same	0.96 (0.67 – 1.39)	0.62 (0.35 – 1.10)
Worse	1.40 (0.85 – 2.30)	2.20 (1.22 – 3.98) *
# Hospitalizations over the past year		
None to 1 time	1.00	1.00
2–3 times	0.98 (0.68 – 1.41)	1.84 (0.86 – 3.94)
4 times	1.41 (0.98 – 2.02)	2.71 (1.19 – 6.20) *
Comorbidity Index		
None	1.00	1.00
Few	1.00 (0.79 – 1.27)	1.53 (0.94 – 2.48)
Many	0.85 (0.65 – 1.25)	1.23 (0.73 – 2.06)
Hemoglobin Level	0.98 (0.91 – 1.05)	1.02 (0.90 – 1.17)
# Prescriptions		
Few (0–2)	1.00	1.00
Moderate (3–5)	0.88 (0.65 – 1.20)	1.60 (0.92 – 2.79)
Large (6)	2.40 (1.58 – 3.66) *	5.22 (2.36 – 11.55) *
Sleep Duration		
Short (6 hours)	0.94 (0.69 – 1.29)	1.41 (0.97 – 2.04)
Normal (7–9 hours)	1.00	1.00
Long (10 hours)	1.17 (0.62 – 2.21)	2.86 (1.09 – 7.50) *
Depression Symptoms		

Variable	Pre-Frail Versus Robust	Frail Versus Robust
None to Minimal	1.00	1.00
Mild to Severe	1.53 (1.05 – 2.22) *	1.88 (1.03 – 3.41) *
Confusion		
No	1.00	1.00
Yes	2.40 (1.45 – 3.96) *	4.67 (2.74 – 7.95) *
Diet		
Excellent/Very Good	1.00	1.00
Good/Fair	1.10 (0.68 – 1.80)	1.20 (0.73 – 1.98)
Poor	1.51 (0.92 – 2.47)	2.69 (1.29 – 5.61) *

Note: Multinomial logistic regression model was used to identify risk factors for frail and pre-frail states. Odds ratios were compared against the robust group.

* Indicates a significant association.