March 7, 2008

Dear Dr. Crimmins,

Thank you for the opportunity to present our research at the Population Association of America 2008 Annual Meeting.

A draft of our study, “Frailty, Vulnerability, and Disability in the Older Adult Population: The Health and Retirement Study,” immediately follows this cover letter.

Since submission of the abstract, we have further developed our analysis:
--We have refined several variables in our study.
--We are now using final respondent weights (as opposed to using the preliminary respondent weights at the time of the abstract submission).
--We are including mortality as outcome; (2006 mortality data was not available at the time of the abstract submission).
These modifications are responsible for the (mostly small) changes in our results.

Also since submission of the abstract, we have elected to submit the results of this research for publication as two separate articles. The first article will focus on methods, demonstrating how we operationalized the frailty models in the Health and Retirement Study. The second article will focus on disability and mortality outcomes at two years. Drafts of both papers are in progress, and we hope to have submitted both for publication in the coming month. The draft which follows is a compilation of parts of both papers (with an undeveloped discussion section). We would be happy to provide you and any discussants copies of the submitted drafts of both papers prior to the 2008 Annual Meeting.

Again, thanks for your time and efforts,
Sincerely,

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Population Association of America 2008 – Paper (DRAFT)

Frailty, Vulnerability, and Disability in the Older Adult Population: The Health and Retirement Study

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INTRODUCTION

The traditional disease model, with its focus on the diagnosis and treatment of single diseases, increasingly has been found to be inadequate as an approach to the health status of the older adult population, especially those older adults having a complex health status with substantial health care needs.(1) In both clinical and research settings, the health status of older adults is more fully described by characteristics other than their individual diseases. These defining clinical characteristics have proven to be useful starting points for discussion and study.(2)

One defining clinical characteristic of older adults is their burden of chronic diseases, that is, the degree of multimorbidity, with multiple diseases interacting to impact health and disability. Using Medicare claims data and not adjusting for disease activity or severity, Wolff et al found that 60% of Medicare beneficiaries had two or more diseases.(3)

A second defining clinical characteristic of some older adults is cognitive impairment. Although often studied as one of the chronic diseases, it has also been useful to examine cognitive impairment separately, as its effects on health and disability are distinctive. Using data from the Study of Assets and Health Dynamics Among the Oldest Old (AHEAD), Langa et al found the prevalence of cognitive impairment among adults age 70 years and older to be ten percent, with 31 percent of those having severe impairment.(4)

A third defining clinical characteristic is disability. Freedman et al examined activity of daily living (ADL) difficulty and dependency trends in older adults, comparing five national data sets, including the Health and Retirement Study (HRS). Using HRS data, among community-dwelling adults age 70 years and older, approximately 25 percent had difficulty with at least one ADL, and approximately 10 percent required assistance with at least one ADL.(5)

As individuals age, multimorbidity, cognitive impairment, and disability become more prevalent and clinically meaningful. The degree or severity of each helps to characterize the health status of older adults and to determine the relationship between older adults and their health care. Yet, this perspective for understanding the health status of older adults may be modified in a valuable way by the additional consideration of the geriatric condition of frailty.

Over the past several decades, the understanding of the term frailty has been in flux.(6) The term has been used to indicate older adults who were vulnerable due to a collection of disparate factors and conditions, including advanced age, disease, dependency, special care needs, at risk environment, etc; these older adults had an increased risk for adverse outcomes such as dependency, falls, need for long term care, and mortality. Researchers have modeled frailty in different ways. Different definitions and models of frailty often included as components or were synonymous with increasing age, multimorbidity, and disability.

Strawbridge and colleagues proposed a frailty measure focusing on deficiencies in four domains of functioning. (Table 1) Each domain can be thought to represent a geriatric condition (e.g. malnutrition, poor vision). The Strawbridge model was developed in the Alameda County Study, a longitudinal study of a cohort of adults that also examined quality of life outcomes; 26% of the sample was classified as frail.(7)

Fried and colleagues proposed to narrow the understanding of frailty to mean a "biologic syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems, and causing vulnerability to adverse outcomes."(8) Here, frailty is not caused by a single altered system or a single disease, and it has a phenotype of different symptoms and signs.(8, 9) This understanding of frailty derives from a hypothesized cycle of frailty, and Fried defined the frailty phenotype in terms of components present in the hypothesized cycle. (Table 1) The Fried model was operationalized in the Cardiovascular Health Study (CHS).(10, 11) Data analysis determined that the presence of three or more criteria was most predictive of mortality risk. The strength of the Fried model of frailty is that it is an explanatory and empirical model, with five domains each linking to the biological cycle of frailty and each captured by a self-report or physical performance measure. The model provides an explanatory link between aging and disease as causes and dependency and mortality as outcomes, and it enables the testing of hypotheses within biological, clinical, and health services research disciplines. The model attempts to provide standardization to the study of frailty, and it offers an empiric way to study frailty in population-based research.

In comparison, Saliba and colleagues, as part of the Assessing Care of the Vulnerable Elders (ACOVE) initiative, developed the Vulnerable Elders Survey (VES-13), a clinical measure of vulnerability whose goal was to identify older adults at risk for functional decline or death.(12) The Survey includes four domains. (Table 1) The ACOVE model was developed in the Medicare Current Beneficiary Survey.

In this study, we used nationally representative data (including physical performance measures) to investigate frailty/vulnerability and disability in the older adult population. We operationalized three models: Fried (frailty as biologic syndrome), Strawbridge (frailty as presence of geriatric conditions), and ACOVE (clinical vulnerability). We examined the populations identified by the models, including how these populations overlap, their demographic characteristics, and their chronic disease profile. We also examined their prediction of disability (incidence and progression) and mortality at two years. We hypothesized that:

1. Frailty/vulnerability models differ in identifying older adults as frail/vulnerable.
2. Low socioeconomic status is highly associated with frailty.
3. Models of frailty/vulnerability are predictive of two-year disability.

METHODS

Data

The data used in this study are from the 2004 and 2006 waves of the Health and Retirement Study (HRS), a population-based, longitudinal health interview survey of a cohort of adults age 51 years and older in the United States.(13, 14) Sponsored by the National Institute on Aging and performed by the Institute for Social Research at the University of Michigan, the HRS is designed to study health transitions among older adults.

The HRS conducted interviews with respondents and their spouses. Respondents included those living in the community and those residing in long-stay nursing facilities. Of the 20,129 respondents interviewed in 2004 wave core survey, 11,113 were 65 years and

older. When the eligible respondent was unable to be interviewed, often due to medical and/or cognitive problems, a proxy, frequently the spouse, was enlisted to answer questions for that respondent.

The 2004 wave included physical performance measures (e.g., grip strength, walk speed) on a sub-sample of community-dwelling non-proxied respondents (n=3,274); of these, 2,111 were 65 years and older. As modeled by Fried in the CHS, we excluded respondents with stroke, depression, and moderate to severe cognitive impairment (single diseases or conditions which could by themselves result in frailty characteristics). The remaining 1,657 respondents in our study sample represented 28.2 million adults aged 65 years and older in the United States in 2004.

Data from the 2006 wave of the HRS was used to determine disability incidence and progression and mortality at two years for the 1,657 respondents in the study sample.

The HRS was approved by the Behavioral Sciences Committee institutional review board at the University of Michigan. The data used for this analysis are publicly available and contain no unique identifiers, thus assuring respondent anonymity.

Variables and Their Measurement

Frailty

We used data from the 2004 wave core survey and from the physical performance measures sub-sample to operationalize the frailty/vulnerability models in the HRS (Table 1).

Fried: The original model was specified by five frailty criteria. Respondents were classified as frail if they met three or more criteria.(8) Weight loss was defined in the CHS as the self-reported unintentional loss of 10 or more pounds in the previous year. We defined weight loss in the HRS as the loss of 10 or more pounds in the previous two years (derived from the self-reported weight in 2004 as compared to that in 2002)or a BMI less than 18.5 kg/m^2 (derived from self-reported height and weight). We used the same CES-D measures as used in the CHS to define exhaustion; respondents answered yes or no to whether they had experienced the CES-D item for much of the time during the past week. Low activity was defined in the CHS in terms of kilocalories expended per week, based on the response to selected items from the Minnesota Leisure Time Activity questionnaire. We used three questions in the HRS asking respondents about their frequency of mild, moderate, and vigorous physical activities to construct an activity scale weighted by the intensity and the frequency of the activities. (Intensity weights were derived from the kilocalories expended for the different types of activities.) We defined low activity as the lowest 20% for each gender. We defined slowness in terms of usual pace walking speed measured over 8 feet (compared to 15 feet in the CHS); we used the same cut points as in the CHS. We measured weakness by assessing grip strength, again using the same cut points as in the CHS. Of note, we also included as slow and as weak those respondents unable to complete the respective physical performance tests (e.g., due to safety concerns). Respondents were classified as frail if they met three or more of the frailty criteria.

Strawbridge: The original model was specified by 16 self-report items grouped into four domains of functioning. Respondents were classified as frail if they had difficulties in two or more domains.(7) The physical functioning domain included measures for dizziness, loss of balance, weakness in the arms, and weakness in the legs. We defined physical functioning in the HRS using measures for dizziness as a persistent problem, two or more falls in the past two years, and difficulty lifting ten pounds. The nutritive functioning domain included measures for unexplained weight loss and appetite loss. We defined nutritive functioning in the HRS using measures for the loss of 10 or more pounds in the

previous two years and/or a BMI less than 18.5 kg/m^2. The cognitive functioning domain included measures for memory and attention difficulties. We defined cognitive functioning in the HRS using a performance-based measure to assess the degree of cognitive impairment (see below). The sensory functioning domain included measures for vision and hearing difficulties in different situations. We defined sensory functioning in the HRS using measures for fair or poor eyesight or hearing despite the use of corrective lenses or hearing aides.

ACOVE: The VES-13 identified older adults as vulnerable by assigning varying numbers of points in four areas(12):

-Age: Age 75-84 years old and ≥85 years old.
-Self-Rated Health: Fair or poor.
-Limitations in Physical Function: Stooping/kneeling, lifting/carrying, reaching, handling small objects, walking ¼ mile, heavy housework.
-Disability in ADLs/IADLs (Instrumental Activities of Daily Living)/mobility: Shopping, managing money, walking across room, light housework, bathing.

With the exception of light housework, the same measures were available in the HRS, enabling us to replicate the ACOVE vulnerability model.

Chronic Diseases(2, 15)

We included the following chronic diseases in our analyses: hypertension, heart disease, chronic lung disease, diabetes, cancer, musculoskeletal conditions, and psychiatric problems. We limited each disease to its active or severe form (e.g., receiving treatment for the disease).

Two diseases, stroke and depression, were exclusion criteria for the study. Respondents with stroke were defined as those reporting stroke who required medication for the stroke (or its complications) and/or who had remaining problems from the stroke. Respondents with depression were defined as those with a positive response to four (of eight) Center for Epidemiologic Studies Depression Scale (CES-D) items.

Cognitive Impairment

Cognitive impairment (moderate to severe) was the third exclusion criterion for the study. Cognitive status was assessed using a performance-based measure, a modified version of the Telephone Interview for Cognitive Status (TICS), a validated cognitive screening instrument patterned on the Mini-Mental State Examination(16) and specifically designed for population-based studies.(4, 17, 18) We defined moderate to severe impairment as a score of 7 or below on the 35-point cognitive scale.

Cognitive impairment is also one of the domains in the Strawbridge model. Whereas respondents with moderate to severe cognitive impairment were excluded, respondents with mild cognitive impairment were included in the study. We defined mild impairment as a score of 8-10 on the 35-point scale.

Disability(2, 15)

We included the following ADLs in our analysis: bathing, dressing, eating, toileting, and transferring. We defined ADL dependency as respondents *both* having difficulty with *and* receiving assistance for the task. (Difficulty included the inability to perform the task due to a health or memory problem.)

We included the following IADLs in our analysis: meal preparation, shopping, money management, telephone use, and taking medications. Similar to ADL dependency, we defined IADL dependency as respondents *both* having difficulty with *and* receiving assistance for the task (due to a health or memory problem).

Incident disability was defined any new ADL/IADL dependency in wave 2006 in respondents having no dependency in wave 2004. Progression of disability was defined any increase of two or more ADL/IADL dependencies in wave 2006 in respondents having previous dependency in wave 2004.

Mortality

Mortality was determined by cross referencing HRS mortality data from the 2006 wave with National Center for Health Statistics National Death Index (NDI).

Demographic Characteristics

Demographic variables included age, gender, race (Caucasian, African-American, Hispanic), marital status, educational attainment, net worth (total household assets minus current debt)(13), and living status (lives with others, lives alone).

Statistical Analysis

To adjust for the complex sample design of the HRS, the differential probability of selection, and non-response, all analyses were weighted and adjusted using the statistical package STATA (Release 9.2, StataCorp, College Station, Texas). In our analyses, we used the respondent weights specific to the physical performance measures sub-sample. We were thus able to take advantage of the nationally representative data set to produce national population estimates.

We used standard descriptive methods to estimate prevalences, determine confidence intervals, and make comparisons among frail groups. We employed multivariate logistic regression to examine the association between demographic characteristics and chronic diseases and the probability of being frail (as defined by each frailty/vulnerability model). We similarly employed multivariate logistic regression to examine the association between frailty/vulnerability and disability incidence and progression and mortality at two years (using data from the 2006 wave of the HRS). Both sets of logistic regression models used binary dependent variables (e.g., presence/absence of frailty/vulnerability, presence/absence of incident/progressive disability and/or mortality).

RESULTS

The first part of the analysis operationalized frailty/vulnerability under the three models (Fried, Strawbridge, ACOVE) in our study sample. Table 1 provides a list of the measures in the HRS that were used. Table 1 also shows the prevalence (weighted) of frailty/vulnerability according to each model: Fried 10.9%, Strawbridge 20.2%, and ACOVE 15.5%.

We found that the frailty/vulnerability models differed substantially in how they classified respondents as frail. The Venn diagram in Figure 1 illustrates how the populations identified as frail by each model overlapped. Overall, 31.7% of respondents were frail/vulnerable by at least one model; 3.2% were frail/vulnerable by all three models. The Strawbridge model showed the least overlap with the other models.

Table 2 shows (column 1) the characteristics of the study population (n=1,657). Table 2 further shows (columns 2-4) the characteristics of those respondents classified as frail/ vulnerable by each model. Compared to those not identified as frail/vulnerable, respondents with frailty/vulnerability were older, female, from a minority ethnic group (not ACOVE), and unmarried; had less education and a lower net worth; and lived alone. Table 2 also shows the prevalence of chronic diseases, cognitive impairment, and ADL and IADL dependency in the study population and in each frail/vulnerable population. For each model, frail respondents had increased prevalence of heart disease, lung disease, diabetes (not ACOVE), and musculoskeletal disorders. Frail/vulnerable respondents also

had increased prevalence of numbers of chronic diseases and of ADL and IADL dependencies; (note that the ACOVE model includes ADL and IADL measures in its formulation).

Table 3 shows the odds ratios from three regression models, indicating the association of demographic characteristics and chronic diseases with frailty/vulnerability. The dependent variable for each model is frailty (Fried), frailty (Strawbridge), and vulnerability (ACOVE). Fried, Strawbridge, and ACOVE models were investigated in two steps, first including only demographic variables in the respective models (data not shown) and then introducing chronic disease variables. In the Fried model, advanced age, female sex, African-American ethnicity, net worth, lung disease, diabetes, and musculoskeletal conditions were associated with frailty. These associations were also generally found with the Strawbridge model, although with smaller odds ratios. Significant associations were found for advanced age, net worth, and heart disease with the ACOVE model. For each of the models, we systematically tested for interactions between the independent variables and found none that seemed meaningful.

Table 4 shows the association of disability incidence/progression and mortality at two years with frailty/vulnerability. Adjusting for demographic and chronic disease covariates, the odds ratio for the association of frailty (Fried model) with disability incidence/progression and/or mortality at two years (the dependent variable in the models) was 3.0. Slightly smaller odds ratios were found for models including frailty (Strawbridge 2.2) and vulnerability (ACOVE 2.7) as the independent variables of interest. Significant covariates in all three models included age, net worth, and diabetes. Of note, odds ratios for frailty/vulnerability were comparable to or greater than those for the chronic diseases.

DISCUSSION

This study examines two models of frailty and a model of vulnerability, each derived from different theoretical understandings of frailty and vulnerability. Our research goal was to operationalize each model in a nationally representative population sample and to compare the older adults identified as frail/vulnerable by each model. To our knowledge, this is the first study using nationally representative data with physical performance measures to do so. (We performed a systematic search of MEDLINE beginning January, 1990 and ending February, 2008 using the term “frailty.” We were unable to find studies comparing frailty models using nationally representative data, physical performance measures, and respondents including both men and women across the age range.) Confirming our hypotheses, the models differed in identifying older adults as frail/vulnerable. All models demonstrated an association with socioeconomic status, with frailty/vulnerability having an inverse relationship with increasing net worth. Last, all models predicted disability incidence and progression and mortality at two years. These findings have implications for frailty/vulnerability in research studies and in clinical applications.

A chief strength of this research is that it is based on a large, nationally representative survey (HRS) that includes physical performance measures and a performance-based determination of cognitive ability in addition to data on chronic diseases and disability. Thus, it enables the operationalization and comparison of different conceptual models of frailty and vulnerability. Further, the HRS samples across the age range of older adults, including the oldest old. Finally, the HRS is a biennial longitudinal survey that includes utilization and cost data, making possible future studies that examine the cross-sectional and longitudinal association of frailty and vulnerability with utilization and cost outcomes.

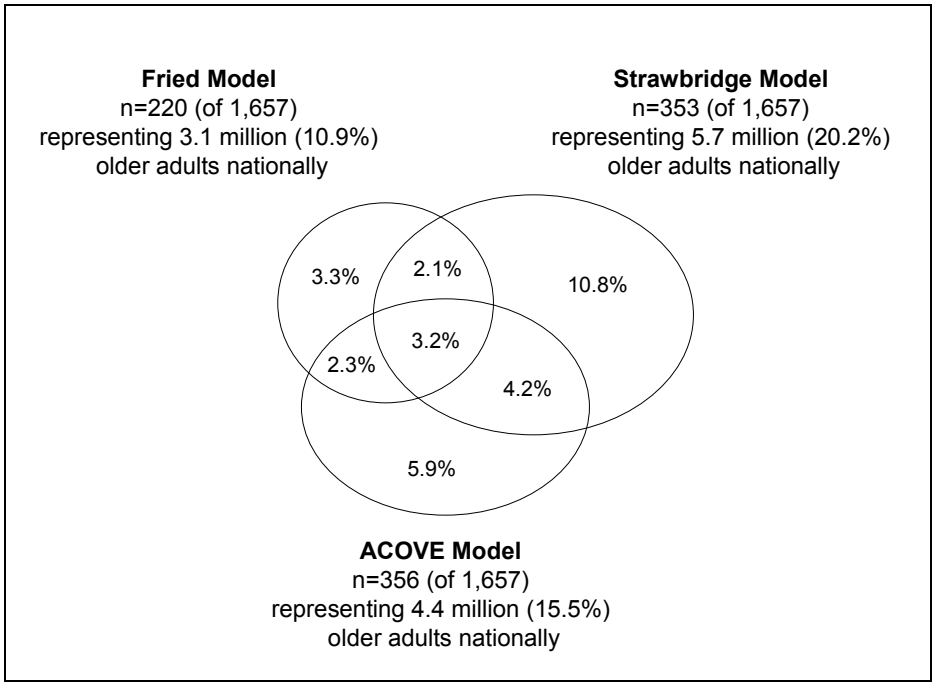
This study has several limitations. First, the HRS is based on self-report data (other than the cognitive and physical performance measures). In particular, the activity/severity

constraints developed for chronic diseases are based on self-report data. Further, the diseases and conditions chosen for this study are limited by the questions included in the HRS survey. For example, the HRS does not have data on Parkinson's disease. Thus, we were limited in our ability to exactly replicate each model. Also, survival bias may play a role in the age-related prevalence of the frailty, especially among the oldest old.

Table 1. Measures used to operationalize frailty/vulnerability in the Health and Retirement Study under the different models.

Frailty Fried Model	**Frailty Strawbridge Model**	**Vulnerability ACOVE Model**
Weight Loss: Loss of >10 pounds in past 2 years. Exhaustion: Yes to 1 of 2 specified CES-D items. Low Energy Expenditure: Frequency of 3 intensities of activity. Slowness: Time to walk 8 feet, slowest 20% (stratified by gender & BMI). Weakness: Grip strength, weakest 20% (stratified by gender & BMI).	Physical Functioning: Weakness, balance, and dizziness measures. Nutritive: Loss of >10 pounds in past 2 years; loss of appetite. Cognitive: Telephone Interview for Cognitive Status (TICS) score and word recall. Sensory: Self-report vision and hearing measures.	Age: Age 75-84 and ≥85. Self-Rated Health: Poor/fair. Limitations in Physical Function: Stooping/kneeling, lifting/carrying, reaching, handling small objects, walking ¼ mile, housework, etc. Disability in Activities of Daily Living/Instrumental Activities of Daily Living: Shopping, managing money, bathing, etc.

Figure 1. Venn diagram depicting how the models differ in classifying respondents as frail.



Weighted percentages derived using the Health and Retirement Study (HRS) respondent population weights to adjust for the complex sampling design of the HRS survey.

ACOVE, Assessing Care of the Vulnerable Elders.

Table 2. Characteristics of the Study Population, Overall and By Frailty/Vulnerability Model.

			Weighted Percentage*		
			Frailty/Vulnerability Models		
		(n=1,657, representing 28.2 million)	**Fried** (n=220, representing 3.1 million)	**Strawbridge** (n=353, representing 5.7 million)	**ACOVE** (n=356, representing 4.4 million)
Age (years)	65-69	31.9	10.1	22.5	7.5
	70-74	24.0	13.1	19.2	3.9
	75-79	17.1	12.6	17.0	16.7
	>80	27.0	64.2	41.4	72.0
	P value		<0.0001	0.0001	0.0000
Gender	Male	44.5	28.5	36.3	33.9
	Female	55.5	71.5	63.7	66.1
	P value		<0.0001	0.0041	0.0004
Race	Caucasian	88.1	78.2	83.4	88.3
	African-American	7.4	16.7	11.8	7.5
	Hispanic	4.5	5.1	4.7	4.2
	P value		0.0001	0.0028	0.99
Marital Status	Married	64.4	43.3	54.5	37.2
	Unmarried	35.6	56.7	45.5	62.8
	P value		<0.0001	0.0016	0.0000
Education (years)	<12	22.2	35.1	28.4	32.0
	12	36.7	35.3	38.1	39.0
	>12	41.1	29.6	33.5	29.0
	P value		0.0003	0.0067	0.0000
Net Worth (dollars)	≤40,000	16.3	32.9	22.0	27.9
	40,001-155,000	21.5	26.3	31.3	29.3
	155,001- 420,000	27.3	21.9	21.7	22.3
	>420,000	34.8	18.9	25.1	20.5
	P value		<0.0001	0.0000	0.0000
Living Status	Lives with others	73.6	64.5	68.6	55.8
	Lives alone	26.4	35.5	31.4	44.2
	P value		0.0211	0.0295	0.0000
Chronic Diseases	Hypertension	53.6	64.6	59.5	62.1
	P value		0.0134	0.1172	0.0049
	Heart disease	19.6	28.0	31.7	31.6
	P value		0.0030	0.0000	0.0000
	Lung disease	4.9	12.2	9.1	9.3
	P value		0.0004	0.0021	0.0087
	Diabetes	15.7	26.8	23.3	15.9
	P value		0.0011	0.0002	0.92
	Cancer	3.3	4.7	3.9	4.5
	P value		0.38	0.57	0.22
	Musculoskeletal	30.2	48.9	39.8	38.0
	P value		<0.0001	0.0013	0.0067
	Psychiatric	4.0	5.6	4.1	4.6

	P value		0.28	0.94	0.66
Number of Chronic Diseases	≥1	75.7	90.6	86.6	85.3
	P value		<0.0001	0.0002	0.0006
	≥2	40.2	67.8	59.0	59.0
	P value		<0.0001	0.0000	0.0000
	≥3	13.0	24.9	21.4	17.9
	P value		<0.0001	0.0000	0.0290
Cognitive Impairment	Mild	1.8	4.1	7.0	6.4
	P value		0.16	0.0000	0.0000
Number of ADL Dependencies	≥1	4.8	20.5	15.3	24.0
	P value		<0.0001	0.0000	0.0000
	≥2	1.7	8.3	4.8	8.6
	P value		<0.0001	0.0010	0.0000
	≥3	0.6	2.5	1.5	3.7
	P value		0.0078	0.0521	0.0000
Number of IADL Dependencies	≥1	7.4	24.2	20.0	40.2
	P value		<0.0001	0.0000	0.0000
	≥2	2.2	8.7	8.0	14.0
	P value		0.0004	0.0000	0.0000
	≥3	0.5	3.5	2.4	3.4
	P value		<0.0001	0.0000	0.0000

*Weighted percentages derived using the Health and Retirement Study (HRS) respondent population weights to adjust for the complex sampling design of the HRS survey. Proportions are related to the columns and not the rows. For example, of those respondents with frailty (Fried model), % are male, and 49.8% are female.

P value from the χ^2 test for association between the indicated variable and the age group.

ACOVE, Assessing Care of the Vulnerable Elders.

ADL, activity of daily living.

IADL, instrumental activity of daily living.

Table 3. Odds ratios for association of demographic characteristics and chronic diseases with frailty.

	Fried		**Strawbridge**		**ACOVE**	
	OR	P value	OR	P value	OR	P value
Age (years)						
70-74	1.6	0.34	1.0	0.91	0.6	0.20
75-79	2.4	0.05	1.3	0.32	**4.3**	0.001
≥80	**10.5**	0.000	**2.2**	0.002	**15.5**	0.000
Female	**1.8**	0.004	1.4	0.05	1.2	0.44
Race						
African-American	**2.2**	0.039	**1.7**	0.016	0.6	0.24
Hispanic	1.0	0.96	1.1	0.83	0.7	0.43
Married	1.3	0.33	1.0	0.85	0.7	0.07
Education (years)						
12	0.9	0.69	1.0	0.91	0.9	0.65
>12	0.8	0.30	0.8	0.24	0.6	0.06
Net Worth (dollars)						
40,001-155,000	0.7	0.11	1.5	0.07	0.7	0.22
155,001- 420,000	**0.5**	0.016	0.7	0.13	**0.4**	0.001
>420,000	**0.4**	0.001	0.8	0.24	**0.4**	0.003
Chronic Diseases						
Hypertension	1.2	0.27	1.0	0.82	1.3	0.09
Heart disease	1.4	0.13	**2.3**	0.000	**1.7**	0.006
Lung disease	**3.2**	0.002	**2.4**	0.010	2.3	0.05
Diabetes	**2.1**	0.007	**1.7**	0.006	1.0	0.91
Cancer	1.6	0.42	1.1	0.82	1.3	0.50
Musculoskeletal	**2.2**	<0.001	**1.6**	0.009	1.4	0.07
Psychiatric	1.9	0.13	1.0	1.0	1.8	0.23

Odds ratios (OR) are weighted, using the Health and Retirement Study (HRS) respondent weights for the physical performance measure sub-sample, to adjust for the complex sampling design of the HRS survey.

ACOVE, Assessing Care of the Vulnerable Elders.

Table 4. Odds ratios for association of frailty (Fried model, Strawbridge model) and vulnerability (ACOVE model) with disability (incidence/progression) and death at two years.

	Fried		**Strawbridge**		**Strawbridge**	
	OR	P value	**OR**	P value	**OR**	P value
Frailty/vulnerability						
Fried model	**3.0**	0.000				
Strawbridge model			**2.2**	0.000		
Strawbridge model					**2.7**	0.000
Age (years)						
70-74	**2.4**	0.039	**2.4**	0.034	**2.5**	0.033
75-79	**3.8**	0.000	**3.8**	0.000	**3.5**	0.001
≥80	**7.4**	0.000	**8.6**	0.000	**6.5**	0.000
Female	0.7	0.08	0.7	0.09	0.8	0.17
Race						
African-American	1.7	0.12	1.7	0.09	**2.1**	0.020
Hispanic	1.0	0.89	1.0	0.93	1.1	0.78
Married	0.8	0.13	0.8	0.14	0.8	0.28
Education (years)						
12	1.4	0.11	1.4	0.14	1.4	0.16
>12	0.9	0.57	0.9	0.55	0.9	0.64
Net Worth (dollars)						
40,001-155,000	0.8	0.46	0.7	0.20	0.8	0.34
155,001- 420,000	0.6	0.07	**0.6**	0.030	0.6	0.07
>420,000	**0.5**	0.032	**0.5**	0.011	**0.6**	0.030
Chronic Diseases						
Hypertension	1.0	0.99	1.0	0.88	1.0	0.94
Heart disease	1.4	0.07	1.2	0.21	1.3	0.08
Lung disease	1.2	0.49	1.3	0.37	1.3	0.39
Diabetes	**2.0**	0.000	**2.1**	0.000	**2.2**	0.000
Cancer	1.0	0.94	1.1	0.72	1.1	0.83
Musculoskeletal	1.0	0.94	1.1	0.82	1.0	0.86
Psychiatric	2.1	0.14	2.2	0.08	2.0	0.15

Odds ratios (OR) are weighted, using the Health and Retirement Study (HRS) respondent weights for the physical performance measure sub-sample, to adjust for the complex sampling design of the HRS survey.

ACOVE, Assessing Care of the Vulnerable Elders.

REFERENCES

1. **Tinetti ME, Fried T.** The end of the disease era. *Am J Med*. 2004;116(3):179-85.
2. **Cigolle CT, Langa KM, Kabeto MU, Blaum CS.** Setting eligibility criteria for a care-coordination benefit. *J Am Geriatr Soc*. 2005;53(12):2051-9.
3. **Wolff JL, Starfield B, Anderson G.** Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. *Arch Intern Med*. 2002;162(20):2269-76.
4. **Langa KM, Chernew ME, Kabeto MU, et al.** National estimates of the quantity and cost of informal caregiving for the elderly with dementia. *J Gen Intern Med*. 2001;16(11):770-8.
5. **Freedman VA, Crimmins E, Schoeni RF, et al.** Resolving inconsistencies in trends in old-age disability: report from a technical working group. *Demography*. 2004;41(3):417-41.
6. **Hogan DB, MacKnight C, Bergman H.** Models, definitions, and criteria of frailty. *Aging Clin Exp Res*. 2003;15(3 Suppl):1-29.
7. **Strawbridge WJ, Shema SJ, Balfour JL, Higby HR, Kaplan GA.** Antecedents of frailty over three decades in an older cohort. *J Gerontol B Psychol Sci Soc Sci*. 1998;53(1):S9-16.
8. **Fried LP, Tangen CM, Walston J, et al.** Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001;56(3):M146-56.
9. **Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G.** Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *J Gerontol A Biol Sci Med Sci*. 2004;59(3):255-63.
10. **Fried LP, Borhani NO, Enright P, et al.** The Cardiovascular Health Study: design and rationale. *Ann Epidemiol*. 1991;1(3):263-76.
11. **Tell GS, Fried LP, Hermanson B, Manolio TA, Newman AB, Borhani NO.** Recruitment of adults 65 years and older as participants in the Cardiovascular Health Study. *Ann Epidemiol*. 1993;3(4):358-66.
12. **Saliba D, Elliott M, Rubenstein LZ, et al.** The Vulnerable Elders Survey: a tool for identifying vulnerable older people in the community. *J Am Geriatr Soc*. 2001;49(12):1691-9.
13. **Juster FT, Suzman R.** An Overview of the Health and Retirement Study. *Journal of Human Resources*. 1995;30(Supplement):S7-S56.
14. **Soldo BJ, Hurd MD, Rodgers WL, Wallace RB.** Asset and Health Dynamics Among the Oldest Old: an overview of the AHEAD Study. *J Gerontol B Psychol Sci Soc Sci*. 1997;52 Spec No:1-20.
15. **Cigolle CT, Langa KM, Kabeto MU, Tian Z, Blaum CS.** Geriatric conditions and disability: the Health and Retirement Study. *Ann Intern Med*. 2007;147(3):156-64.
16. **Folstein MF, Folstein SE, McHugh PR.** "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12(3):189-98.
17. **Blaum CS, Ofstedal MB, Liang J.** Low cognitive performance, comorbid disease, and task-specific disability: findings from a nationally representative survey. *J Gerontol A Biol Sci Med Sci*. 2002;57(8):M523-31.
18. **Herzog AR, Wallace RB.** Measures of cognitive functioning in the AHEAD Study. *J Gerontol B Psychol Sci Soc Sci*. 1997;52 Spec No:37-48.