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Authors

Lee, David R
Kawas, Claudia H
Gibbs, Lisa
[et al.](#)

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Prevalence of Frailty and Factors Associated with Frailty in Individuals Aged 90 and Older: The 90+ Study

David R. Lee, MD, MBA, Claudia H. Kawas, MD,^{†‡} Lisa Gibbs, MD,[§] and María M. Corrada, ScM, ScD^{†||}

OBJECTIVES: To evaluate the prevalence of frailty and examine factors associated with frailty in the 90+ Study.

DESIGN: Cross-sectional.

SETTING: Population-based longitudinal study of people aged 90 and older.

PARTICIPANTS: 90+ Study participants (N = 824).

MEASUREMENTS: Participants were assessed at baseline for five components of frailty (low weight, weakness, exhaustion, slowness, low physical activity). Frailty status was defined as meeting the criteria for at least three of the five components of frailty. The prevalence of frailty in people aged 90 and older was estimated according to sex and age (90–94, ≥95). Logistic regression models were constructed to assess the relationship between the prevalence of frailty and sex, age, education level, living situation, and marital status.

RESULTS: This study estimated the overall prevalence of frailty in people aged 90 and older to be 28.0%. The overall prevalence of frailty was 24% in those aged 90 to 94 and 39.5% in those aged 95 and older. The prevalence of frailty was significantly associated with age in women but not men and with living with relatives or caregiver or in a group setting. Sex, education, and marital status were not significantly associated with frailty.

CONCLUSION: The prevalence of frailty was high in people aged 90 and older and continued to increase with age, particularly for women. As the number of people aged 90 and older continues to increase, it will be increasingly important to identify factors associated with frailty that may provide potential targets for the prevention of adverse health outcomes in this population. *J Am Geriatr Soc* 64:2257–2262, 2016.

Key words: prevalence; frailty; oldest-old; aged 90 and over

Frailty is a syndrome in older adults that is described as a decrease in physiological reserve with increasing susceptibility to undesirable health outcomes, including disability, hospitalization, and mortality.^{1,2} Although this syndrome is clinically important, there is no consensus on how to define it. Some studies define frailty using an index calculated from an accumulation of deficits, including sensory and functional impairments, comorbidities, cognitive functioning tests, and a depression scale.³ Other studies define frailty using phenotypic characteristics such as exhaustion, weight loss, low activity level, slow walking, and grip strength.² Regardless of methodology, the prevalence of frailty has been shown in many studies to increase with age, ranging from 10% to 27% in those aged 65 and older⁴ to an estimated 48% in those aged 85 and older.⁵

Few studies have evaluated frailty in people aged 90 and older because most studies categorize the oldest participants as aged 80 and older.⁶ People aged 90 and older are the fastest growing age group in the United States.^{7,8} Understanding frailty in this group is necessary to develop interventions that may reduce burden in this rapidly growing population. The aim of this study was to use the phenotypic criteria of frailty² to determine the prevalence of frailty in 90+ Study participants and to evaluate factors associated with frailty.

METHODS

Study Population

90+ Study participants are survivors from the Leisure World Cohort Study (LWCS), founded in 1981. The LWCS included the 14,000 residents of the Leisure World retirement community in Orange County, California. Beginning in 2003, individuals aged 90 and older from the LWCS were asked to join The 90+ Study and

From the *School of Medicine; [†]Department of Neurology; [‡]Department of Neurobiology and Behavior; [§]Division of Geriatric Medicine and Gerontology; and ^{||}Department of Epidemiology, University of California at Irvine, Irvine, California.

Address correspondence to María M. Corrada, ScM, ScD, 1513 Hewitt Hall, Irvine, CA 92697. E-mail: mcorrada@uci.edu

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continue to be added each year as they turn 90. The 90+ Study is a population-based longitudinal study that consists of participants who are mostly female and Caucasian, of middle to upper socioeconomic status, and well educated.⁹ This study evaluated frailty status at the first in-person visit, whether at home or in the clinic, from 2003 to 2012. Consent was obtained from all participants or their authorized representative, and the institutional review board of the University of California at Irvine approved all procedures.

Operationalization of Frailty

Frailty was evaluated using a phenotypic definition² with modifications (described below) to accommodate the data in The 90+ Study. Participants had to meet at least three of five possible criteria for frailty to be considered frail (low weight, weakness, exhaustion, slowness, low physical activity).²

Low Weight

Participants were asked if they had unintentionally lost at least 10 pounds in the past year. Body mass index (BMI), calculated using weight and height as kg/m^2 , was also evaluated because it was previously found to be associated with frailty.¹⁰ An answer of yes to the weight loss question or having a BMI of less than $20.0 \text{ kg}/\text{m}^2$ ¹¹ met the low-weight criterion.

Weakness

Weakness was determined according to grip strength using a dynamometer (Lafayette Hand Dynamometer, model 78010; Lafayette Instrument Company, Lafayette, IN) with the dominant hand based on the average of three trials and categorized on a scale from 0 to 4, with 0 representing inability to perform and 4 representing the highest sex-specific performance quartile based on previously established cutoff points.¹² Individuals who were unable to perform (0) or were in the lowest quartile (1) for grip strength met the weakness criteria.

Exhaustion

Exhaustion was measured using the Geriatric Depression Scale question “Do you feel full of energy?” (yes, no)¹³ and the question “How do you feel about your energy level most of the time?” (poor, fair, good, excellent). An answer of no to the first question or poor or fair to the second met the criteria for exhaustion.

Slowness

Participants walked 4 m along a defined path at their usual pace using any necessary aids such as canes or walkers. The time to complete the path was measured in seconds. Participants were scored based on performance, with 0 representing unable to perform and 1, 2, 3, and 4 representing respective sex-specific quartiles of performance.¹² Participants with a score of 0 or 1 for walk time met the frailty criteria for slowness.

Low Physical Activity

Participants completed two questionnaires about physical activity level. The first questionnaire estimated the number of minutes on an average weekday spent engaging in active activities such as swimming, biking, vigorous walking, dancing, and exercising. The second questionnaire asked about the frequency of five leisure activities, including being outside (walking and enjoying nature), going shopping, doing vigorous exercise, gardening indoors or outdoors, and traveling with at least one overnight stay. Participants scored each leisure activity from 0 to 5 (5 = daily or almost daily, 4 = a few times per week, 3 = a few times per month, 2 = approximately monthly, 1 = a few times per year, 0 = rarely or never). These scores were added together for a maximum total of 25. Participants were separated into sex-specific quartiles based on total score. Individuals with 0 minutes performing the active activities (first questionnaire) or in the lowest quartile of the leisure activities (second questionnaire) met the frailty criteria for low physical activity.

Determination of Frailty

Participants with three or more frailty criteria as defined above were classified as frail.² Individuals with two or fewer criteria were classified as nonfrail. Participants who were missing three or more criteria were excluded from this study.

Statistical Analysis

Characteristics of excluded and included participants were compared using chi-square tests. The prevalence of frailty was estimated according to sex and age categories (90–94, ≥ 95). A 95% confidence interval (CI) was computed using binominal methods for each sex and age category. Logistic regression models were used to assess the effects of sex, age, education, living situation, and marital status on prevalence of frailty. The effect of sex was assessed after adjusting for age, and the effect of age was assessed after adjusting for sex. The effects of education, living situation, and marital status were assessed after adjusting for sex and age. All analyses were conducted using SAS version 9.3 for Windows (SAS Institute, Inc., Cary, NC).

RESULTS

Study Sample

Of the 1,574 participants enrolled in The 90+ Study, 636 were excluded because they did not have in-person visits, and an additional 114 were excluded because they were missing three or more frailty components, leaving 824 participants for these analyses. Figure 1 shows a flowchart of participant inclusion.

Baseline characteristics of the 824 participants are shown in Table 1. The study sample was 72.1% female; 73.9% were aged 90 to 94; 74.0% had education levels beyond high school; 74.4% were widowed; and 48.8% were living alone, 30.9% with a relative or caregiver, and 20.3% in a group setting.

Of the excluded participants, 82.0% were female, 64.4% were aged 90 to 94, 64.4% had education levels beyond high school, 75.0% were widowed, and 53.4% lived in a group setting. Baseline characteristics of the excluded participants, many of whom were not seen in person, were compared with those of the 824 included participants. There was no significant difference in marital status ($P = .68$), but excluded participants were more likely to be female ($P < .001$), be older ($P < .001$), have a lower level of education ($P < .001$), and be living in a group setting ($P < .001$).

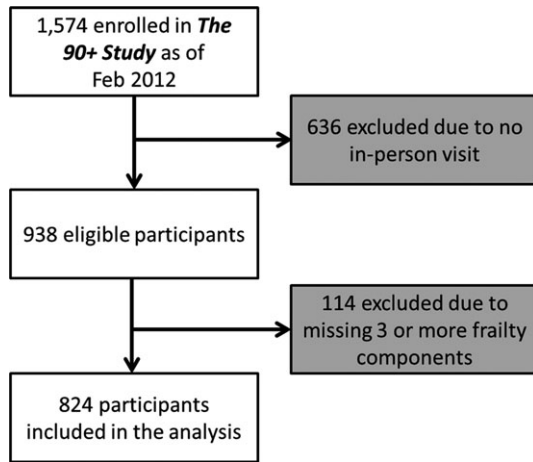


Figure 1. Flowchart of participants included in the analysis. Participants were excluded if they were not seen in person or were missing information on three or more frailty components.

Table 1. Baseline Participants Characteristics

Characteristic	Overall, N = 824	Men, n = 230	Women, n = 594
	n (%)		
Sex			
Male	27.9 (230)		
Female	72.1 (594)		
Age (median 93, range 90–106)			
90–94	73.9 (609)	79.1 (182)	71.9 (427)
≥95	26.1 (215)	20.9 (48)	28.1 (167)
Education^a			
≤High school	26.0 (213)	21.3 (49)	27.9 (164)
Vocational or college degree	53.0 (434)	45.2 (104)	56.0 (330)
>College	21.0 (172)	33.5 (77)	16.1 (95)
Living situation^b			
Alone	48.8 (402)	40.9 (94)	51.9 (308)
With relative or caregiver	30.9 (254)	46.5 (107)	24.8 (147)
Group setting	20.3 (167)	12.6 (29)	23.3 (138)
Marital status^c			
Married	16.1 (132)	41.9 (96)	6.1 (36)
Divorced, separated	3.9 (32)	1.8 (4)	4.7 (28)
Widowed	74.4 (610)	53.7 (123)	82.4 (487)
Never married	5.6 (46)	2.6 (6)	6.8 (40)

^aExcludes 5 women with missing education.

^bExcludes 1 woman with missing living situation.

^cExcludes 4 participants with missing marital status (1 man, 3 women).

Frequency of Frailty Criteria

Table 2 presents the distribution of the frailty criteria and the number of frailty components. Exhaustion was the most prevalent criteria (71.0%), followed by low physical activity (47.2%), weakness (35.9%), slowness (31.4%), and weight (11.6%). The majority of frail participants met three components of frailty; seven participants met all five components of frailty.

Prevalence of Frailty

In The 90+ Study, 231 participants met criteria for frailty, resulting in an overall prevalence of 28.0%. Table 3 presents the prevalence of frailty according to sex and age (90–94, ≥95). The overall prevalence was greater in those aged 95 and older (39.5%) than in those aged 90 to 94 (24.0%). The prevalence in men was estimated to be 21.4% of those aged 90 to 94 and 29.1% of those aged 95 and older; the prevalence in women was estimated to be 25.1% of those aged 90 to 94 and 42.5% of those aged 95 and older.

Table 2. Prevalence of Frailty Phenotype Criteria

Frailty Phenotype	Overall, N = 824	Men, n = 230	Women, n = 594
Frailty component, n/N (%)			
Low physical activity	389/824 (47.2)	92/230 (40.0)	297/594 (50.0)
Weight	71/613 (11.6)	17/179 (9.5)	54/434 (12.4)
Weakness	245/683 (35.9)	58/194 (30.0)	187/489 (38.2)
Slowness	244/776 (31.4)	61/219 (27.9)	183/557 (32.9)
Exhaustion	516/727 (71.0)	148/208 (71.2)	368/519 (70.9)
Number of frailty components, n (%)			
0	134 (16.3)	45 (19.6)	89 (15.0)
1	239 (29.0)	68 (29.6)	171 (28.8)
2	220 (26.7)	64 (27.8)	156 (26.2)
3	145 (17.6)	33 (14.3)	112 (18.9)
4	79 (9.6)	19 (8.2)	60 (10.1)
5	7 (0.8)	1 (0.4)	6 (1.0)

Table 3. Prevalence of Frailty According to Age at Baseline and Sex

Sex	90–94	≥95	Total
Overall			
Cases, n/N	146/609	85/215	231/824
Prevalence, % (95% CI)	24.0 (20.6–27.6)	39.5 (33.0–46.4)	28.0 (25.0–31.2)
Men			
Cases, n/N	39/182	14/48	53/230
Prevalence, % (95% CI)	21.4 (15.7–28.1)	29.1 (17.4–44.2)	23.0 (17.8–29.0)
Women			
Cases, n/N	107/427	71/167	178/594
Prevalence, % (95% CI)	25.1 (21.0–29.5)	42.5 (35.0–50.4)	30.0 (26.3–33.8)

CI = confidence interval.

Frailty and Associated Variables

Table 4 summarizes the results of the logistic regression analysis. After adjusting for variables as described in Methods, age and living situation were significantly associated with frailty. The prevalence of frailty was found to significantly increase with age after adjusting for sex (odds ratio (OR) = 2.0, $P < .001$). When viewed separately, women had a significant increase in prevalence of frailty with age (OR = 2.2, $P < .001$), whereas men did not (OR = 1.5, $P = .26$). Frailty was significantly higher in individuals living with relatives or a caregiver (OR = 2.7, $P < .001$) or in a group setting (OR = 3.6, $P < .001$) than in those living alone, after adjusting for age and sex. The prevalence of frailty was not significantly different in men and women after adjusting for age (OR = 1.4, $P = .09$). Although education was not significantly associated with frailty, there was a trend toward lower prevalence in women with higher levels of education (OR = 0.6, $P = .08$). Marital status was also not associated with frailty after adjusting for age and sex.

DISCUSSION

This study examined the prevalence of frailty and associated factors in a large population-based sample of participants aged 90 and older. The overall prevalence of frailty was 28.0%. The prevalence of frailty increased with age, particularly for women, and was associated with living with relatives or a caregiver and in a group setting. The overall prevalence of frailty was not associated with sex, education, or marital status.

Prevalence of Frailty

The prevalence of frailty estimated in this study approximates the upper limit for studies that include data for individuals aged 90 and older and use the phenotypic definition of frailty. Most previous studies have included participants aged 90 and older in the 85-and-older group and did not provide specific estimates for this age group. The range in prevalence seen in these studies (19.5–29.1%^{14–18}) may be related in part to the varying

inclusion and exclusion criteria, participant demographic characteristics, age categories used, and different operationalization of frailty.⁶ Inclusion or exclusion of individuals in care facilities^{2,14,15,17,18} could have also contributed to differences in prevalence, because exclusion of institutionalized participants with disabilities and physical limitations can lead to underestimation of the prevalence of frailty.¹⁹

The two studies that included a 90-and-older group and used the phenotypic definition of frailty reported prevalence values that differed substantially (23.1%,² 65.0%²⁰). These studies had considerably fewer people aged 90 and older ($n = 39$ and $n = 64$, respectively). Therefore, the prevalence of frailty in the current study may be a more-precise estimate for individuals aged 90 and older. To the knowledge of the authors of the current study, no other study with a phenotypic definition of frailty further classifies the prevalence of frailty into groups aged 90 and older. Thus, this study provides the first estimate for the burden of frailty in those aged 95 and older.

Frailty Syndrome and Associated Variables

This study found an association between frailty prevalence, age, and living situation, similar to studies in younger elderly populations.^{2,11,16,18,20,21} Men and women aged 90 to 94 had similar frailty prevalence estimates (women, 25.1%; men 21.4%), but the prevalence of frailty in women aged 95 and older was twice that of women aged 90 to 94; the increase was smaller for men. Differential mortality risk for oldest frail men and women could explain, in part, the difference in prevalence rates for men and women in this study. One study examining frailty in individuals aged 90 and older over 3 years found that men had higher mortality than women with the same level of frailty.²² Thus, the apparent increase in the prevalence of frailty with age for women may be in part a result of frail women outliving frail men.

Similar to other studies, living with others in a group setting or with a caregiver or relative was associated with frailty.⁶ It is likely that this is because frail individuals need more assistance with activities of daily living and

Table 4. Association Between Frailty and Baseline Characteristics

Variable	Overall, N = 824	Men, n = 230	Women, n = 594
	Odds Ratio (95% Confidence Interval) P-Value		
Female ^a	1.4 (1.0–1.9) .09		
Aged $\geq 95^b$	2.0 (1.5–2.8) <.001	1.5 (0.7–3.0) .26	2.2 (1.5–3.2) <.001
Education (reference \leq high school) ^c			
Vocational or college degree	0.7 (0.5–1.0) .09	0.6 (0.3–1.3) .16	0.8 (0.5–1.2) .24
>College	0.6 (0.4–1.0) .10	0.6 (0.3–1.4) .25	0.6 (0.3–1.1) .08
Living situation (reference alone) ^c			
With relative or caregiver	2.7 (1.8–4.0) <.001	1.5 (0.7–3.0) .28	3.5 (2.3–5.5) <.001
Group setting	3.6 (2.4–5.5) <.001	4.8 (1.9–12.0) <.001	3.4 (2.1–5.4) <.001
Marital status (reference married) ^c			
Divorced, separated	1.0 (0.4–2.4) .95	1.2 (0.1–12.6) .86	0.9 (0.3–2.8) .82
Widowed	1.1 (0.7–1.9) .63	1.2 (0.6–2.3) .58	1.0 (0.5–2.3) .94
Never married	1.8 (0.9–4.0) .12	1.9 (0.3–11.3) .47	1.7 (0.6–4.6) .30

From logistic regression, adjusting for ^aage, ^bsex, and ^csex and age.

caring for themselves²³ rather than the living situation leading to a frail state.

Contrary to previous studies,^{2,11,16,18,20,21} this study did not find sex, education, or marital status to be associated with frailty prevalence. The study had proportionally fewer participants who were male, had low education, or were married, which could have affected the ability to assess these factors. Additionally, most previous studies included younger individuals, making it possible that these factors are associated with frailty in younger elderly populations and are no longer associated with frailty in people aged 90 and older. Further research is necessary to determine whether these associations differ in individuals aged 90 and older.

Strengths of this study include the large number of participants aged 90 and older used to estimate the prevalence of frailty, which provides a stable estimation of prevalence. This is the largest study to use the phenotypic definition of frailty to analyze prevalence in this age group, allowing further analysis according to age- and sex-specific groups. The incorporation of home and nursing home visits also allowed participants with physical limitations, who are more likely to be frail, to be included in this study.¹⁹

This study has some limitations. The excluded participants were not seen in person or were missing information. Excluded participants were more likely to be living in a group setting, which is associated with frailty. The excluded participants were also significantly older, primarily female, and had lower levels of education, which are factors that could be related to frailty status. These findings suggest that the prevalence of frailty in the current study could be an underestimation. Additionally, the study cohort consisted primarily of women who were ethnically Caucasian and had high education levels. These features could limit the generalizability of this study, although according to the U.S. Census Bureau, the demographic characteristics of U.S. individuals aged 90 and older are similar to those of the participants in this study. In the United States, 76% of people aged 90 and older are women, 88% are white, and 84% are widowed.⁸ A difference between Census data and demographic characteristics in this study is that 72% of people aged 90 and older in the U.S. Census had a high school level education or less,⁸ whereas 74% of the participants in this study had more than high school level education. Hence, on most parameters other than education, this study cohort was similar to the general population of people aged 90 and older in the United States. Future studies in individuals aged 90 and older should evaluate frailty in relation to cognitive impairment, because it has been shown to be an important factor associated with frailty,¹¹ and should evaluate the prefrail group, because most interventions focus on preventing transitions between prefrailty and frailty or reversing prefrail status.²⁴

The 90+ Study is one of the only studies to estimate the prevalence of frailty in a large group of people aged 90 and older. This study demonstrates that the prevalence of frailty is high in this age group; continues to rise with age, particularly in women; and is associated with living situation. People aged 90 and older are the fastest-growing segment of the U.S. population, and the number of individuals in this age group will continue to rise in the years to come.⁸

Understanding frailty in individuals aged 90 and older will help elucidate risk factors and potential interventions to reduce frailty and adverse health outcomes and, ultimately, reduce costs for the care of these individuals.²⁵

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Conflict of Interest: None.

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Author Contributions: Lee: drafting the manuscript. Kawas, Gibbs, Corrada: critical revision. All authors: approval of final version.

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