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Frailty Versus Stopping Elderly Accidents, Deaths and Injuries Initiative Fall Risk Score: Ability to Predict Future Falls

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Abstract

Objectives—To compare the ability of frailty status to predict fall risk with that of community fall risk screening tools.

Setting—National Health and Aging Trend Study (NHATS) 2011

Participants—Individuals aged 65 and older (N=7,392).

Measurements—Fall risk was defined according to the Stopping Elderly Accidents, Deaths and Injuries (STEADI) initiative. Frailty was defined as exhaustion, weight loss, low activity, slow gait speed, and weak grip strength. Robust was defined as meeting 0 criteria, prefrailty as 1 or 2 criteria, and frailty as 3 or more criteria. Falls were self-reported and ascertained using NHATS subsequent rounds (2012–2015). We compared the ability of frailty to predict future falls with that of STEADI score, adjusting for age, race, sex, education, comorbidities, hearing and vision impairment, and disability.

Results—Of the 7,392 participants (58.5% female), there 3,545 (48.0%) were classified as being at low risk of falling, 2,966 (40.1%) as being at moderate risk, and 881 (11.9%) as being at high risk. The adjusted risk of falling over the 4 subsequent years was 2.5 times as great for the moderate-risk group (hazard ratio (HR)=2.50, 95% confidence interval (CI)=2.16–2.89) and almost 4 times as great (HR=3.79, 95% CI=2.76–5.21) for the high-risk group as for the low-risk group. Risk of falling was greater for those who were prefrail (HR=1.22, 95% CI=1.05–1.41) and frail (HR=1.12, 95% CI=0.87–1.44) than for those who were robust.

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Arthur Contributions: All authors: study concept and design, data analysis and interpretation, preparation of manuscript.

Conclusion—STEADI score is a strong predictor of future falls. Addition of frailty status does not improve the ability of the STEADI measure to predict future falls.

Keywords

falls; frailty; pre-frailty

Preventing falls is a public health priority because falls are associated with greater risk of mortality, poor function, loss of independence, and greater use of long-term care facilities [1–3]. Falls and their consequences are expected to increase as the population ages, so efforts to identify those at high risk of future falls is of great importance[4]. The American Geriatrics Society recommends an annual fall risk assessment for individuals aged 65 and older using an algorithm that includes initial screening for falls followed by an evaluation of gait and balance and an assessment for potential benefit from a list of multicomponent interventions[5]. Existing fall risk assessments are assessed subjectively, require training or expertise in geriatric principles, or are targeted to the inpatient setting[6–12]. Despite the availability of evidence-based guidelines, there are implementation barriers for providers, such as limited time and insufficient knowledge regarding fall assessment and prevention[13]. The Centers for Disease Control and Prevention (CDC) developed Stopping Elderly Accidents, Death and Injuries (STEADI), which provides tools and techniques that focus on falls for primary care practitioners and educational material for patients[14]. STEADI includes an adapted evidenced-based gait and balance assessment algorithm that simplifies and streamlines the fall risk assessment in stratifying individuals into fall risk categories.

A meta-analysis examining community-dwelling individuals demonstrated frailty to be a significant predictor of future falls, whereas prefrailty's association was less definite[15]. Although the frailty phenotype was never originally conceptualized or designed to screen for falls, this meta-analysis demonstrates it as a potential screening tool for future fall prediction in this population subset. Studies evaluating frailty's ability to predict future falls have been performed within the confines of a fall history, and many studies mentioned in this meta-analysis did not have clear explanation as to how falls were reported. One study assessed frailty and fall risk performance testing using sensor data for 3 physical assessments in 124 community-dwelling adults. The results suggested that the joint use of these assessments strengthened the ability to classify participants into fall risk and frailty classification[16], but the predictive value of using fall risk and frailty in tandem to predict future falls was not evaluated.

Reliably characterizing fall risk and frailty in a clinical setting has been challenging[17–19]. A tool such as STEADI may have potential to reduce future falls by nearly 25%, but there is a lack of data on its use in healthcare practice settings [14, 20]. The CDC is working with state health departments to show proof of concept[14], but we are unaware of any studies demonstrating the accuracy of this tool for fall risk prediction. In addition, although we know that frailty has been associated with falls, it is not clear whether frailty can serve as consistent, valid predictor of future falls alone or in conjunction with a tool such as STEADI. The purpose of our study was to evaluate the predictive value of STEADI and frailty's ability to predict future falls and to determine whether these scales used in tandem could incrementally maximize the predictive value of future falls.

Methods

Study Design and Participants

We identified participants age 65 and older interviewed in the National Health and Aging Trend Study (NHATS) at baseline (2011). NHATS is a nationally representative cohort of older adults in the United States that oversamples non-Hispanic blacks and individuals aged 90 and older to investigate trends in late-life functioning[21]. NHATS focuses on physical function using standardized assessments rather than self-reported data alone[21]. Round 1 data included 8,245 Medicare beneficiaries randomly subsampled from the Medicare enrollment database who were living in the contiguous United States. Trained research staff assessed cognitive and physical function in person in participants' homes.[22] We excluded nursing home residents (n=636) and others who had insufficient data on critical study variables (n= 217), leaving a final sample size of 7,392 participants. The Committee for the Protection of Human Subjects at Dartmouth College exempted this study from review because of the de-identified nature of the data.

Study Variables

Frailty—We defined frailty according to 5 phenotypic criteria derived from the Cardiovascular Health Study [23] and adapted them based on available data as noted below in parentheses: unintentional weight loss of more than 10 pounds in a year (weight loss of 10 pounds in the last year without trying); self-reported exhaustion (easily exhausted, limiting activities); weakness, defined according to grip strength (grip strength using maximum dominant hand grip strength over 2 trials as ≤ 20th percentile within 8 sex-by–body mass index (BMI) categories); slow walking speed (gait speed using the first of 2 usual-pace walking trials as being ≤ 20th percentile of the weighted population distribution within 4 sex-by-height categories); and low physical activity (ever go walking or do vigorous activities). Participants who met 0 of the criteria were classified as robust, those who met 1 or 2 as prefrail, and those who met 3 or more as frail.

Fall Risk—Fall risk was assessed using an adapted version of the STEADI algorithm [14] based on our available data (Figure 1). Participants were labeled as being at low risk of falls if they answered “no” to all questions: “Have you fallen in the last year?” “Are you worried about falling down?” “Do you feel unsafe standing or walking?” If they answered “yes” to at least 1 question, they were further stratified according to physical functioning test scores. We used the Four-Stage Balance Test and Five-Time Sit to Stand (FTSTS) Test to evaluate function. According to the Four-Stage Balance Test outlined by the CDC, an older adult who is unable to hold a tandem stance for at least 10 seconds is at greater risk of falling[14]. The FTSTS Test evaluates lower extremity strength and is associated with dysfunction in balance and mobility[24]. Completion of fewer than 5 repetitions of sit to stand in 15 seconds is associated with greater risk of falling[25]. If the participant completed the Four Stage Balance and the FTSTS tests, they were stratified as being at low risk of falls. If they were unable to perform either of these tests, they were further stratified based on their response to the questions: “Have you have multiple falls in the last year?” “Have you broken a hip since age 50?” If they answered “yes” to either question, they were categorized as being at high risk, and an answer of “no” to both questions would categorize them as being at intermediate risk. We considered participants who were ineligible for physical assessments because of pain, recent surgery, or lack of facilities to be missing respective physical measures.

Outcomes—Future falls were ascertained as at least 1 fall over 4 annual follow-up rounds (2012–2015) using 2011 data for baseline fall and frailty assessment.

Covariates—Demographic variables included self-reported age, sex, and education. We also assessed smoking status, BMI (kg/m^2), and race and ethnicity. Age was categorized in 5-year increments from 65 to 90 and 90 and older. Participants were classified as ever smokers if they reported ever regularly smoking at least 1 cigarette per day. Height and weight were self-reported in feet and pounds. We categorized race and ethnicity as non-Hispanic white, non-Hispanic black, Hispanic, and Non-Hispanic other.

Chronic health conditions such as heart disease, hypertension, arthritis, osteoporosis, diabetes mellitus, lung disease, probable dementia, stroke, non-skin cancer, and hearing and vision impairment were based on a self-reported questionnaire. Participants were asked a number of questions regarding limitations in basic activities of daily living (ADLs: bathing, dressing, eating, toileting, household activities) and instrumental activities of daily living (IADLs: doing laundry, preparing meals, shopping for groceries or personal items, managing medications, paying bills, banking). NHATS also included a mobility assessment that evaluated a participant's ability to leave home, get around inside the home, and get out of bed with or without device or assistance. Based on the above, we calculated a disability score[26]. A summary score was created for overall functional ability, with higher scores representing greater need for assistance.

Statistical Analysis

Continuous variables are presented as means±standard deviations and counts and percentages. We estimated the distribution of demographic and health-related variables in the analytical sample and compared these characteristics across fall risk categories using chi-square tests for categorical variables and analysis of variance for continuous variables. The distribution of frailty components and frailty status across fall risk categories were evaluated similarly. The primary outcome was fall risk categorization and future falls. Logistic regression models were used to estimate the adjusted associations between frailty status, fall risk categories, and fall occurrence. In 4 successive logistic regression models, falls (1= fell at least once, 0=did not fall) were regressed on the primary predictors of fall risk category and frailty status and adjusted for differing sets of potential confounders; Model 1 was unadjusted, Model 2 was adjusted for sociodemographic factors (age, race and ethnicity, sex, education); Model 3 was additionally adjusted for chronic health conditions (heart disease, hypertension, arthritis, osteoporosis, diabetes mellitus, lung disease, stroke, dementia, cancer); Model 4 was additionally adjusted for hearing and visual impairment. Fully adjusted logistic regression models were used to calculate the marginal probability of falling within each frailty level and fall risk category. All analyses were performed using STATA version 14.1 (Stata Corp., College Station, TX). P<.05 was considered statistically significant.

Results

The 7,392 participants had a mean BMI of 27.4±5.7 kg/m^2, and 58.5% were female. The majority of the participants were non-Hispanic white (Table 1). Based on the STEADI criteria 5,011 (67.8%) were classified as being at low fall risk, 1,500 (20.3%) at moderate risk, and 881 (11.9%) at high risk, based on STEADI classification. Participants at high fall risk were more likely to be female and older and have more comorbidities and greater functional limitation. Factors such as vision impairment, hearing impairment, and living alone were significantly more prevalent in those at high fall risk; smoking was not shown to be related to fall risk.

The odds of experiencing at least one fall in the 4 years after baseline were assessed according to frailty and fall risk status (Supplementary Table S1). Generally, low risk of falls at baseline was associated with lower degrees of frailty, whereas those at high risk of falls based on STEADI were more predominantly classified as frail.

The adjusted risk of falling over the 4 subsequent years (Table 2) was greater for the moderate-(HR=1.76, 95% CI=1.49–2.09) and high-(HR=2.62, 95% CI=1.97–3.47) risk STEADI groups than for the low-risk group and for those who were prefrail (HR=1.34, 95% CI=1.16–1.55) and frail (HR=1.20, 95% CI=0.94–1.54) than for those who were not. When stratifying participants according to STEADI categorization and frailty status, greater STEADI fall risk predicted greater likelihood of falling, overall and within each level of frailty, but frailty status, although a significant predictor of falls alone, did not significantly improve prediction of subsequent falls within given levels of STEADI fall risk (Figure 2).

Discussion

STEADI and frailty have predictive capacity for future falls. STEADI had a much stronger predictive value than frailty in this large, nationally representative, older adult cohort. Although the association and predictive validity of frailty was significant, it was not additive to STEADI's fall prediction potential. This study provides evidence for busy outpatient care providers that STEADI alone is a clear, validated algorithm that can be used in lieu of frailty assessments if the goal is fall risk prediction. STEADI is more than a fall risk algorithm; it also includes resources for providers and patients to reduce the risk of outpatient falls. Some of STEADI's strengths over other fall risk tools are its objectives of following the U.S. and British practice guidelines[5] closely and addressing falls prevention in individuals at all levels of risk. STEADI is a broader screening assessment than most other ambulatory fall risk assessments, with fewer subjective elements that may reduce predictive accuracy. The commonly used Berg Balance Scale, for instance, was not useful in its ability to predict falls alone and was best used in conjunction with other fall risk tests because of great variation in accuracy[27]. Our findings have considerable importance in clinical practice, where one goal is to reduce provider burden by using the fewest assessments while maximizing clinically relevant information.

Although we demonstrated STEADI to be a valid predictive tool, evidence regarding its implementation is limited. A trial of 416 participants examined the potential ease of inserting STEADI into an electronic medical record, the feasibility of educating providers and support staff, and the strategies needed to address work flow successfully[28]. STEADI may be a pragmatic way to identify and intervene in all individuals at risk of falling, but future studies should be conducted to evaluate whether it can be implemented in busy clinical settings on a larger scale.

Our study had a number of strengths, including large sample size and objective measures of gait speed, balance, mobility, and strength assessment, which improved our ability to classify participants accurately according to frailty and fall risk. We needed to modify the STEADI tool to the data available. STEADI suggests the Timed Up and Go test in addition to strength and balance testing, but this information was unavailable in the dataset, and other means of evaluating gait such as gait speed would have conflicted with our frailty assessment. Other than physical assessment measures, all participant data were by self-report. STEADI further stratifies individuals based on injury, but because of limitations in the available data, we categorized injury based only on a history of hip fracture. Other injuries that were acquired from past falls could have stratified some participants differently between the moderate and high fall risk groups.

The results of this analysis provide empirical evidence of the predictive validity of STEADI as a fall risk assessment tool in a large, nationally representative elderly cohort. We were also able to demonstrate that, although frailty has some predictive ability for future falls, it is not nearly as good as STEADI in achieving this purpose. We were also able to show the limited utility of classifying participants according to frailty and STEADI stratification if the goal is to predict future falls. We demonstrated that knowing frailty status does not add any greater predictive value over STEADI classification alone. Future studies are needed to confirm this relationship, but our findings offer the first steps in demonstrating the validity of a new, potentially useful fall risk assessment tool and clarifying frailty's role in fall prediction in outpatient practice.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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References

1. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. J Am Geriatr Soc. 1986; 34:119–126. [PubMed: 3944402]
2. Rubenstein LZ, Josephson KR, Robbins AS. Falls in the nursing home. Ann Intern Med. 1994; 121:442–451. [PubMed: 8053619]
3. Sterling DA, O'Connor JA, Bonadies J. Geriatric falls: Injury severity is high and disproportionate to mechanism. J Trauma. 2001; 50:116–119. [PubMed: 11231681]
4. Guideline for the prevention of falls in older persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. J Am Geriatr Soc. 2001; 49:664–672. [PubMed: 11380764]
5. Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. J Am Geriatr Soc. 2011; 59:148–157. [PubMed: 21226685]
6. Godi M, Franchignoni F, Caligari M, Giordano A, Turcato AM, Nardone A. Comparison of reliability, validity, and responsiveness of the mini-BESTest and Berg Balance Scale in patients with balance disorders. Phys Ther. 2013; 93:158–167. [PubMed: 23023812]
7. Cleary K, Skornyakov E. Predicting falls in community dwelling older adults using the Activities-specific Balance Confidence Scale. Arch Gerontol Geriatr. 2017; 72:142–145. [PubMed: 28633057]
8. Beninato M, Fernandes A, Plummer LS. Minimal clinically important difference of the functional gait assessment in older adults. Phys Ther. 2014; 94:1594–1603. [PubMed: 24947198]
9. Downs S, Marquez J, Chiarelli P. The Berg Balance Scale has high intra- and inter-rater reliability but absolute reliability varies across the scale: A systematic review. J Physiother. 2013; 59:93–99. [PubMed: 23663794]
10. Sardo PM, Simoes CS, Alvarelhao JJ, Simoes JF, Melo EM. Fall risk assessment: retrospective analysis of Morse Fall Scale scores in Portuguese hospitalized adult patients. Appl Nurs Res. 2016; 31:34–40. [PubMed: 27397816]
11. Hendrich AL, Bender PS, Nyhuis A. Validation of the Hendrich II Fall Risk Model: A large concurrent case/control study of hospitalized patients. Appl Nurs Res. 2003; 16:9–21. [PubMed: 12624858]
12. Hnizdo S, Archuleta RA, Taylor B, Kim SC. Validity and reliability of the modified John Hopkins Fall Risk Assessment Tool for elderly patients in home health care. Geriatr Nurs. 2013; 34:423–427. [PubMed: 23816376]
13. Chou WC, Tinetti ME, King MB, Irwin K, Fortinsky RH. Perceptions of physicians on the barriers and facilitators to integrating fall risk evaluation and management into practice. J Gen Intern Med. 2006; 21:117–122. [PubMed: 16336618]
14. Stevens JA, Phelan EA. Development of STEADI: A fall prevention resource for health care providers. Health Promot Pract. 2013; 14:706–714. [PubMed: 23159993]
15. Kojima G. Frailty as a predictor of future falls among community-dwelling older people: A systematic review and meta-analysis. J Am Med Dir Assoc. 2015; 16:1027–1033. [PubMed: 26255098]
16. Greene BR, Doheny EP, Kenny RA, Caulfield B. Classification of frailty and falls history using a combination of sensor-based mobility assessments. Physiol Meas. 2014; 35:2053–2066. [PubMed: 25237821]
17. Lawson B, Sampalli T, Wood S, et al. Evaluating the implementation and feasibility of a web-based tool to support timely identification and care for the frail population in primary healthcare settings. Int J Health Policy Manag. 2017; 6:377–382. [PubMed: 28812833]
18. Cesari M, Marzetti E, Calvani R, et al. The need of operational paradigms for frailty in older persons: The SPRINTT project. Aging Clin Exp Res. 2017; 29:3–10. [PubMed: 28155179]

19. Fougere B, Oustric S, Delrieu J, et al. Implementing Assessment of cognitive function and frailty into primary care: Data from Frailty and Alzheimer disease prevention into Primary care (FAP) Study Pilot. J Am Med Dir Assoc. 2017; 18:47–52. [PubMed: 27650669]
20. Houry D, Florence C, Baldwin G, Stevens J, McClure R. The CDC Injury Center's response to the growing public health problem of falls among older adults. Am J Lifestyle Med. 2016; 10
21. Montaquila, J., Freedman, VA., Kasper, JD. NHATS Technical Paper #2. Vol. 2017. Baltimore: Johns Hopkins University School of Public Health; 2012. National Health and Aging Trends Study Development of Round 1 Survey Weights.
22. Kasper JD, Freedman VA. Findings from the 1st round of the National Health and Aging Trends Study (NHATS): Introduction to a special issue. J Gerontol B Psychol Sci Soc Sci. 2014; 69B(1):S1–S7.
23. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: Evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001; 56A:M146–M156.
24. Whitney SL, Wrisley DM, Marchetti GF, Gee MA, Redfern MS, Furman JM. Clinical measurement of sit-to-stand performance in people with balance disorders: Validity of data for the Five-Times-Sit-to-Stand Test. Phys Ther. 2005; 85:1034–1045. [PubMed: 16180952]
25. Buatois S, Miljkovic D, Manckoundia P, et al. Five times sit to stand test is a predictor of recurrent falls in healthy community-living subjects aged 65 and older. J Am Geriatr Soc. 2008; 56:1575–1577. [PubMed: 18808608]
26. Bandeen-Roche K, Seplaki CL, Huang J, et al. Frailty in older adults: A nationally representative profile in the United States. J Gerontol A Biol Sci Med Sci. 2015; 70A:1427–1434.
27. Neuls PD, Clark TL, Van Heuklon NC, et al. Usefulness of the Berg Balance Scale to predict falls in the elderly. J Geriatr Phys Ther. 2011; 34:3–10. [PubMed: 21937886]
28. Casey CM, Parker EM, Winkler G, Liu X, Lambert GH, Eckstrom E. Lessons learned from implementing CDC's STEADI falls prevention algorithm in primary care. Gerontologist. 2016 Apr 29. Epub ahead of print.

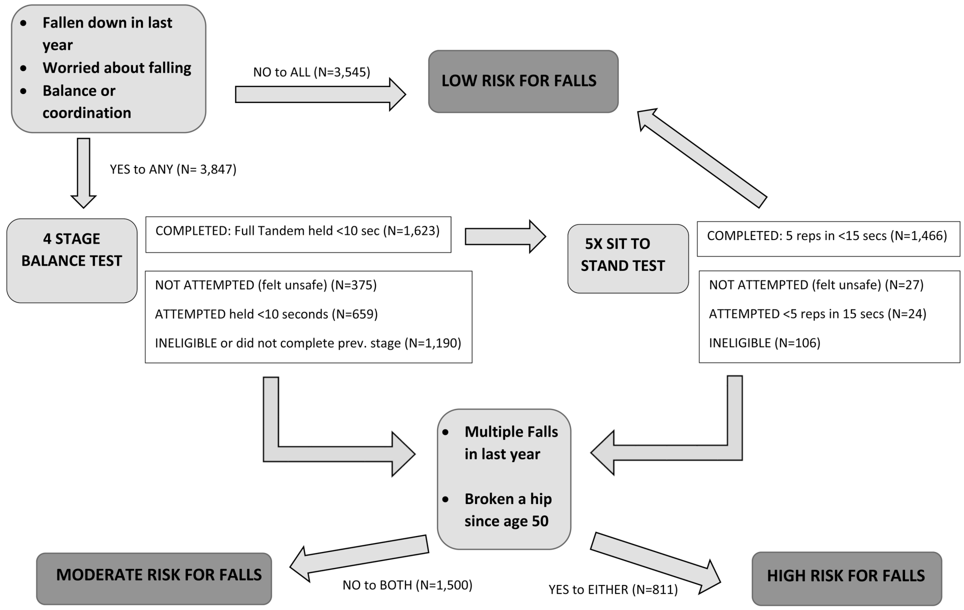

Figure 1.

Adapted Stopping Elderly Accidents, Deaths and Injuries algorithm demonstrating number of participants stratified into three fall risk categories (low, moderate, high).

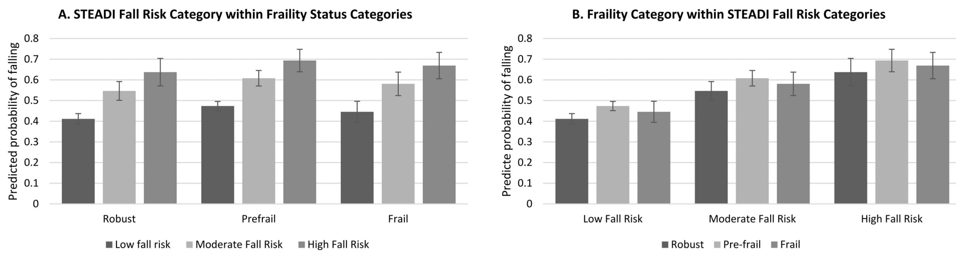

Figure 2.

Predicted probability of falling over subsequent 4 years according to frailty status and Stopping Elderly Accidents, Deaths and Injuries (STEADI) initiative. Frailty status defined according to the Fried phenotypic model[23] as: frail, ≥ 3 criteria, prefrail; 1–2 criteria; robust, 0 criteria. Fall risk defined according to Centers for Disease Control and Prevention STEADI initiative, Preventing Falls in Older Patients—A Provider Tool Kit.[14] Number of falls defined as answer of “yes” to the question, “Have you fallen in the last 12 months?” in the succeeding four rounds of longitudinal data collection (2012–2015 National Health and Aging Trends Study). Answering “no” in all four subsequent rounds=0. Answering “yes” in at least one of the four subsequent rounds, ≥1. Bars denote 95% confidence intervals.

Table 1

Baseline Characteristics of Study Participants According to Fall Risk: National Health and Aging Trends Study (NHATS) 2011

Characteristic	Total, N=7,392	Low Risk, n=5,011	Moderate Risk, n=1,500	High Risk, n=881	P-Value
Age, n (%)					<.001
65–69	1,373 (18.6)	1,157 (23.1)	143 (9.5)	73 (8.3)	
70–74	1,534 (20.8)	1,225 (24.5)	195(13.0)	114 (12.9)	
75–79	1,472 (19.9)	1,042 (20.8)	284 (18.9)	146 (16.6)	
80–84	1,463 (19.8)	876 (17.5)	368 (24.5)	219 (24.9)	
85–89	921 (12.5)	472 (9.4)	276 (18.4)	173 (19.6)	
≥90	629 (8.5)	239 (4.8)	234 (15.6)	156 (17.7)	
Female, n (%)	4,321 (58.5)	2,724 (54.4)	1,014 (67.6)	583 (66.2)	<.001
Race and ethnicity, n (%)					<.001
Non-Hispanic white	5,066 (68.8)	3,429 (68.7)	1,022 (68.2)	615 (69.9)	
Non-Hispanic black	1,635 (22.2)	1,126 (22.6)	333 (22.2)	176 (20.0)	
Non-Hispanic other	218 (3.0)	161 (3.2)	39 (2.6)	18 (2.1)	
Hispanic	448 (6.1)	272 (5.5)	105 (7.0)	71 (8.1)	
≥College degree, n (%)	1,868 (25.4)	1,441 (28.9)	282 (18.9)	145 (16.6)	<.001
Lives alone, n (%)	2393 (32.5)	1,478 (29.6)	617 (41.3)	298 (33.9)	<.001
Smoker, n (%)					.12
Never	3,647 (49.8)	2,425 (48.8)	778 (52.5)	444 (51.2)	
Former	3,104 (42.4)	2,129 (42.8)	605 (40.8)	370 (42.6)	
Current	574 (7.8)	420 (8.4)	100 (6.7)	54 (6.2)	
Body mass index, kg/m^2, mean±SD	27.4±5.7	27.3±5.4	27.9±6.3	26.9±6.2	<.001
Hearing, n (%)					<.001
No impairment	6,407 (86.7)	4,424 (88.3)	1,265 (84.3)	718 (81.5)	
Hearing aid	965 (13.1)	575 (11.5)	232 (15.5)	158 (17.9)	
Deaf	20 (0.3)	12 (0.2)	3 (0.2)	5 (0.6)	
Vision, n (%)					<.001
No impairment	2,823 (38.2)	2,003 (40.1)	516 (34.4)	304 (34.6)	
Corrective lenses	4,516 (61.2)	2,986 (59.6)	967 (64.5)	563 (64.1)	

Characteristic	Total, N=7,392	Low Risk, n=5,011	Moderate Risk, n=1,500	High Risk, n=881	P-Value
Blind	45 (0.6)	17 (0.3)	16 (1.1)	12 (1.4)	
Disability score, mean±SD	4.3±4.6	3.1±3.5	6.0±5.1	8.6±5.7	<.001
Number of comorbidities, mean±SD	2.6±1.6	2.3±1.5	3.1±1.5	3.7±1.7	<.001
Comorbidity, n (%)					
Heart disease	1,378 (18.7)	750 (15.0)	361 (24.1)	267 (30.4)	<.001
Hypertension	4,972 (67.3)	3,191 (63.7)	1,125 (75.2)	656 (74.6)	<.001
Arthritis	4,118 (55.8)	2,432 (48.6)	1,043 (69.6)	643 (73.1)	<.001
Osteoporosis	1,518 (20.6)	842 (16.8)	376 (25.3)	300 (34.1)	<.001
Diabetes	1,872 (25.3)	1,087 (21.7)	463 (30.9)	322 (36.6)	<.001
Lung disease	1,124 (15.2)	637 (12.7)	273 (18.2)	214 (24.3)	<.001
Stroke	873 (11.8)	403 (8.0)	255 (17.0)	215 (24.5)	<.001
Dementia (probable)	442 (6.0)	167 (3.3)	118 (7.9)	157 (17.9)	<.001
Non-skin cancer	1,905 (25.8)	1,247 (24.9)	408 (27.2)	250 (28.4)	<.001
Frailty status[a]					
Robust	2,621 (35.4)	2,341 (46.7)	204 (13.6)	76 (8.6)	<.001
Prefrail	3,794 (51.3)	2,376 (47.4)	905 (60.3)	513 (58.2)	<.001
Frail	977 (13.2)	294 (5.9)	391 (26.1)	292 (33.1)	<.001

Analysis of unweighted data from the NHATS.

Fall risk defined according to Centers for Disease Control and Prevention Stopping Elderly Accidents, Deaths and Injuries initiative, Preventing Falls in Older Patients—A Provider Tool Kit[14]

[a]Fried phenotypic model: frail, ≥ 3 criteria; prefrail, 1–2 criteria; robust, 0 criteria. [23]
SD=standard deviation.

Table 2

Odds of Falling for Stopping Elderly Accidents, Deaths and Injuries Fall Risk Groups and Frailty Categories in 4 Years After Initial Stratification

	Model 1	Model 2	Model 3	Model 4
	Odds Ratio (95% Confidence Interval)			
Fall risk (reference low)				
Moderate	1.93 (1.65–2.26)	1.89 (1.61–2.22)	1.77 (1.50–2.09)	1.76 (1.49–2.09)
High	3.02 (2.31–3.96)	2.97 (2.27–3.88)	2.63 (1.99–3.49)	2.62 (1.97–3.47)
Frailty status (reference robust)				
Prefrail	1.39 (1.22–1.60)	1.46 (1.27–1.67)	1.35 (1.17–1.54)	1.34 (1.16–1.55)
Frail	1.29 (1.02–1.63)	1.41 (1.13–1.77)	1.22 (0.97–1.53)	1.20 (0.94–1.54)

All models account for National Health and Aging Trends Study survey nonweighting and stratified sampling methods.

Variables including fall risk, frailty status, and number of falls defined in Table 3.

Model 1: Unadjusted.

Model 2: Adjusted for age, race/ethnicity, gender, education.

Model 3: Adjusted for Model 2 variables plus comorbidities including heart disease, hypertension, arthritis, osteoporosis, diabetes mellitus, lung disease, stroke, dementia, and non-skin cancer.

Model 4: Adjusted for Model 3 variables plus hearing impairment, vision impairment, disability score.