Predictors of Falls in Older Adults With and Without Dementia

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Abstract

INTRODUCTION: Persons living with, versus without, dementia (PLWD) have heightened fall-risk. Little is known about whether fall-risk factors differ by dementia status.

METHODS: Using the 2015 and 2016 National Health and Aging Trends Study we prospectively identified fall-risk factors over a 12-month period among community-living older adults 65 years with and without dementia (*n*=5,581).

RESULTS: Fall rates were higher among PLWD compared to persons without dementia (45.5% vs. 30.9%). In a multivariable model including sociodemographic, health, function, and environmental characteristics as predictors; vision impairment (OR: 2.22, 95% CI: 1.12–4.40), and living with a spouse vs. alone (OR: 2.43, 95% CI: 1.09–5.43) predicted falls among PLWD, but not among persons without dementia. History of previous falls predicted subsequent falls regardless of dementia status (OR: 6.20, 95% CI: 3.81–10.09, and OR: 2.92, 95% CI: 2.50–3.40, respectively).

DISCUSSION: Incorporating appropriate fall-risk factors could inform effective falls screening and prevention strategies for PLWD.

Keywords

accidental falls; dementia; fall risk factors; vision impairment; living arrangement

Falls cause millions of injuries in older adults each year, [1,2] and related medical spending by public and private payers in the United States has been estimated to approach $50 billion per year. [3] Falls are a significant public health concern for all older adults; [1,2] however, older adults living with dementia have twice the risk of falling and up to three times the risk of incurring serious fall-related injuries such as fractures. [4] Fall prevention among the estimated 5.8 million older Americans living with dementia[5] is of high priority because falls are a leading cause of hospitalization. [6] Moreover, when hospitalized, older adults living with dementia are more likely to incur high costs[7] and to experience negative

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health consequences such as delirium[8] and in-hospital falls[9] than those without dementia. Even minor fall-related injuries in persons with dementia are associated with discharge to a nursing home instead of returning home. [6]

Notably, very few studies to date have examined risk factors for falls among community-living persons with dementia (PLWD) in the United States; [10] a recent systematic review did not include any United States-based studies. [11] Knowledge of fall-risk factors is currently limited to small studies in Australia, Japan, and the United Kingdom. [12–15] These studies find that community-living older adults with dementia share some predictors of falls with general populations of older adults, including: history of falls, low falls efficacy (one's level of confidence of their ability to avoid falls), lower physical activity, use of a walking aid, gait and balance problems, medications, depression, and hypotension. [12–15] Exploratory studies provide preliminary evidence that other fall-risk factors such as brain lesions and other central nervous system disorders, [14,15] anxiety and caregiver distress[16] are more common among those living with dementia. [4,11]

It is well-established that fall risk is multifactorial[17] and the result of behavior[18] as well as aspects of the social and physical environment, [19–21] which interrelate with health and function. Most research on fall risk factors among older adults with dementia is focused on how ones' health (e.g., physiological, psychological, neurological) and function (e.g., sensory, motor, disability) characteristics relate to fall risk. [4,11–15] Less understood is whether social and physical aspects of the environment differentially contribute to fall risk among older adults with dementia. Existing research establishes that home environmental hazards are common among community-living older adults with dementia; [22] and that socioeconomic disadvantage of one's geographic area of residence is a contributor to dementia in the U.S. [23] Both of these factors have also been shown to be relevant to fall risk. [20] Examining a comprehensive set of potential fall-risk factors, including environmental factors, is therefore a necessary prerequisite for prevention efforts in this high risk population.

Differences in the relationship between social position and dementia, [23] patterns of caregiving, [24] and types of available services and supports [25] amplify the importance of specifically examining fall-risk factors within the U.S. Knowledge of multiple domains of fall-risk factors among older Americans with dementia could inform screening, caregiver education and support, and prevention strategies for this population —of which few have been trialed. Documentation of fall risk factors in the U.S. will also facilitate international comparisons. Therefore, to fill this gap, we conducted a longitudinal study to assess the contribution of multiple domains of risk factors to falls over the course of a 12-month period among older community-living adults in the US with and without dementia. We draw on a nationally representative dataset with comprehensive information on sociodemographic characteristics (used to measure social position which is relevant to falls and other older adult health outcomes in the U.S.), [21,26] health and function (e.g., health conditions, sensory impairments), and the environment (e.g., home and neighborhood), linked to measures of county- and census tract-level characteristics of the social and economic environment.

Methods

We used the 2015 (Round 5) and 2016 (Round 6) National Health and Aging Trends Study (NHATS), a population-based survey of health and disability trends and trajectories among older Americans (ages 65). The study design and procedures of NHATS have been described previously. [27] Briefly, the Medicare enrollment database is the sampling frame for the NHATS study and the study oversamples Black older adults and persons at older ages. In Round 1 (2011) an initial cohort was enrolled and in Round 5 (2015) the sample was replenished to replace those in the youngest age group (65–69) and those who had died or been lost to follow-up in older age groups. NHATS fields annual in-person interviews with participants or a proxy if the participant is unable to respond. During data collection a 2-hour survey is administered in a home visit to obtain information related to the domains of the NHATS Conceptual Framework. [28] In addition to potential sociodemographic, health and function predictors of falls, this study includes potential social and physical environmental predictors and draws on participants' geocoded place of residence, which is linked to characteristics at the census tract level from the American Community Survey. [29] We use census-tract level metrics to approximate individuals' neighborhoods, drawing on 5-year estimates that cover the years 2011 through 2015.

Participants

For this study, we included participants who participated in both the 2015 and 2016 rounds, who lived in community settings (defined as not a nursing home or other residential care facility), and who had information about their home environment. There were 8,334 NHATS participants who responded to the 2015 NHATS survey. We excluded 1,264 participants who lived in residential care facilities or nursing homes. Also excluded were 581 participants without information about their home environment in 2015, and 908 participants who did not complete the follow-up 2016 interview [298 were deceased, 426 refused the survey, 184 did not complete the survey for other reasons], yielding a final unweighted sample of 5,581 (Supplemental Table 1).

Measures

Falls.—In the follow-up round (2016) interviewers asked participants, "In the last month have you fallen down?" and provided a definition of "any fall, slip, or trip in which you lose your balance and land on the floor or ground or at a lower level." Those responding "no" were asked, "In the last 12 months have you fallen down?" Participants responding "yes" to either question were asked if they fell more than one time in the last 12 months. The primary outcome of this study is whether a participant reported one or more falls in the last 12 months given the significance of any fall in persons living with dementia – even falls resulting in minor injuries are consequential and associated with negative outcomes such as hospitalization. [6] Responses of having fallen from the baseline round (2015) are examined as a possible predictor of falls in the subsequent 12 months and referred to as *history of falling*. *Fear of falling* was measured by affirmative responses to a question from the baseline round (2015) asking whether participants had worried about falling in the last month.

Dementia.—Dementia refers to a 2015 classification of *probable dementia*, derived from a composite measure that encompasses measures of self-report of medical provider-diagnosed dementia or Alzheimer's disease (positive response to the question "Please tell me if a doctor ever told you that you had dementia or Alzheimer's Disease"), the AD8 Dementia Screening questionnaire[30] administered to proxy respondents (score of   2), and neuropsychological tests of memory, orientation, and executive function (scores   1.5 standard deviations from the mean for self-respondents in at least 2 out of the 5 cognitive domains tested). [31] We chose the *probable dementia* classification for our study because it is most consistent with accepted criteria for Alzheimer's disease (as opposed to mild cognitive impairment). [31]

Sociodemographic Characteristics include sex, race and ethnicity, income, and educational attainment from 2015. Three income categories were created based on sample tertile (<$26,000, $26,001-$60,000, and >$60,001). We classified participants as having financial hardship if they reported skipping a meal during the previous month because there was not enough food or money to buy food, or if they reported not having enough money to pay for medical expenses, the rent or mortgage, or utility bills during the previous year. [32]

Health and Function Characteristics.—We examined established 2015 health and function characteristics understood to affect fall-risk in addition to history of falls and fear of falling, including: poor lower extremity performance, vision impairment, hearing impairment, depressive symptoms, low physical activity, and activity of daily living (ADL) disability. [33] We used the Short Physical Performance Battery (SPPB) to assess lower extremity performance, including muscle strength, gait, and balance. We differentiated poor function (SPPB score   6) from moderate and high lower-extremity function (SPPB score   7). [34] For the 349 participants who were eligible for the SPPB tests but did not have a result recorded because they were unable to complete the test due to non-safety related reasons we assigned a score of zero, following prior precedent. [35] Vision impairment was measured by reports of blindness, inability to see well enough to recognize someone across the street, or inability to see well enough to read newspaper print. [36] Hearing impairment was measured by reports of deafness, hearing aid use, inability to hear well enough to use the telephone or inability to hear well enough to carry on conversation in a room with the television or radio playing. [36] Depressive symptoms were measured using a cut-point of >3 on the Patient-Health Questionnaire-2. [37] Physical activity was measured by reports of engaging in walking and/or vigorous activity in the previous month (versus no activity). Self-care disability was measured by receiving help with any of four activities in the last month: eating, bathing, toileting, or dressing. We distinguished between those who received help with   2 activities (high self-care disability) versus 0 or 1 activities.

Social and Physical Environment.—We categorized 2015 living arrangement as alone, with spouse, or with others who are not a spouse. NHATS interviewers recorded conditions inside and outside of the home. Following Samuel and colleagues (2015) we constructed three separate binary measures as follows: [35] *household disorder* refers to report of any broken furniture or lamps, flooring in need of repair, tripping hazards, clutter, peeling or flaking paint, or evidence of pests; *exterior household disrepair* refers to report of

any broken or boarded up windows, crumbling foundation, missing bricks or siding, roof problems, or uneven walking surfaces or broken steps; *street disorder* refers to report of any litter, graffiti, or vacant houses. We used a binary measure for continuous sidewalks, based on interviewer-reported observation of the presence or absence of continuous sidewalks in both directions in front of the home.

We include a composite measure of neighborhood social and economic deprivation, the 2015 Social Deprivation Index (SDI) which encompasses seven characteristics at the census-tract level from the American Community Survey. [38] SDI scores range from 0 to 100, with higher values corresponding to greater deprivation. To assess the relationship of living in an area with extreme deprivation with falls, we compared census tracts with the 85% lowest deprivation scores to those with the 15% highest deprivation scores. [39] We also examined relationships of falls with each of the seven components of the SDI, as categorized by the percent of the resident population with the following characteristics: income less than 100% of the federal poverty level; living in single-parent households with dependents <18 years of age; 25 years of age with less than 12 years of education; without a car; living in rental housing; living in crowded housing; non employed. We classify urbanity/rurality by whether participants lived in a metropolitan or non-metropolitan county based on designation by the U.S. Office of Management and Budget.

Approach to analysis

First, in order to understand the context of falls among older adults with dementia we examined the distribution of sociodemographic characteristics, health and function characteristics, and environmental characteristics among older adults with and without dementia. Chi-square tests and t-tests were used to assess statistical significance of these contrasts. Next, we constructed a series of bivariate (unadjusted) logistic regression models to assess the strength of the associations between factors from each domain and experiencing a fall, stratified by dementia status. We then examine the independent effects of all factors on falls among older adults with and without dementia using multivariable logistic regression models for each subgroup. Finally, in order to more closely examine the relationship of neighborhood socioeconomic characteristics with falls we examine associations of each of the SDI components with falls, stratified by dementia status. Data was analyzed in Stata version 17. We used 2016 survey weights for our estimates to account for nonresponse, oversampling of subgroups (oldest old and Black non-Hispanic persons), incomplete interviews, and replenishment of the original sample. [27] Alpha of <.05 indicated statistical significance. The Institutional Review Board of Johns Hopkins Bloomberg School of Public Health approved this study.

Results

The unweighted sample for this study comprises 5,581 community-living older adults; 5,093 without dementia (weighted percentage of 94.5) and 488 with dementia (weighted percentage of 5.5) (Table 1). Proxy respondents were more common among older adults with dementia than those without dementia (unweighted percentage Round 5: 37.1 vs 0.5; Round 6: 42.2 vs 1.4; Supplemental Table 2). In 2016, nearly half (45.5%) of all

persons living with dementia (PLWD) in the community experienced one or more falls, as compared with 30.9% of older adults without dementia (*P*<.001). Regardless of dementia status fall prevalence was greater among proxy-respondents than self-respondents (weighted percentages were 63.3 vs 30.5 among those without dementia and 58.5 vs 35.6 among those with dementia; Supplemental Table 3). Compared with older adults without dementia, PLWD had lower socioeconomic status (i.e., fewer years of education, lower income, and more financial hardship), were twice as likely to be Black or Hispanic, and had worse health and function. PLWD more commonly lived with someone other than a spouse (34.1% vs 13.0%), compared to older adults without dementia. Home disorder and street disorder were also more common among PLWD. Nearly twice as many PLWD lived in neighborhoods with high social deprivation than older adults without dementia (28.0% vs 14.8%).

The results of bivariate regressions indicated no relationship between personal and area-level socioeconomic disadvantage and deprivation and fall risk, despite PLWD more commonly experiencing personal and area-level socioeconomic disadvantage and deprivation than persons without dementia (Table 2). In fact, among PLWD, education below (versus above) high school (OR 0.47, 95% CI: 0.26 0.87), Black (versus White) racial status (OR 0.58, 95% CI: 0.37, 0.93), and living in the neighborhoods with the 15% highest (versus lower) deprivation scores (OR 0.43, 95% CI: 0.27, 0.69) were associated with lower odds of falling. In contrast, among older adults without dementia, indicators of socioeconomic disadvantage (such as having an education below high school, lower income, and financial hardship) were associated with greater odds of falls in bivariate regressions. Health and function fall-risk factors (e.g., history of falling, fear of falling and poor lower extremity performance) were associated with greater odds of falls across both subgroups, although there were exceptions. Most notably, having vision impairment (OR 1.93, 95% CI: 1.06, 3.49) was associated with greater odds of falling among PLWD, but not among the subgroup without dementia. Hearing impairment and high self-care disability were predictors of falls for older adults without dementia only. Living with a spouse (OR 3.12, 95% CI: 1.68, 5.80) or non-spouse (OR 1.85, 95% CI: 1.05, 3.28) compared to living alone was associated with greater odds of falling only among the subgroup of PLWD.

In multivariable models, history of falling (OR 6.20, 95% CI: 3.81, 10.09), vision impairment (OR 2.22, 95% CI: 1.12, 4.40), living with a spouse (versus alone; OR 2.43, 95% CI: 1.09, 5.43), and neighborhood social deprivation (15% highest deprivation scores: OR 0.55, 95% CI: 0.31, 0.98) were significantly associated with falling among PLWD (Table 2). Among older adults without dementia, financial hardship, history of falling, fear of falling, poor lower extremity performance, depressive symptoms, and home disrepair were associated with higher odds of falls in the multivariable model.

Bivariate associations between SDI component items and falls among PLWD were consistent with the relationship between SDI total scores and falls: indicators of high (top 15th percentile of scores) social deprivation were associated with lower odds of falls (Supplemental Table 4). SDI components were similarly associated with lower odds of falls among those without dementia, however these associations were not statistically significant.

Discussion

This is the first nationally representative study to compare a comprehensive set of potential risk factors for falls for older Americans living with dementia to those without dementia. We confirmed high rates of falls among older adults with dementia. [4,14] Nearly half (45.5%) of U.S. community-living older adults with dementia experienced a fall in the 1-year study period. This estimate is consistent with findings of a prevalence of 37–65% from a meta-analysis of non-US studies[11] and notably higher than the 30.9% of older adults without dementia who experienced a fall in our sample. Among PLWD, four characteristics stood out as significantly associated with falls in both unadjusted and adjusted models: history of falling; vision impairment; living with others (versus alone); and high neighborhood social deprivation, which was counterintuitively associated with lower odds of falls. Taken together, our findings demonstrate the importance of understanding and addressing fall risk among older adults living with dementia – and confirm that fall risk is multidimensional and influenced by environmental context in addition to health and function factors. Our findings set the stage for further investigation and the design of fall-prevention interventions specifically for PLWD.

Current clinical practice guidelines for falls-prevention among older adults recognize dementia as a major risk factor. [40] However, these guidelines conclude insufficient evidence is available to recommend a specific set of screening and treatment guidelines for falls-prevention among PLWD due to a dearth of studies on risk factors and fall-prevention interventions specific to the subpopulation. [40] History of falling is the only consistent predictor of falls across our study and others undertaken in the population of community-living older adults with dementia. [12] A prior history of falling and vision impairment are well-known risk factors for falls among older adults in general; [40] our findings that these were strong risk factors for falls among PLWD, reinforces that PLWD should be assessed for these characteristics and, if present, should receive further assessment and treatment such as a "multi-factorial assessment." [40] Our findings, taken together with evidence that co-occurring vision impairment and cognitive impairment is associated with greater functional disability than either impairment alone, [41] support regular screening and treatment for vision impairment among PLWD in order to mitigate this risk. In a comprehensive search using electronic databases and snowball sampling, we identified just two interventions for fall prevention that have been tested for efficacy among PLWD and which included screening for vision impairment. [42,43] Neither included treatment interventions such as refractive eyewear, low-vision rehabilitation, or behavioral interventions to increase vision (e.g., use of eyeglasses, adequate lighting, contrast strips on steps). Because the cognitive impairment of PLWD presents challenges to vision screening and treatment activities, [44] further research funding is needed to build interventions in this area.

Living with a spouse or with others was associated with higher odds of having a fall among PLWD, compared to living alone. After accounting for a comprehensive set of health, function, social and physical environmental factors, living with a spouse remained statistically significantly associated with higher odds of experiencing a fall. In contrast, we did not find a statistically significant association between living arrangement and falls in the subgroup of older adults without dementia. A recent (2020) large cohort study from

the United Kingdom found that older adults with dementia living alone were more likely to be older, women, and with milder cognitive and functional impairment than those living with others; [45] this is supported by earlier studies in the U.S. [46] It is plausible that the milder cognitive and functional impairment of the PLWD living alone drove the lower fall risk in this group. Also worth consideration is that for PLWD who reside with a spouse, their primary caregiver most commonly is their spouse. In contrast, PLWD who live alone most commonly receive care from family, friends, paid helpers and social services providers. [46] It is possible that spousal caregivers of PLWD have aging-related physical or cognitive health challenges of their own, and that they may be unable to mitigate fall risk of the PLWD they live with. Caregiver support and education is an understudied component of falls prevention programs for PLWD living with family caregivers, and deserves greater attention from clinicians, researchers, and policy makers.

Counterintuitively, indicators of lower socioeconomic status, specifically lower educational attainment and high neighborhood social deprivation, were statistically significantly associated with lesser odds of falls among PLWD. A related trend, in which the relationship between socioeconomic status and falls differed between subgroups of older adults, was found in Australia where fewer years of education predicted *more* falls among Australian-born older men, but *lower* falls among non-Australian born men (a subgroup with fewer average years of education and lower overall socioeconomic position). [47] In the present study, the relationship between neighborhood disadvantage and lower odds of falls was consistent across all the component measures that make up the SDI, suggesting that some of these component measures may be indicative of environmental or social supports that decrease the likelihood of falls. For example, previous studies have found public housing rental units and subsidized private rental units more likely than owner occupied units to be accessible for persons with moderate mobility difficulties. [48]

The socioeconomic disparities in dementia incidence are well studied; [49,50] however, there is little research on how personal or area-level indicators of socioeconomic disadvantage influence the trajectories of disability, quality of life, or other important outcomes among PLWD. Our findings suggest that the socioeconomic predictors of dementia incidence are different from the socioeconomic predictors of falls among PLWD. In general populations of older adults, there is evidence of area-level socioeconomic disadvantage predicting lower odds of both falls and negative falls-related outcomes; specifically, street disorder was associated with lower odds of recurrent falls in a stratified analysis of Black participants in NHATS[21] and higher U.S. county-level poverty concentration was associated with lower fall-injury mortality rates. [51] We did not find other studies documenting an association between neighborhood or other area-level disadvantage and falls or other functional outcomes among PLWD. More research is required to further investigate these observed associations. Selection and survival biases, and/or cohort effects may be contributing to the observed associations between indicators of socioeconomic disadvantage and a lower risk of falls among community-living older adults with dementia. [52]

Study Strengths and Limitations

This observational study relies on participant reports of falls involving a one-year recall period. Relying on recall to measure falls is less reliable than prospective measurement and may underestimate fall rates. [53] The survey is not able to determine the stage or severity of dementia, nor does it measure behaviors common among persons with dementia that may contribute to fall risk such as being verbally disruptive or attention seeking. [11] Further, the survey does not include information about medications that are relevant to falls (e.g., hypnotics, anxiolytics, anti-depressants, pain medication), and relies on a single-item measure of fear of falling for which there is weak evidence of validity. [54] By limiting our sample of analysis to community-living U.S. older adults we cannot generalize our findings to the population of older adults who live in nursing homes and other institutional residences, or to older adults living outside the U.S. Strengths of this study are inclusion of a representative sample of community-dwelling Medicare beneficiaries in the United States, the longitudinal design, and the inclusion of multiple dimensions of potential fall-risk factors.

Conclusions

To decrease the high rates of falls among older adults with dementia, additional tailored fall-risk screening and fall-prevention interventions should be developed and tested.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

References

1. Centers for Disease Control and Prevention NCfIPaC. 10 Leading Causes of Injury Deaths by Age Group Highlighting Unintentional Injury Deaths, United States - 2017. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Accessed January 21, 2020, 2020. https://www.cdc.gov/injury/images/lc-charts/leading_causes_of_death_by_age_group_unintentional_2017_1100w850h.jpg

2. Centers for Disease Control and Prevention NCfIPaC. National Estimates of the 10 Leading Causes of Nonfatal Injuries Treated in Hospital Emergency Departments, United States - 2017. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. https://www.cdc.gov/injury/images/lc-charts/leading_causes_of_nonfatal_injury_2017_1100w850h.jpg

3. Florence CS, Bergen G, Atherly A, Burns E, Stevens J, Drake C. Medical Costs of Fatal and Nonfatal Falls in Older Adults. Journal of the American Geriatrics Society. 2018;66(4):693–698. doi:10.1111/jgs.15304 [PubMed: 29512120]

4. Shaw FE. Falls in cognitive impairment and dementia. Clin Geriatr Med. May 2002;18(2):159–73. doi:10.1016/s0749-0690(02)00003-4 [PubMed: 12180241]

5. 2020 Alzheimer's disease facts and figures. 10.1002/alz.12068. Alzheimer's & Dementia. 2020/03/01 2020;16(3):391–460. doi:

6. Rowe MA, Fehrenbach N. Injuries sustained by community-dwelling individuals with dementia. Clin Nurs Res. May 2004;13(2):98–110, discussion 111–6. doi:10.1177/1054773803262520 [PubMed: 15104853]

7. Lin PJ, Fillit HM, Cohen JT, Neumann PJ. Potentially avoidable hospitalizations among Medicare beneficiaries with Alzheimer's disease and related disorders. Alzheimers Dement. Jan 2013;9(1):30–8. doi:10.1016/j.jalz.2012.11.002 [PubMed: 23305822]

8. Ahmed S, Leurent B, Sampson EL. Risk factors for incident delirium among older people in acute hospital medical units: a systematic review and meta-analysis. Age Ageing. May 2014;43(3):326–33. doi:10.1093/ageing/afu022 [PubMed: 24610863]

9. Watkin L, Blanchard MR, Tookman A, Sampson EL. Prospective cohort study of adverse events in older people admitted to the acute general hospital: risk factors and the impact of dementia. Int J Geriatr Psychiatry. Jan 2012;27(1):76–82. doi:10.1002/gps.2693 [PubMed: 21360591]

10. Yoshikawa A, Smith ML, Ory MG. Differential risk of falls associated with pain medication among community-dwelling older adults by cognitive status. Age Ageing. Sep 11 2021;50(5):1578–1585. doi:10.1093/ageing/afab051 [PubMed: 33765121]

11. Fernando E, Fraser M, Hendriksen J, Kim CH, Muir-Hunter SW. Risk Factors Associated with Falls in Older Adults with Dementia: A Systematic Review. Physiother Can. 2017;69(2):161–170. doi:10.3138/ptc.2016-14 [PubMed: 28539696]

12. Asada T, Kariya T, Kinoshita T, et al. Predictors of Fall-related Injuries among Community-dwelling Elderly People with Dementia. Age and Ageing. 1996;25(1):22–28. doi:10.1093/ageing/25.1.22 [PubMed: 8670525]

13. Taylor ME, Delbaere K, Lord SR, Mikolaizak AS, Brodaty H, Close JCT. Neuropsychological, Physical, and Functional Mobility Measures Associated With Falls in Cognitively Impaired Older Adults. The Journals of Gerontology: Series A. 2014;69(8):987–995. doi:10.1093/gerona/glt166

14. Allan LM, Ballard CG, Rowan EN, Kenny RA. Incidence and prediction of falls in dementia: a prospective study in older people. PLoS One. 2009;4(5):e5521. doi:10.1371/journal.pone.0005521 [PubMed: 19436724]

15. Horikawa E, Matsui T, Arai H, Seki T, Iwasaki K, Sasaki H. Risk of falls in Alzheimer's disease: a prospective study. Intern Med. Jul 2005;44(7):717–21. doi:10.2169/internalmedicine.44.717 [PubMed: 16093593]

16. Maggio D, Ercolani S, Andreani S, et al. Emotional and psychological distress of persons involved in the care of patients with Alzheimer disease predicts falls and fractures in their care recipients. Dement Geriatr Cogn Disord. 2010;30(1):33–8. doi:10.1159/000288774 [PubMed: 20689280]

17. WHO. WHO global report on falls prevention in older age. 2007. 2007. https://extranet.who.int/agefriendlyworld/wp-content/uploads/2014/06/WHo-Global-report-on-falls-prevention-in-older-age.pdf

18. Scheffer AC, Schuurmans MJ, van Dijk N, van der Hooft T, de Rooij SE. Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. Age and Ageing. 2008;37(1):19–24. doi:10.1093/ageing/afm169 [PubMed: 18194967]

19. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. Epidemiology (Cambridge, Mass). 2010;21(5):658–668. doi:10.1097/EDE.0b013e3181e89905 [doi] [PubMed: 20585256]

20. Li W, Procter-Gray E, Lipsitz LA, et al. Utilitarian Walking, Neighborhood Environment, and Risk of Outdoor Falls Among Older Adults. American Journal of Public Health. 2014/09/01 2014;104(9):e30–e37. doi:10.2105/AJPH.2014.302104 [PubMed: 25033118]

21. Okoye SM, Samuel LJ, Fabius C, et al. Home and Neighborhood Context of Falls Among Black and White Older Americans. Journal of Aging and Health. 2021:08982643211009436. doi:10.1177/08982643211009436

22. Lowery K, Buri H, Ballard C. What is the prevalence of environmental hazards in the homes of dementia sufferers and are they associated with falls. International Journal of Geriatric Psychiatry. 2000/10/01 2000;15(10):883–886. doi:10.1002/1099-1166(200010)15:10<883::AID-GPS981>3.0.CO;2-9 [PubMed: 11044868]

23. Samuel LJ, Szanton SL, Wolff JL, Ornstein KA, Parker LJ, Gitlin LN. Socioeconomic disparities in six-year incident dementia in a nationally representative cohort of U.S. older adults: an examination of financial resources. BMC Geriatrics. 2020/05/06 2020;20(1):156. doi:10.1186/s12877-020-01553-4 [PubMed: 32370792]

24. Wallhagen MI, Yamamoto-Mitani N. The Meaning of Family Caregiving in Japan and the United States: A Qualitative Comparative Study. Journal of Transcultural Nursing. 2006/01/01 2006;17(1):65–73. doi:10.1177/1043659605281979 [PubMed: 16410438]

25. Lillo-Crespo M, Riquelme J, Macrae R, et al. Experiences of advanced dementia care in seven European countries: implications for educating the workforce. Glob Health Action. 2018;11(1):1478686. doi:10.1080/16549716.2018.1478686 [PubMed: 30099937]

26. Seeman TE, Charpentier PA, Berkman LF, et al. Predicting Changes in Physical Performance in a High-Functioning Elderly Cohort: MacArthur Studies of Successful Aging. Journal of Gerontology. 1994;49(3):M97–M108. doi:10.1093/geronj/49.3.M97 [PubMed: 8169338]

27. DeMatteis J, Freedman VA, Kasper JD. National Health and Aging Trends Study Round 5 Sample Design and Selection. NHATS Technical Paper #16. 2017. www.nhats.org

28. Freedman VA. Adopting the ICF Language for Studying Late-life Disability: A Field of Dreams? The Journals of Gerontology: Series A. 2009;64A(11):1172–1174. doi:10.1093/gerona/glp095

29. Bureau USC. Data from: American Community Survey (ACS). 2020.

30. Galvin JE, Roe CM, Powlishta KK, et al. The AD8. Neurology. 2005;65(4):559. doi:10.1212/01.wnl.0000172958.95282.2a [PubMed: 16116116]

31. Kasper JD, Freedman VA, Spillman B. Classification of Persons by Dementia Status in the National Health and Aging Trends Study. Technical Paper #5. . 2013. https://www.nhats.org/scripts/documents/DementiaTechnicalPaperJuly_2_4_2013_10_23_15.pdf

32. Samuel LJ, Szanton SL, Seplaki CL, Cudjoe TKM, Thorpe RJ, Agree EM. Longitudinal and reciprocal associations between financial strain, home characteristics and mobility in the National Health and Aging Trends Study. BMC Geriatrics. 2019/12/02 2019;19(1):338. doi:10.1186/s12877-019-1340-7 [PubMed: 31791252]

33. Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. Clin Geriatr Med. 2002;18(2):141–158. doi:10.1016/S0749-0690(02)00002-2 [PubMed: 12180240]

34. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. The New England journal of medicine. 1995;332(9):556–561. doi:10.1056/NEJM199503023320902 [doi] [PubMed: 7838189]

35. Samuel LJ, Glass TA, Thorpe RJ Jr., Szanton SL, Roth DL. Household and neighborhood conditions partially account for associations between education and physical capacity in the National Health and Aging Trends Study. Soc Sci Med. Mar 2015;128:67–75. doi:10.1016/j.socscimed.2015.01.009 [PubMed: 25594954]

36. Kuo P-L, Huang AR, Ehrlich JR, et al. Prevalence of Concurrent Functional Vision and Hearing Impairment and Association With Dementia in Community-Dwelling Medicare Beneficiaries. JAMA Network Open. 2021;4(3):e211558–e211558. doi:10.1001/jamanetworkopen.2021.1558 [PubMed: 33739429]

37. Lowe B, Kroenke K, Grafe K. Detecting and monitoring depression with a two-item questionnaire (PHQ-2). J Psychosom Res. Feb 2005;58(2):163–71. doi:10.1016/j.jpsychores.2004.09.006 [PubMed: 15820844]

38. Butler DC, Petterson S, Phillips RL, Bazemore AW. Measures of social deprivation that predict health care access and need within a rational area of primary care service delivery. Health Serv Res. Apr 2013;48(2 Pt 1):539–59. doi:10.1111/j.1475-6773.2012.01449.x [PubMed: 22816561]

39. Kind AJH, Jencks S, Brock J, et al. Neighborhood Socioeconomic Disadvantage and 30-Day Rehospitalization. Annals of Internal Medicine. 2014/12/02 2014;161(11):765–774. doi:10.7326/M13-2946 [PubMed: 25437404]

40. Panel on Prevention of Falls in Older Persons AGSaBGS. Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. J Am Geriatr Soc. Jan 2011;59(1):148–57. doi:10.1111/j.1532-5415.2010.03234.x [PubMed: 21226685]

41. Patel N, Stagg BC, Swenor BK, Zhou Y, Talwar N, Ehrlich JR. Association of Co-occurring Dementia and Self-reported Visual Impairment With Activity Limitations in Older Adults. JAMA Ophthalmol. Jul 1 2020;138(7):756–763. doi:10.1001/jamaophthalmol.2020.1562 [PubMed: 32407444]

42. Mackintosh SF, Sheppard LA. A Pilot Falls-prevention Programme for Older People with Dementia from A Predominantly Italian Background. Hong Kong Physiotherapy Journal. 2005/01/01/ 2005;23(1):20–26. doi:10.1016/S1013-7025(09)70055-7

43. Shaw FE, Bond J, Richardson DA, et al. Multifactorial intervention after a fall in older people with cognitive impairment and dementia presenting to the accident and emergency department: randomised controlled trial. BMJ. 2003;326(7380):73. doi:10.1136/bmj.326.7380.73 [PubMed: 12521968]

44. Wittich W, Höbler F, Jarry J, McGilton KS. Recommendations for successful sensory screening in older adults with dementia in long-term care: a qualitative environmental scan of Canadian specialists. BMJ Open. 2018;8(1):e019451. doi:10.1136/bmjopen-2017-019451

45. Clare L, Martyr A, Henderson C, et al. Living Alone with Mild-To-Moderate Dementia: Findings from the IDEAL Cohort. J Alzheimers Dis. 2020;78(3):1207–1216. doi:10.3233/jad-200638 [PubMed: 33104029]

46. Prescop KL, Dodge HH, Morycz RK, Schulz RM, Ganguli M. Elders with dementia living in the community with and without caregivers: an epidemiological study. Int Psychogeriatr. Sep 1999;11(3):235–50. doi:10.1017/s1041610299005803 [PubMed: 10547124]

47. Khalatbari-Soltani S, Stanaway F, Sherrington C, et al. The Prospective Association Between Socioeconomic Status and Falls Among Community-Dwelling Older Men. The Journals of Gerontology: Series A. 2021;76(10):1821–1828. doi:10.1093/gerona/glab038

48. Chan S, Ellen IG. Housing for an Aging Population. Housing Policy Debate. 2017/03/04 2017;27(2):167–192. doi:10.1080/10511482.2016.1184696

49. Zuelsdorff M, Larson JL, Hunt JFV, et al. The Area Deprivation Index: A novel tool for harmonizable risk assessment in Alzheimer's disease research. Alzheimers Dement (N Y). 2020;6(1):e12039. doi:10.1002/trc2.12039 [PubMed: 32548238]

50. Arapakis K, Brunner E, French E, McCauley J. Dementia and disadvantage in the USA and England: population-based comparative study. BMJ Open. Oct 6 2021;11(10):e045186. doi:10.1136/bmjopen-2020-045186

51. Karb RA, Subramanian SV, Fleegler EW. County Poverty Concentration and Disparities in Unintentional Injury Deaths: A Fourteen-Year Analysis of 1.6 Million U.S. Fatalities. PLoS One. 2016;11(5):e0153516. doi:10.1371/journal.pone.0153516 [PubMed: 27144919]

52. Banack HR, Kaufman JS, Wactawski-Wende J, Troen BR, Stovitz SD. Investigating and Remediating Selection Bias in Geriatrics Research: The Selection Bias Toolkit. J Am Geriatr Soc. Sep 2019;67(9):1970–1976. doi:10.1111/jgs.16022 [PubMed: 31211407]

53. Mackenzie L, Byles J, D'Este C. Validation of self-reported fall events in intervention studies. Clinical Rehabilitation. 2006;20(4):331–339. doi:10.1191/0269215506cr947oa [PubMed: 16719031]

54. Jørstad EC, Hauer K, Becker C, Lamb SE. Measuring the psychological outcomes of falling: a systematic review. J Am Geriatr Soc. Mar 2005;53(3):501–10. doi:10.1111/j.1532-5415.2005.53172.x [PubMed: 15743297]

Table 1.

Characteristics of Community-Living Older Adults Overall and by Dementia Status

	Overall n=5581	Without Dementia n=5093 n (Weighted %)	With Dementia n= 488 n (Weighted %)	P value[a]
Weighed Estimate	34,404,128	32,513,108 (94.5)	1,891,019 (5.5)	
Fall (2016)	10,900,310 (31.7)	10,037,680 (30.9)	862,630 (45.5)	<.001
Sociodemographic				
Age				
65 to 74	2192 (58.0)	2132 (60.1)	60 (22.4)	<.001
75 to 84	2254 (31.4)	2065 (30.8)	189 (41.3)	
>85	1135 (10.6)	896 (9.1)	239 (36.3)	
Female	3246 (55.8)	2949 (55.9)	297 (54.5)	.67
Education				
Above High School	2901 (57.1)	2762 (58.8)	139 (27.5)	<.001
High School	1503 (26.2)	1372 (26.0)	131 (29.5)	
Below High School	1177 (16.7)	959 (15.2)	218 (43.1)	
Race[b]				
White non-Hispanic or Other	4080 (84.2)	3811 (85.2)	269 (67.0)	<.001
Black non-Hispanic	1157 (8.3)	1006 (8.0)	151 (13.1)	
Hispanic	344 (7.6)	276 (6.8)	68 (19.9)	
Income				
>$60,001	1404 (31.4)	1362 (32.6)	42 (10.8)	<.001
$26,001–$60,000	1841 (34.3)	1733 (34.9)	108 (24.7)	
$0–$26,000	2336 (34.3)	1998 (32.5)	338 (64.6)	
Financial Hardship	420 (7.2)	377 (7.0)	43 (11.5)	.007
Health and Function				
History of falling (2015)	1780 (30.4)	1578 (29.6)	202 (43.7)	<.001
Fear of falling	1611 (25.9)	1422 (25.0)	189 (41.4)	<.001
Poor lower extremity performance	1844 (25.0)	1465 (22.0)	379 (75.3)	<.001
Vision impairment	374 (5.6)	283 (4.8)	91 (20.6)	<.001
Hearing impairment	1365 (21.9)	1189 (20.9)	176 (38.9)	<.001
Depressive symptoms	2382 (40.4)	2090 (39.1)	292 (63.3)	<.001
Physical activity in last month	3787 (71.9)	3557 (73.2)	230 (49.2)	<.001
High Self-care Disability	345 (4.4)	182 (2.7)	163 (33.9)	<.001
Social & Physical Environment				
Lives with:				
Alone	1756 (27.8)	1641 (28.2)	115 (20.6)	<.001
Spouse	2795 (58.0)	2616 (58.8)	179 (45.3)	
Others	1030 (14.2)	836 (13.0)	194 (34.1)	
Home Disorder	1608 (27.4)	1445 (27.0)	163 (34.6)	.004
Home Disrepair	840 (14.3)	761 (14.3)	79 (14.1)	.93

	Overall n=5581	Without Dementia n=5093 n (Weighted %)	With Dementia n= 488 n (Weighted %)	P value[a]
Street Disorder	628 (9.6)	540 (9.2)	88 (17.0)	<.001
Lacks Continuous sidewalks	3382 (60.2)	3104 (60.5)	278 (55.1)	.06
Highest 15% Social Deprivation[c]	1168 (15.5)	1008 (14.8)	160 (28.0)	<.001
Non-Metropolitan County	1094 (18.1)	1008 (18.2)	86 (15.7)	.20

Note. Data related to predictors are from the National Health and Aging Trends Study (NHATS) (2015). Falls refers to 1 fall in twelve months preceding 2016 interview.

[a]*P* values of tests of difference using χ^2 tests between participants with and without dementia.

[b]Due to small cell-sizes, American Indian, Asian, Native, Hawaiian, Pacific Islander were combined with the White non-Hispanic group.

[c]Based on the Social Deprivation Index using 2015 American Community Survey Data.

Table 2.

Associations of Social and Environmental Characteristics with Falls Among Community-Living Older Adults, n= 5581

	Without Dementia, n=5093		With Dementia, n=488	
	Unadjusted OR (95% CI)	Adjusted aOR (95% CI)	Unadjusted OR (95% CI)	Adjusted aOR (95% CI)
Sociodemographic				
Age				
65 to 74	Reference	Reference	Reference	Reference
75 to 84	1.15 (0.97, 1.37)	0.97 (0.80, 1.18)	0.70 (0.36, 1.38)	0.86 (0.41, 1.82)
>85	1.65 (1.37, 1.97)	1.08 (0.85, 1.36)	0.89 (0.50, 1.57)	1.13 (0.55, 2.31)
Female	1.20 (1.03, 1.41)	1.09 (0.90, 1.31)	0.89 (0.57, 1.38)	0.86 (0.47, 1.55)
Education				
Above High School	Reference	Reference	Reference	Reference
High School	1.05 (0.90, 1.23)	0.91 (0.76, 1.10)	0.71 (0.38, 1.33)	0.69 (0.33, 1.45)
Below High School	1.31 (1.09, 1.59)	1.18 (0.92, 1.51)	0.47 (0.26, 0.87)	0.50 (0.22, 1.13)
Race[a]				
White non-Hispanic or Other	Reference	Reference	Reference	Reference
Black non-Hispanic	0.71 (0.59, 0.86)	0.68 (0.52, 0.88)	0.58 (0.37, 0.93)	1.44 (0.76, 2.71)
Hispanic	0.80 (0.59, 1.08)	0.77 (0.54, 1.10)	0.83 (0.36, 1.89)	1.87 (0.70, 5.04)
Income				
>$60,001	Reference	Reference	Reference	Reference
$26,001-$60,000	1.23 (1.05, 1.45)	1.11 (0.93, 1.33)	1.39 (0.54, 3.60)	2.32 (0.94, 5.71)
$0-$26,000	1.32 (1.10, 1.59)	0.94 (0.73, 1.20)	0.88 (0.37, 2.11)	2.36 (0.90, 6.23)
Financial Hardship	1.76 (1.30, 2.37)	1.50 (1.04, 2.17)	0.81 (0.35, 1.88)	1.15 (0.43, 3.06)
Health and Function				
History of falling (2015)	3.59 (3.10, 4.15)	2.92 (2.50, 3.40)	6.12 (3.99, 9.39)	6.20 (3.81, 10.09)
Fear of falling	2.61 (2.17, 3.14)	1.65 (1.34, 2.02)	1.82 (1.22, 2.72)	1.39 (0.80, 2.41)
Poor lower extremity performance	2.20 (1.85, 2.61)	1.63 (1.32, 2.01)	2.01 (1.22, 3.31)	1.44 (0.79, 2.62)
Vision impairment	1.37 (0.99, 1.90)	0.93 (0.65, 1.33)	1.91 (1.06, 3.47)	2.22 (1.12, 4.40)
Hearing impairment	1.42 (1.17, 1.73)	1.25 (0.98, 1.58)	1.25 (0.73, 2.12)	0.94 (0.53, 1.67)
Depressive symptoms	1.90 (1.63, 2.20)	1.37 (1.15, 1.64)	2.20 (1.40, 3.44)	1.43 (0.84, 2.43)
Physical activity in last month	0.70 (0.60, 0.82)	0.98 (0.82, 1.17)	0.74 (0.48, 1.15)	0.83 (0.49, 1.42)

	Without Dementia, n=5093		With Dementia, n=488	
	Unadjusted OR (95% CI)	Adjusted aOR (95% CI)	Unadjusted OR (95% CI)	Adjusted aOR (95% CI)
High Self-care Disability	1.67 (1.23, 2.28)	0.67 (0.45, 1.00)	1.66 (0.96, 2.88)	0.76 (0.40, 1.45)
Social & Physical Environment				
Lives with:				
Alone	Reference	Reference	Reference	Reference
Spouse	0.89 (0.74, 1.06)	1.05 (0.84, 1.31)	3.12 (1.68, 5.80)	2.43 (1.09, 5.43)
Non-spouse	1.19 (0.99, 1.43)	1.09 (0.88, 1.34)	1.88 (1.07, 3.30)	1.25 (0.63, 2.48)
Home Disorder	1.16 (0.96, 1.39)	0.94 (0.76, 1.15)	0.67 (0.41, 1.08)	0.72 (0.40, 1.29)
Home Disrepair	1.45 (1.22, 1.72)	1.34 (1.12, 1.61)	0.96 (0.55, 1.69)	1.24 (0.63, 2.45)
Street Disorder	1.00 (0.78, 1.30)	0.94 (0.69, 1.28)	0.55 (0.28, 1.12)	0.57 (0.26, 1.25)
Lacks Continuous Sidewalks	1.20 (1.04, 1.38)	1.12 (0.94, 1.33)	1.35 (0.84, 2.17)	1.45 (0.86, 2.44)
Highest 15% Social Deprivation[b]	0.87 (0.69, 1.09)	0.91 (0.66, 1.25)	0.43 (0.27, 0.69)	0.55 (0.31, 0.98)
Non-Metropolitan County	1.08 (0.89, 1.30)	0.91 (0.75, 1.11)	1.08 (0.57, 2.03)	0.96 (0.46, 2.03)

Note. Data are from the National Health and Aging Trends Study. Characteristics were measured at the time of the 2015 interview. Falls refers to ≥1 fall in twelve months preceding 2016 interview. OR=odds ratio; CI=confidence interval.

[a] Due to small cell-sizes, American Indian, Asian, Native, Hawaiian, Pacific Islander were combined with the White non-Hispanic group.

[b] Based on the Social Deprivation Index using 2015 American Community Survey Data. Adjusted models adjusted for all variables in table as well as history of falling, fear of falling, lower extremity performance, vision impairment, hearing impairment, and physical activity.