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Incidence of Potentially Disruptive Medical and Social Events in Older Adults With and Without Dementia

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Abstract

Background: Potentially disruptive medical, surgical, and social events—such as pneumonia, hip fracture, and widowhood—may accelerate the trajectory of decline and impact caregiving needs in older adults, especially among people with dementia. Prior research has focused primarily on nursing home residents with dementia. We sought to assess the incidence of potentially disruptive events in community-dwelling people with and without dementia.

Methods: Retrospective cohort study of participants aged 65+ enrolled in the Health and Retirement Study between 2010–2018 (n=9,346), including a subset who were married/partnered at baseline (n=5,105). Dementia was defined with a previously validated algorithm. We calculated age-adjusted and gender-stratified incidence per 1000 person-years and incidence rate ratios of: 1) hospitalization for pneumonia; 2) hip fracture and; 3) widowhood in people with and without dementia.

Results: People with dementia (PWD) (n=596) were older (mean age 84 vs. 75) and a higher proportion were female (67% vs 57%) than people without dementia (PWoD) (n=8,750). Age-adjusted incidence rates (per 1000 person-years) of pneumonia were higher in PWD (113.1; 95% CI 94.3, 131.9) compared to PWoD (62.1; 95% CI 54.7, 69.5), as were hip fractures (12.3; 95% CI 9.1, 15.6 for PWD compared to 8.1; 95% CI 6.9, 9.2 in PWoD). Point estimates of widowhood incidence were slightly higher for PWD (25.3; 95% CI 20.1, 30.5) compared to PWoD (21.9; 95% CI 20.3, 23.5), but differences were not statistically significant. The association of dementia with

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hip fracture—but not pneumonia or widowhood—was modified by gender (male incidence rate ratio (IRR) 2.24, 95% CI 1.34, 3.75 versus female IRR 1.31 95% CI 0.92,1.86); interaction term $p=0.02$).

Conclusions: Compared to PWD, community-dwelling PWD had higher rates of pneumonia and hip fracture, but not widowhood. Knowing how often PWD experience these events can aid in anticipatory guidance and care planning for this growing population.

Keywords

Dementia; hip fracture; pneumonia; widowhood

Introduction

Dementia afflicts 5.6 million Americans and costs upwards of \$200 billion/year.¹ The existing paradigm is that the course of dementia follows a slow and steady decline of increasing functional and cognitive impairment.^{2,3} Alternatively, there are data that suggest that for some the course of dementia is punctuated by major medical and social events that accelerate the trajectory of decline and increase risk of mortality to a greater extent than in people without dementia (PWoD).³⁻⁵ These events may be disruptive to both the people with dementia (PWD) and their caregivers, requiring burdensome and exhausting hospitalizations and reformulations of caregiving and/or living arrangements following the event.

There are numerous examples of events that could be considered disruptive, and one could argue that any medical, surgical, or social events that results in hospitalization, transfer to long-term care, or change in living situation could qualify. From among the many possible events, we identified exemplar events that met the following criteria: (1) associated with poor outcomes in older adults in prior literature; (2) represented distinct domains, specifically, medical, surgical, and social; and (3) were measurable in the Health and Retirement Study-Medicare linked dataset. Our final selection of events included hospitalization for pneumonia (medical), hip fractures (surgical), and widowhood (social). Hospitalization for pneumonia is a medical event that is one of the leading causes of morbidity and mortality for older adults, and, has been shown to be associated with potentially burdensome interventions, such as parental antibiotics and feeding tube placement, in nursing home residents.^{6,7} Hip fractures are traumatic injuries and surgical events associated with high levels of geriatric and palliative care needs and functional decline before and after the event.^{8,9} Widowhood is a social event with consequences on health, financial, and socioemotional experience of the surviving spouse.^{10,11}

Even for events as important to the geriatric population as pneumonia, hip fracture, and widowhood, basic information about the frequency of these events in PWD is lacking. Despite the fact that 80% of PWD in the U.S. reside in the community with a range of dementia severity¹², most studies of hip fracture and pneumonia incidence and outcomes in PWD are limited to hospital or nursing home based samples of people with severe dementia.¹³⁻¹⁶ Other studies have found higher rates of both overall and potentially avoidable hospitalizations among PWD in the U.S., but have not specifically examined hip fracture or pneumonia.^{17,18} The few population-based studies of incidence rates of

hip fracture and pneumonia in community-dwelling PWD have mainly been carried out in Europe and Asia.^{19,20} Studies of widowhood have primarily been limited to cognitively intact adults and have not documented the incidence of widowhood in people with and without dementia.²¹

Although previous studies have examined events such as hip fracture, pneumonia, and widowhood in isolation, few studies have considered disruptive events as conceptually similar in their likelihood to lead to a shift in health status and other outcomes. As part of a larger study that will assess trajectories following disruptive events in community-dwelling people with and without dementia, the objective of this initial study was to quantify the frequency of our selected disruptive events in these groups. We hypothesized that the cognitive, physical, and functional declines that characterize dementia make PWD more susceptible to serious falls, infections, or aspiration that lead to hip fractures and pneumonia.^{7,22} With limited evidence on the incidence of widowhood to guide us, we considered the widowhood analyses exploratory. However, based on research demonstrating that caregiving for PWD is associated with high rates of caregiver strain and may be associated with accelerated aging and death, our exploratory hypothesis was that widowhood rates would be higher in PWD.²³ Finally, because prior research indicated there may be gender differences in the incidence of these disruptive events (e.g., higher incidence of hip fractures in women),²⁴ we explored gender differences in incidence rates between groups by stratifying results by gender. Of note, we chose to use the term “disruptive event”, instead of “sentinel event” which has sometimes been used to describe these types of events in dementia, to avoid confusion with the more common use of “sentinel event” in patient safety.²⁵

Methods

Data Sources and Participants

We used data from the Health and Retirement Study (HRS), a longitudinal, nationally-representative study of older adults begun in 1992. Interviews are conducted every two years via telephone in most cases, with face-to-face interviews conducted for most participants 80 and older, those too ill to participate in a telephone interview, or those unable to access a phone. Response rates for core interviews range from 85–90%. The HRS uses a national area probability sample of U.S. households, with supplemental oversamples of Black and Hispanic participants. HRS design and data collection procedures are available elsewhere.²⁶

Our cohort included all HRS participants with a completed 2010 core interview (n=22,033). We selected 2010 because it balances data recency with adequate follow-up time and enough events to estimate incidence rates with precision. This time frame also allowed us to avoid excluding Medicare Advantage (MA) enrollees in our analysis, since Medicare required reporting of MA inpatient visits starting in 2008. We excluded individuals younger than 65 (n=11,521), nursing home residents at baseline (n=449), individuals who did not agree to have their data linked to Medicare claims (n=585), individuals without continuous Part A enrollment 2010–2018 (n=18), and those missing a baseline dementia status (n=114), for a final sample of 9,346. The widowhood cohort was a subset of the larger cohort and included participants who were married or partnered and currently living with a spouse in 2010

(n=5,105). We followed participants through 2018 - the most recent year of Medicare-linked data available from HRS.

Outcomes

Hip Fracture: Based on previous algorithms^{27,28}, we identified inpatient hospitalizations for hip fracture (femoral neck or intertrochanteric fractures) in the Medicare inpatient claims file using ICD-9 codes before 2015 and ICD-10 thereafter. For ICD-9 codes, we included admissions with code 820.xx and excluded admissions that were considered late effects from a prior hip fracture (733.81, 733.82, 905.3, V540-V549). ICD-10 codes included S72.0XX, S72.1XX, M80.05X, M84.45, M80.85X, M84.65X with letters A, B, or C to indicate an initial encounter. Both ICD-9 and 10 definitions included a period of 100 days to ensure we identified distinct events. We excluded admissions to long-term acute care (LTAC) facilities. While some studies have included both outpatient and inpatient claims to identify hip fractures, and have also included contiguous fractures (e.g. pelvic fractures), we opted against this approach for several reasons: 1) 90–95% of all hip fracture events will be captured in the inpatient file²⁷; 2) Non-operative outpatient management of hip fractures is rare in community-dwelling older adults and usually reserved for those at the very end of life; and 3) We sought a uniform definition of hip fracture based on prior work.^{4,5,8,9,29}

Pneumonia: Guided by prior algorithms^{30–32}, we defined pneumonia using ICD-9 and ICD-10 diagnostic codes in the Medicare inpatient claims file (see Supplement Table S1 for full list). We included ICD codes in any position in the claims and applied a 30-day period to define a single pneumonia event. While we considered including outpatient files to identify pneumonia, we opted to only include pneumonia that resulted in hospitalization because: 1) we were interested in events that would lead to a substantial disruption in an older person's life, and reasoned that pneumonia managed in the outpatient setting would not meet those criteria; 2) We wanted to create consistency with our definition of hip fractures; 3) Data on outpatient claims for MA (MA) enrollees have not been validated to our knowledge, thus including outpatient events in our definition would have required excluding MA enrollees. This exclusion would have reduced generalizability since a large proportion (~ 30%) of our sample were enrolled in MA. Admissions to LTAC facilities were excluded.

Widowhood: We defined widowhood as a new report of a spouse's death (not gender specific) based on self or proxy response in the biennial HRS interview, which also includes the date of the spouse's death. This approach has been used previously with HRS data.³³

Primary Predictor

Our primary predictor was time-varying dementia status based on the validated Hurd algorithm.³⁴ This algorithm uses cognitive and functional data from the HRS interviews to estimate a predicted probability that the participant has dementia at the time of each biennial interview. We classified participants with a predicted probability of 0.5 or greater as having dementia based on prior studies.³⁵ The distribution of dementia probabilities in our sample demonstrated that vast majority of people were either <0.3 or equal to 1, further justifying this approach.

Other Variables

We described our sample by examining sociodemographic and clinical characteristics at the time of the baseline interview. These included mean age and age by category (65–74/75–84/85+), gender (male/female); race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic/non-Hispanic Other); educational attainment (greater or less than high school education); median household wealth; marital status (married or partnered/divorced or separated/never married/widowed); living situation (lives alone or with spouse only if married/lives with others); Medicaid eligible (yes/no); Medicare Part C (also referred to as Medicare Advantage) enrollee (yes/no); mean number of comorbidities; impairments in activities of daily living (0–1/2+); and smoking status (never/past or current).

Statistical Analysis

We used Poisson regression to estimate incidence rates for each disruptive event by dementia status and incidence rate ratios comparing PWD to PwOD. Multiple episodes of pneumonia and hip fracture were included in the calculation of incidence rates, while widowhood could occur once. Because dementia status could vary over the study period, participants could contribute time to both the dementia and non-dementia calculations. We report rates in number of events per thousand person-years. All analyses were adjusted for age as a continuous variable and stratified by gender. We opted against adjusting for other sociodemographic variables (race, education, wealth, etc) due to their high correlation with dementia, which would reduce our ability to assess the independent effect of dementia on our outcomes.

Twelve percent of participants were missing data on dementia status at any follow-up assessment. Based on the assumption that a person with dementia would continue to have dementia, if a participant was categorized as having dementia we then categorized all future assessments as dementia. Conversely, we assigned missing assessments to the no dementia group if that participant was classified as having no dementia in a later round but were missing dementia status in an earlier round. This reduced missing to 8.7%. For the remaining missing, we excluded interviews with missing data (lost to follow-up). We conducted several sensitivity analyses to examine different approaches to dealing with missing data: 1) carry forward last dementia status for all assessments; 2) classify all missing assessment as dementia; 3) classify all missing assessments as no dementia.

All analyses take into account the complex survey design in HRS. Analyses were conducted in SAS Version 9.4 and Stata Version 17. This study was approved by the UCSF and ISMMS Internal Review Boards

Results

Sample characteristics are in Table 1. At baseline (2010), 596 participants met criteria for dementia and 8,750 did not. PWD were older (mean age 84 vs. 75), were more likely to be female (67% vs. 57%), less often reported being non-Hispanic White (69% versus 84%), and had lower median household wealth (\$74,096 vs. \$225,869) than PwOD. In the married at baseline subset, 273 met criteria for dementia and 4,382 did not. Differences in

characteristics between those with and without dementia in this subset were similar to the entire cohort. Overall, the married at baseline subset were younger, less likely to be male, more likely to report being Non-Hispanic White, and had lower household wealth than the cohort as a whole. The mean follow-up time for the baseline cohort was 4.0 years (SD 2.7) for PWD and 6.9 years (SD 2.3) for PWoD. In the married cohort, the mean follow-up time was 4.1 years (SD 2.7) for PWD and 7.0 years (SD 2.1) for PWoD. Among the baseline cohort, 81 (13.6%) PWD and 451 (5.2%) PWoD were hospitalized for pneumonia, 22 (3.7%) PWD and 90 (1.0%) PWoD had a hip fracture, and 36 (16.9%) PWD and 760 (15.8%) PWoD were widowed.

Age-adjusted incidence rate estimates of all three disruptive events were higher in PWD compared to those without (Table 2, Figure 1). The incidence rate of pneumonia in PWD was 113.1 (95% CI 94.3, 131.9) per 1000 person-years, which was almost double that of PWoD 62.1 (95% CI 54.7, 69.5), IRR 1.82 (95% CI 1.53, 2.17). The hip fracture rate was 12.3 (95% CI 9.1, 15.6) per 1000 person-years in PWD compared to 8.1 (95% CI 6.9, 9.2) in PWoD, IRR 1.53 (95% CI 1.09, 2.4). Widowhood incidence rate was slightly higher in PWD (25.3 per 1000 person-years, 95% CI 20.1, 30.5) compared to PWoD (21.9 per 1000 person-years, 95% CI 20.3, 23.5), though differences were not statistically significant (IRR 1.15, 95% CI 0.93, 1.44). Values of incidence rates and IRR's were similar in sensitivity analyses, with slight attenuation in values when missing values were changed to having dementia (Table 3).

Gender differences in the incidence rates of the disruptive events were noted. Men had higher rates of pneumonia, while women had higher rates of hip fracture and widowhood in both the dementia and no dementia groups (Table 2). Males had a higher IRR for hip fracture (IRR 2.24, 95% CI 1.34, 3.75) compared to females (IRR 1.31, 95% CI 0.92, 1.86) and the interaction term for gender and dementia was statistically significant ($p=0.02$). The interaction term was not statistically significant for pneumonia ($p=0.2$) and widowhood ($p=0.7$).

Discussion

In this study of a nationally-representative sample of community-dwelling older adults in the United States, about 1 in 10 PWD were hospitalized for pneumonia, 1 in 100 were hospitalized with a hip fracture, and 1 in 40 were widowed annually. As a point of comparison, just under 1 in 50 adults 65 and older were hospitalized for COVID-19 between March 2020 and September 2021.³⁶ Compared to PWoD, these rates were 80% higher for pneumonia and 40% higher for hip fracture. Although not statistically significant, point estimates for widowhood were 15% higher among PWD. Gender modified the association between dementia and hip fracture (higher ratios among males than females).

Our findings provide initial evidence that for a substantial proportion of community dwelling PWD, the clinical course is not one of gradual physical and cognitive decline^{2,3} – but is staggered, punctuated by potentially disruptive medical and social events that have the potential to markedly alter prognoses and care needs. As we expected, pneumonia and hip fractures were more common among PWD than PWoD. The higher hip fracture rates among

men with dementia but not women with dementia (compared to those without dementia) is likely explained by the higher prevalence of osteoporosis in women compared to men.³⁷ Osteoporotic women are more likely to sustain fractures following less severe falls and this may attenuate differences between women with and without dementia. Men, conversely, are less often affected by osteoporosis, and thus will only experience a hip fracture in the event of a severe fall, which are more common in PWD.³⁸ We did not find evidence for increased widowhood by dementia status. While this may be due to a small sample size and insufficient power, further research that measures the spousal caregiver stress experience is required to adequately examine this issue.

These findings fill a gap in our knowledge about how frequently these disruptive events occur in community-dwelling PWD in the U.S. and are also novel in considering these potentially disruptive medical, surgical, and social events congruently, rather than in isolation. Most U.S. based studies examining pneumonia and hip fractures have sampled from nursing home or hospital-based populations have focused on assessing prevalence and outcomes, not incidence.^{7,39} Findings from the few international studies that have examined incidence of these events in community-based populations are generally consistent with our findings.^{19,20,40–43} While recent studies of widowhood have examined the association between widowhood and risk of incident dementia^{44,45}, our study flips this equation to examine the association between dementia and risk of widowhood. By considering both medical/surgical and social potentially disruptive events as conceptually linked, we expand our examination of such events beyond a medically-focused paradigm to a paradigm that incorporates the social sphere, which may have equal or greater consequences on one's health.⁴⁶

Information on the absolute and relative frequency of these events will be useful for clinicians, healthcare systems, and policymakers. Clinicians can use these data as the basis for anticipatory guidance to PWD and caregivers about the likely course of illness to help inform financial and care planning, as well as help surrogates prepare for the complex medical decision making that may be required for PWD in the setting of what we have identified as not-uncommon acute disruptive events. Healthcare systems require these types of data to better manage their patient populations – particularly as reimbursement shifts from fee-for-service to value-based payments.⁴⁷ Planning for and managing high-need high-cost patient populations as exemplified by PWD experiencing disruptive events, is a key component of successful value-based care.⁴⁸ Policymakers can use these data for resource planning, risk adjustment and quality reporting, and development of payment models. Economic analyses that consider dementia as a gradually progressive disease with predictable expenditures are likely to underestimate the true yearly costs of this disease. Metrics for pneumonia and hip fracture care under the Centers for Medicare and Medicaid Services value-based and public reporting programs do not consider the contributions of dementia to patient outcomes.⁴⁹ Our data support the development of new measures that account for these interactions. Finally, payment models should be informed by our data when establishing case rates for PWD.

Widowhood likely has critical implications for community-dwelling PWD that will require further study. Spouses are often the primary, and frequently the only, caregiver

for community-dwelling PWD.⁵⁰ Thus, the death of a spouse may mean that alternate caregiving arrangements (e.g., moving in with adult children, hiring an in-home caregiver, or moving to facilities or settings with higher levels of care (e.g., assisted living, nursing homes) will need to be arranged. These arrangements may occur under potentially stressful circumstances and at significant financial cost to families and/or government payors, such as Medicaid, which most often covers the cost of in-home and facility-based long-term care.⁵¹ Since, as our results show, PWD already have much lower household wealth than PWD, it is critical that future research address the financial impacts of widowhood for PWD, not only for individuals and families, but also for long-term care payors.

This study has limitations. First, the algorithm to determine dementia status is not as rigorous as a formal clinical diagnosis, and misclassification may have occurred.³⁵ Misclassification may also have occurred because dementia status was only assessed at two-year time intervals, and it is possible that some people who developed dementia in the intervening time would be classified as not having dementia. However, this would likely have the effect of diminishing differences between the two groups, so if anything, differences are greater than what we observe. Furthermore, the algorithm-based approach does not allow for determinations of the severity of dementia, and there may be differences in incidence rates between people with mild versus moderate to severe dementia. Second, there was a relatively high proportion of participants missing data necessary to ascertain dementia status. However, sensitivity analyses demonstrated robust consistency in our estimates. Slight attenuations in differences when assigning those with missing data to the dementia group are to be expected, since most of those individuals will not have dementia and will therefore have lower incidence of events. Third, although about 85% of HRS respondents agree to have their data linked to Medicare, we cannot rule out selection bias from including only those HRS respondents with a Medicare linkage. Fourth, although studies show that 90% of MA hospitalizations are captured in Medicare claims data⁵², we may be missing some hip fractures and pneumonia cases among MA enrollees. However, we believe it is important to include MA enrollees in our analysis, considering that they recently comprise 30–40% of all Medicare enrollees. Fifth, our pneumonia events only included those that resulted in hospitalization and should not be construed as representing the rate of all community-acquired pneumonia cases. Finally, we do not yet know if the events examined in this study are disproportionately disruptive for PWD and whether findings of higher incidence and impact extend to other events, such as myocardial infarction and stroke.

In conclusion, this initial study provides data on the incidence of three potentially disruptive medical, surgical, and social events in community-dwelling people with dementia relative to people without dementia. These data fill a gap in our basic understanding of the frequency of these events, which can begin to inform anticipatory guidance discussions with patients and families and the development of services and supports to better support PWD and their caregivers. Forthcoming studies will assess the impacts of disruptive events on the trajectories of people with dementia, as well as the social and economic impacts of these events on caregivers and families.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Points

- Potentially disruptive medical, surgical, and social events may accelerate the trajectory of decline and impact caregiving needs in people with dementia.
- The incidence of potentially disruptive events has not been previously examined in community-dwelling people with dementia, who comprise the majority of the dementia population.
- We found that compared to people without dementia, people with dementia had higher age-adjusted incidence rates of pneumonia and hip fracture, while differences in widowhood rates were not statistically significant.

Why Does This Matter?

Knowing how often community-dwelling people with dementia experience potentially disruptive events can aid in anticipatory guidance and care planning for this growing population.

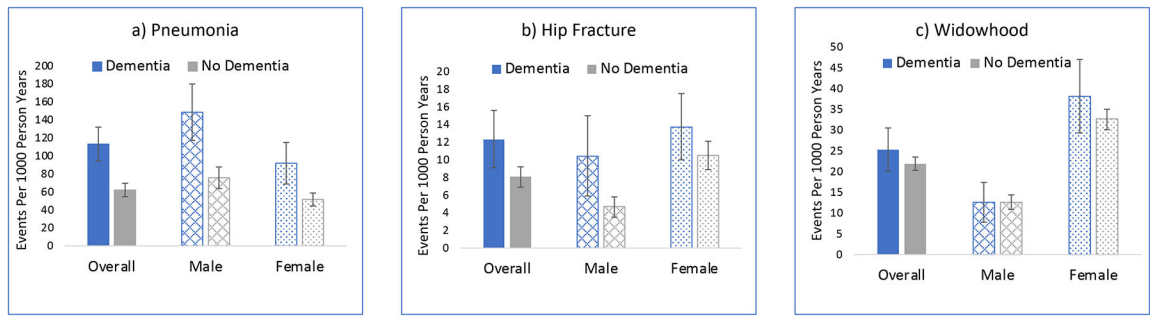


Figure 1. Age-adjusted incidence rates for: a) pneumonia; b) hip fracture; and c) widowhood in Health and Retirement Study participants, 2010–2018 (N=9,346). Bars indicate 95% confidence intervals.

Table 1.

Participant characteristics at baseline

	Total		Married/Partnered Subset	
	Dementia (N=596)	No Dementia (N=8,750)	Dementia (N=273)	No Dementia (N=4,823)
Mean follow-up time, years (SD)	4.0 (2.7)	6.9 (2.3)	4.1 (2.7)	7.0 (2.1)
Mean age (SD)	84 (6.6)	75 (5.7)	81 (7)	74 (6)
Age category, n (%)				
65–74	75 (13)	4435 (52)	39 (17)	2723 (59)
75–84	210 (33)	3337 (36)	142 (49)	1793 (34)
85+	311 (54)	978 (12)	92 (35)	307 (7)
Female, n(%)	381 (67)	5026 (57)	113 (39)	2177 (44)
Race and Ethnicity, n (%)				
Non-Hispanic White	371 (69)	6785 (84)	205 (77)	3972 (88)
Non-Hispanic Black	129 (14)	1103 (8)	29 (7)	416 (5)
Hispanic/Non-Hispanic Other	94 (17)	861 (8)	39 (16)	434 (7)
Less than high school education, n(%)	275 (44)	2308 (23)	98 (35)	961 (17)
Median household wealth, US \$ (IQR)	74,096 (1,905–278,505)	225,869 (65,960–569,840)	176,700 (132,000–772,118)	325,563 (58,000–579,000)
Current marital status, n (%)				
Married	226 (35)	5246 (58)	273 (100)	4,823 (100)
Divorced/separated/never married	70 (15)	1102 (15)	N/A	N/A
Widowed	200 (51)	2400 (27)	N/A	N/A
Living situation, n (%)				
Lives alone (or with spouse only in married/partnered subset)	166 (34)	2509 (32)	196 (74)	3940 (84)
Medicare Part C enrollee, n (%)	180 (29)	2784 (31)	85 (32)	1487 (31)
Medicaid dual eligible, n (%)	174 (28)	990 (10)	64 (14)	246 (4)
Number of comorbidities, mean (SD)	1.9 (1.2)	1.7 (1.1)	2.1 (1.2)	1.6 (1.1)
Impairments in activities of daily living, n (%)				
0–1	314 (54)	7890 (91)	128 (59)	4463 (94)
2+	276 (46)	854 (9)	145 (41)	360 (6)
Smoking status, n (%)				
Never smoker	306 (56)	3685 (42)	120 (50)	1997 (42)
Past or current smoker	282 (44)	4957 (57)	148 (50)	2782 (58)

Notes. Data Source: Health and Retirement Study, 2010–2018. Estimates are weighted to adjust for complex survey design. SD=standard deviation.

Table 2.

Age-adjusted incidence rate per 1000 person-years and incidence rate ratio of pneumonia, hip fracture, and widowhood in people with and without dementia (N=9,346)

	No Dementia	Dementia	
	Incidence Rate Per 1000 Person-Years (95% CI)	Incidence Rate Per 1000 Person-Years (95% CI)	Incidence Rate Ratio¹ (95% CI)
Pneumonia (all)	62.1 (54.7, 69.5)	113.1 (94.3, 131.9)	1.82 (1.53, 2.17)
Male	75.6 (63.6, 87.6)	148.4 (117.1, 179.8)	1.96 (1.57, 2.45)
Female	51.5 (44.3, 58.7)	91.8 (68.7, 114.9)	1.78 (1.39, 2.30)
Hip fracture (all)	8.1 (6.9, 9.2)	12.3 (9.1, 15.6)	1.53 (1.09, 2.14)
Male	4.7 (3.5, 5.8)	10.4 (5.9, 15.0)	2.24 (1.34, 3.75)
Female	10.5 (8.9, 12.1)	13.7 (10.0, 17.5)	1.31 (0.92, 1.86)
Widowhood (all)	21.9 (20.3, 23.5)	25.3 (20.1, 30.5)	1.15 (0.93, 1.44)
Male	12.6 (10.9, 14.4)	12.6 (7.8, 17.4)	1.00 (0.66, 1.13)
Female	32.7 (30.1, 35)	38.1 (29.3, 47.0)	1.17 (0.91, 1.49)

Notes. Data Source: Health and Retirement Study, 2010–2018. Estimates are weighted to adjust for complex survey design.

¹Reference group is people without dementia. Abbreviations: CI=Confidence interval

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Table 3. Sensitivity analysis using different approaches to missing assessment data on dementia status

	Pneumonia			Hip Fracture			Widowhood		
	Dementia	No Dementia	Incidence Rate Ratio (95% CI)	Dementia	No Dementia	Incidence Rate Ratio (95% CI)	Dementia	No Dementia	Incidence Rate Ratio (95% CI)
Last dementia status carried forward	114.5 (95.4, 133.6)	65.2 (57.4, 72.9)	1.76 (1.48, 2.09)	12.4 (9.2, 15.7)	8.0 (7.0, 9.1)	1.6 (1.1, 2.2)	25.6 (20.4, 30.8)	21.2 (19.6, 22.7)	1.2 (1.0, 1.5)
Change all missing to dementia	109.1 (92.8, 125.4)	63.4 (55.9, 71.0)	1.72 (1.49, 1.99)	10.9 (8.5, 13.3)	8.2 (7.0, 9.3)	1.3 (1.0, 1.8)	18.5 (15.1, 22.0)	22.2 (20.6, 23.9)	0.8 (0.7, 1.0)
Change all missing to no dementia	114.7 (95.6, 133.8)	65.2 (57.4, 72.9)	1.76 (1.48, 2.09)	12.5 (9.2, 15.7)	8.0 (7.0, 9.1)	1.6 (1.1, 2.2)	25.7 (20.5, 31.0)	21.2 (19.6, 22.7)	1.2 (1.0, 1.5)

Notes. Data source: Health and Retirement Study, 2010–2018. All analyses age-adjusted and weighted to account for complex survey design. Abbreviations: CI=confidence interval