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Authors
Brown, Rebecca T
Diaz-Ramirez, L Grisell
Boscardin, W John
et al.

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Functional impairment and decline in middle age: a cohort study

Rebecca T. Brown, MD, MPH[*,†], **L. Grisell Diaz-Ramirez, MS**[*,†], **W. John Boscardin, PhD**[*,†], **Sei J. Lee, MD**[*,†], and **Michael A. Steinman, MD**[*,†]

[*]Division of Geriatrics, University of California, San Francisco

[†]San Francisco Veterans Affairs (VA) Medical Center

Abstract

Background—Difficulties with daily functioning are common in middle-aged adults. However, little is known about the epidemiology or clinical course of these functional problems, including the extent to which they share common features with functional impairment in older adults.

Objective—To determine the epidemiology and clinical course of functional impairment and decline in middle age.

Design—Cohort study.

Setting—The Health and Retirement Study.

Participants—6874 community-dwelling adults aged 50–56 who did not have functional impairment at enrollment.

Measurements—Impairment in activities of daily living (ADLs), defined as self-reported difficulty performing 1 or more ADLs, assessed every 2 years over a maximum follow-up period of 20 years, and impairment in instrumental ADLs (IADLs), defined similarly. Data were analyzed using multi-state models which estimate probabilities of different outcomes.

Results—Twenty-two percent of participants developed ADL impairment between ages 50 and 64. Among these individuals, further functional transitions were common. Two years after the initial impairment, 4% (95% CI, 3%–5%) of participants had died, 9% (CI, 8%–11%) had experienced further ADL decline, 50% (CI, 48%–52%) had persistent impairment, and 37% (CI, 35%–39%) had recovered independence. In the 10 years following the initial impairment, 16% (CI, 14%–18%) had one or more episodes of functional decline, and 28% (CI, 26%–30%) recovered from their initial impairment and remained independent throughout. The pattern of findings was similar for IADLs.

Limitations—Functional status was self-reported.

Corresponding author and reprint requests: Rebecca T. Brown, MD, MPH, San Francisco Veterans Affairs Medical Center, 181G, 4150 Clement Street, San Francisco, CA 94121 (telephone: (415) 221-4810 X2-5863; Fax: (415) 750-6641; rebecca.brown@ucsf.edu).

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Statistical code: available as data supplement at Annals website

Data: publicly available from the Health and Retirement Study website at http://hrsonline.isr.umich.edu/

Conclusions—Functional impairment and decline are common in middle age, as are transitions from impairment to independence and back again. Because functional decline in older adults has similar features, interventions currently used to prevent functional decline among older adults may hold promise for adults in middle age.

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INTRODUCTION

To live independently, individuals must be able to perform basic activities of daily living, such as bathing, dressing, and transferring out of a bed or chair. Older adults who develop difficulty performing these activities, or "functional impairment," experience decreased quality of life and an increased risk of acute care utilization, nursing home admission, and death (1–3). For these reasons, slowing or preventing the progression to functional impairment is a key focus of the care of older adults.

Many people think of functional impairment as a problem affecting adults aged 65 and older, and especially the oldest old. Yet functional impairment is also common in middle age. About 15% of community-dwelling adults aged 55–64 have difficulty performing basic daily activities (4), compared to 20–25% of those aged 65 and older (5). Despite the high prevalence of functional impairment in this younger age group, little is known about the epidemiology or clinical course of functional impairment in middle age, including the extent to which it shares common features with functional impairment in older adults. Some have hypothesized that midlife functional impairments may be more transient and related to acute injuries or single diseases than are late-life impairments (6), which often result from a gradual, multifactorial process without a clear precipitating event (7, 8). However, previous studies in middle-aged adults have often focused on prevalent functional impairment, and do not distinguish between long-standing impairments due to congenital conditions or trauma versus impairments that are newly acquired in middle age and may have different risk factors and characteristics (9–12).

Understanding the epidemiology and course of functional impairment in middle age is key in developing appropriate strategies to manage functional impairment in our aging population and address rising societal costs from long-term care (1). If functional impairment in middle age has similar clinical course and risk factors to late life functional impairment, existing interventions to address functional impairment in older adults could potentially be adapted for this younger age group. Conversely, different risk factors and progression may require a different clinical approach.

We used nationally representative, longitudinal data to determine the incidence of functional impairment in adults aged 50–64, explore the course of functional decline in this age group, and identify risk factors for functional impairment in middle age.

METHODS

Participants

We analyzed longitudinal data from participants in the Health and Retirement Study (HRS). The HRS is a nationally representative longitudinal study of changes in the health and wealth of Americans over age 50 (13). Enrollment began in 1992 and additional participants are enrolled every 6 years so the study remains representative of the U.S. population over age 50. Participants are interviewed every 2 years by telephone; face-to-face interviews are conducted for participants unable to access a telephone or too ill to participate by telephone.

Our analytic cohort included participants who were aged 50–56 upon enrollment in the 1992, 1998, or 2004 survey waves. Of 8430 participants aged 50–56 at enrollment, we excluded 1280 who reported difficulty performing either activities of daily living (ADLs) or instrumental activities of daily living (IADLs) at the baseline interview, 252 who did not complete any follow-up interviews, and 24 who had missing ADL or IADL information at baseline. We analyzed data from the remaining 6874 individuals at approximately 2-year intervals until 2014.

The institutional review boards of the University of California, San Francisco, and the San Francisco Veterans Affairs Medical Center approved the study.

Measures

Functional impairment—We first examined two outcomes: the cumulative incidence of the first episode of ADL impairment in middle age, and the cumulative incidence of the first episode of IADL impairment. To assess cumulative incidence, we determined the proportion of participants who developed ADL and IADL impairment between ages 50 and 64, accounting for death as a competing risk (14, 15).

At baseline and each follow-up assessment, participants reported if they had difficulty performing each of 5 ADLs (bathing, dressing, transferring, toileting, eating) and 5 IADLs (managing money, managing medications, shopping for groceries, preparing meals, making telephone calls). Participants who reported that they had difficulty performing an activity were asked if they required help from another person to perform that activity. We defined ADL impairment as experiencing difficulty performing 1 or more ADLs. We defined IADL impairment similarly. For individuals enrolled in 1992, we considered 1994 to be the baseline assessment, as ADL and IADL measures in 1992 differed from those used subsequently. We determined date of death from the National Death Index and interviews with family members.

Functional trajectories—Studies in older adults suggest that functional status is dynamic and follows complex trajectories. While some people have persistent functional impairment after an initial episode, many others improve, although these latter individuals are at high risk for recurrence of functional problems (7, 16). Moreover, both groups are subject to worsening of functional status over time (7, 16, 17).

To evaluate trajectories of functional change in participants who experienced incident ADL impairment, we examined several functional outcomes over the course of follow-up. At 2 years' follow-up, we examined 4 outcomes: recovery of functional independence, persistent functional impairment, further functional decline, and death. We defined ADL recovery as returning to ADL independence, persistent ADL impairment as having as similar or improved function relative to the initial episode of impairment, and ADL decline as having worsened function relative to the initial episode of impairment. We also examined the worst functional outcomes over the 10 years following the initial impairment, using the same categories.

Other measures—Sociodemographic characteristics included self-reported age, sex, race/ethnicity, marital/partner status, educational attainment, household income, and household net worth. Income for the previous 12 months was based on a comprehensive list of before-tax income. Net worth was calculated by summing assets and subtracting debts.

Measures of health status included self-reported medical conditions. We defined visual impairment as self-rated fair or poor eyesight despite best correction, and hearing impairment as self-rated fair or poor hearing or use of a hearing aid. Other measures included cognitive impairment, assessed using a modified version of the Telephone Interview for Cognitive Status (range, 0–35; impairment defined as a score <5) (18); depression, assessed using the 8-item Center for Epidemiologic Studies Depression Scale (range, 0–8; clinically significant depressive symptoms defined as a score ≥3) (19, 20); and body mass index, calculated from self-reported weight and height.

Measures of health-related behaviors included self-reported alcohol use (21), smoking status, and infrequent physical activity (defined as participating in activity once weekly or less) (22). Measures of access to health care included health insurance and financial barriers to health care (defined as delaying filling a prescription or taking a medication because of cost). Measures of the physical environment included the self-reported condition of one's housing and safety of one's neighborhood.

Statistical analysis

We used descriptive statistics to examine participant characteristics and characteristics of episodes of functional impairment. These analyses included the prevalence of impairment in 1, 2, 3, 4, or 5 ADLs, and the most common pairings of ADL impairments among those with 2 impairments; we performed similar analyses for IADLs. These and the following analyses were adjusted for the complex HRS survey design to provide nationally representative estimates.

To calculate the cumulative incidence of the first episode of ADL impairment between ages 50 and 64, we used a survival analysis framework. We defined the baseline as age 50 and the event time as the age of onset of ADL impairment. Participants who enrolled after age 50 were considered to have a delayed entry time. As assessments occur every 2 years, the date of onset of ADL impairment could not be observed exactly. We estimated the event time to be midway between the date when impairment was first reported and the date of the previous assessment. We censored participants who ended their observation period or were lost to

follow-up; participants who missed the first follow-up but had a subsequent assessment were retained in analyses (Appendix, Approach to Missing Data). To account for the competing risk of death, we used competing risks survival analysis (23). We used a similar analytic framework to determine the cumulative incidence of IADL impairment and impairments in individual ADLs and IADLs.

To determine the predicted trajectories of functional impairment over time, we used multi-state survival modeling. Briefly, multi-state models describe the probability that participants transition between 3 or more states, and can be used to characterize longitudinal trajectories in datasets in which participants enroll at different ages and are followed for different time periods (24). We used a 6-state Markov model to examine the probability of transitioning between different states of functional impairment, using the SPACE (Stochastic Population Analysis for Complex Events) programs for SAS (25). We defined states using a summed ADL score. For each individual ADL, the score could take a value of 0 (independent), 1 (difficulty performing that ADL), or 2 (need for help performing that ADL). The maximum score for all 5 ADLs thus ranged from 0 to 10. We defined 6 states by categorizing the ADL scores as 0, 1, 2, 3, 4 or more, and a final absorbing state for death. We chose the 6-state model for its clinical relevance and to ensure adequate frequencies of observed transitions between all possible states.

We first used the multi-state model to determine the probability at each age of transitioning between each state. We next used these transition probabilities to simulate functional outcomes every 2 years through age 76 for 1,000,000 microsimulated participants who were independent at study entry at age 50. Using an analytic framework similar to that used for the cumulative incidence analyses, we then calculated the percentage of participants who experienced a first episode of ADL impairment before age 65. Among individuals with incident impairment, we calculated the percentage of participants who experienced functional recovery, persistence, decline, or death at 2 and 10 years following the initial impairment. We defined ADL recovery as returning to ADL independence (ADL score of 0), persistent ADL impairment as having the same ADL score as the initial episode of impairment or an improved (but non-zero) score, and ADL decline as an increase in ADL score relative to the initial episode of impairment. We performed survey-weighted bootstrapping (with 100 resampled datasets and 100,000 microsimulations per dataset) to calculate 95% confidence intervals for these estimated probabilities.

We identified risk factors for functional impairment using competing risks regression (Appendix, Risk Factors). We performed similar analyses for IADLs. Analyses were performed using Stata 14.2 (Stata Corp., Chicago, IL) and SAS 9.4 (SAS Institute Inc., Cary, NC).

Role of the Funding Source—The National Institute on Aging and National Center for Advancing Translational Sciences had no role in the study's design, conduct, or reporting.

RESULTS

Of the 6874 participants, 54% percent were men, 80% were white, and 15% had less than a high school education (Table 1). A substantial proportion of participants experienced a first episode of ADL impairment between ages 50 and 64. The cumulative incidence of ADL impairment increased with age, reaching 22% at age 64 (95% CI, 21%–23%; Figure 1). Difficulty in dressing was the most common ADL impairment, affecting 14% of individuals during at least one biennial assessment through age 64 (CI, 13%–15%; Figure 2). Less common were impairments in transferring (cumulative incidence, 11%, CI, 10%–12%), toileting (7%, CI, 7%–8%), bathing (7%, CI, 6%–8%), and eating (3%, CI, 3%–4%).

Most participants with a first episode of ADL impairment had impairment in 1 ADL (70%), with a smaller percentage having impairment in 2 ADLs (19%), 3 ADLs (6%), 4 ADLs (4%), or 5 ADLs (1%; Appendix Table 1). Among participants with 2 ADL impairments, the most common pairing was impairments in transferring and dressing.

Analyses of further functional transitions after the index impairment were estimated using multi-state models. Among participants who experienced an initial episode of ADL impairment, further functional transitions were common. Two years after an initial episode of impairment, 37% (CI, 35%–39%) of participants had fully regained ADL independence (Figure 3). The remainder fared worse: 50% (CI, 48%–52%) remained at a stable or improved (but not fully independent) level of functional impairment; 9% (CI, 8%–11%) had worse functional status; and 4% died (CI, 3%–5%).

During the 10 years following the initial episode of ADL impairment, 28% (CI, 26%–30%) recovered independence and remained independent throughout. An additional 37% (CI, 35%–39%) had one or more episodes of stable or improved functional impairment, 16% (CI, 14%–18%) had one or more episodes of further ADL decline, and 19% died (CI, 16%–21%).

The pattern of findings for IADLs was similar. The cumulative incidence of IADL impairment at age 64 was 19% (CI, 18%–20%; Appendix Figure 1). Difficulty in shopping for groceries was the most common impairment, affecting 10% of participants by age 64 (CI, 9%–11%), followed by difficulty in managing money (cumulative incidence, 8%, CI, 7%–8%) and preparing meals (6%, CI, 5%–7%; Appendix Figure 2). Most participants with a first episode of IADL impairment had impairment in 1 IADL (78%), with a smaller percentage having impairment in 2 IADLs (15%), 3 IADLs (4%), 4 IADLs (2%), or 5 IADLs (2%; Appendix Table 2). Difficulties with shopping and preparing meals was the most common combination of IADL impairments.

Baseline characteristics differed in people who developed a first episode of ADL impairment in middle age versus those who did not. Participants who developed ADL impairment were more likely to be women, less likely to be white, and less likely to be married, and had lower socioeconomic status, including lower education, income, and net worth (Table 1). They also had worse health status, including a higher prevalence of chronic medical conditions, sensory impairments, depression, and obesity. Participants who developed ADL impairment were more likely to smoke and to exercise infrequently, and more likely to lack health

insurance and report financial barriers to health care. They were also more likely to report that the condition of their housing and the safety of their neighborhood was fair or poor.

In multivariable analyses, the strongest predictors of ADL impairment included low income, stroke, and arthritis; additional risk factors included other chronic medical conditions, sensory impairment, depression, obesity, infrequent physical activity, lacking health insurance, and living in a neighborhood with fair or poor safety. Risk factors for IADL impairment were generally similar (Appendix Tables 3 and 4).

DISCUSSION

In this nationally representative study of community-dwelling adults, functional impairment and decline were common in middle age. Nearly one-quarter of participants developed new functional impairment between ages 50 and 64, and nearly two-fifths of individuals who developed functional impairment died or experienced further functional decline in at least one time period over the next 10 years, either directly or after an intervening period of functional stability or improvement. However, other patterns of functional transitions were also common, including durable return to independence. Risk factors for functional impairment spanned several domains, including sociodemographics, health status, health-related behaviors, and the physical environment.

Previous cross-sectional studies have shown that functional impairment is common in middle age. However, these impairments have traditionally been viewed as transient and related to acute injuries or single diseases, in clinical distinction to the more chronic and progressive impairments in older adults (6). A growing body of research in adults aged 70 and older has now shown that functional impairment in older adults is actually surprisingly dynamic, with difficulties in basic daily activities developing and regressing over relatively short time periods (7, 16). This dynamism is thought to result from intervening events that precipitate disability, such as illness, injury, and hospitalization, followed by periods of recovery (26). This work has also shown that even though initial recovery from disability is common, a first episode of functional impairment is a seminal event that strongly predicts progression to more chronic impairment (7, 16, 17).

Our findings suggest that the same general patterns are true of functional impairment in middle age. Although the cumulative incidence of ADL impairment was nearly 25% by age 64, more than one-third of these participants had recovered functional independence 2 years later. However, overall nearly two-fifths of individuals with an initial episode of ADL impairment died or experienced worsened functional status over time. These findings suggest that an initial episode of ADL impairment was an important prognostic marker, even in this relatively young age group.

Our findings also point to key differences in the patterns of incident ADL and IADL impairment in middle-aged versus older adults. The cumulative incidences of ADL and IADL impairment were comparable in this cohort, at 22% and 19%, respectively, a finding consistent with previous cross-sectional research in middle-aged adults (27, 28). In older adults, in contrast, the prevalence of IADL impairment typically substantially exceeds that

of ADL impairment (29, 30). The higher prevalence of IADL impairment in older adults is thought to reflect a hierarchical disabling process, in which loss of independence in IADLs precedes that of ADLs, driven largely by the effect of cognitive impairment on the ability to perform cognitively complex IADL tasks (6, 31). The lower burden of IADL impairment in this middle-aged cohort may reflect the low prevalence of cognitive impairment.

Our findings also reveal differences in the onset of individual ADL impairments in middle-aged versus older adults. Dressing impairment had the highest cumulative incidence and the earliest age of onset in this cohort, followed by transferring, toileting, bathing, and eating; previous cross-sectional studies of middle-aged adults show similar findings (28, 32). In contrast, research in adults aged 70 and older shows that bathing is typically the first ADL disability that develops, followed by dressing, transferring, toileting, and eating (33–35). It is unclear why dressing and transferring difficulties precede bathing difficulty in middle-aged adults, because these tasks require similar abilities, including upper and lower extremity strength and mobility (35, 36). However, these findings suggest that interventions to address functional impairment in middle age must be tailored to meet the specific functional needs of this age group, which may differ from those of older adults.

Our findings further point to key similarities between risk factors for functional problems in middle age and those in older age, but also important differences. Shared risk factors across age groups include low income, chronic medical conditions, sensory impairment, depression, obesity, and low physical activity (31, 37). However, other classic risk factors for functional impairment in older age were not risk factors in this cohort, including sex, cognitive impairment, and low body mass index.

Several factors may explain these differences. Previous research shows that older women report more functional problems than do men, and that this disparity may be related to a higher burden of disabling conditions among older women, including osteoporosis, osteoarthritis, and depression (38–42). However, gender differences in disability may not emerge until age 65, when differential risk factors reach a critical mass (41). The prevalence of cognitive impairment in this middle-aged cohort was too low to examine its association with functional outcomes; the same was true of low body mass index.

Finally, we found that functional impairment was multifactorial, with risk factors including sociodemographics, health status, and health-related behaviors. This finding is important because many geriatric models of care that address functional impairment are multi-component interventions that target individual patients' multiple risks and needs. Our findings suggest that a similar approach may be appropriate for middle-aged adults. Indeed, proven geriatric models of care have already been successfully delivered to vulnerable middle-aged adults (43, 44). Novel models of care that improve functioning in low income older adults (45) may hold similar promise for low income adults in middle age.

This study has several limitations. Measures of function were based on self-report rather than objective measures. However, self-reported function is an important patient-centered measure (46) that strongly predicts adverse outcomes (2, 47, 48). We excluded individuals who lacked follow-up data; individuals with more functional impairment may have more

difficulty completing follow-up interviews, potentially leading to underestimation of functional outcomes and affecting generalizability. However, HRS performs in-person interviews with participants unable to complete interviews by telephone due to illness or functional limitations, which may mitigate this issue. Finally, because assessments occurred every 2 years, shorter periods of functional impairment may be missed, leading to underestimation of functional outcomes.

In conclusion, we found that functional impairment was common in middle age, and that nearly two-fifths of individuals who developed functional impairment went on to experience death or further functional decline. Risk factors for functional impairment spanned multiple domains, including socioeconomic status, health status, and health-related behaviors. These findings challenge traditional thinking that functional impairment in middle age is merely a transient phenomenon, and point to common features between functional impairment in middle and older age. At the same time, functional impairments in middle age had distinct characteristics from those in older age, including a relatively lower cumulative incidence of IADL versus ADL impairment and differing patterns of impairment in individual ADLs. Taken together, these findings suggest that interventions commonly used to prevent functional decline in older adults may hold promise for adults in middle age, but will need to be tailored to meet the unique needs of middle-aged adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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All contributors are included as authors.

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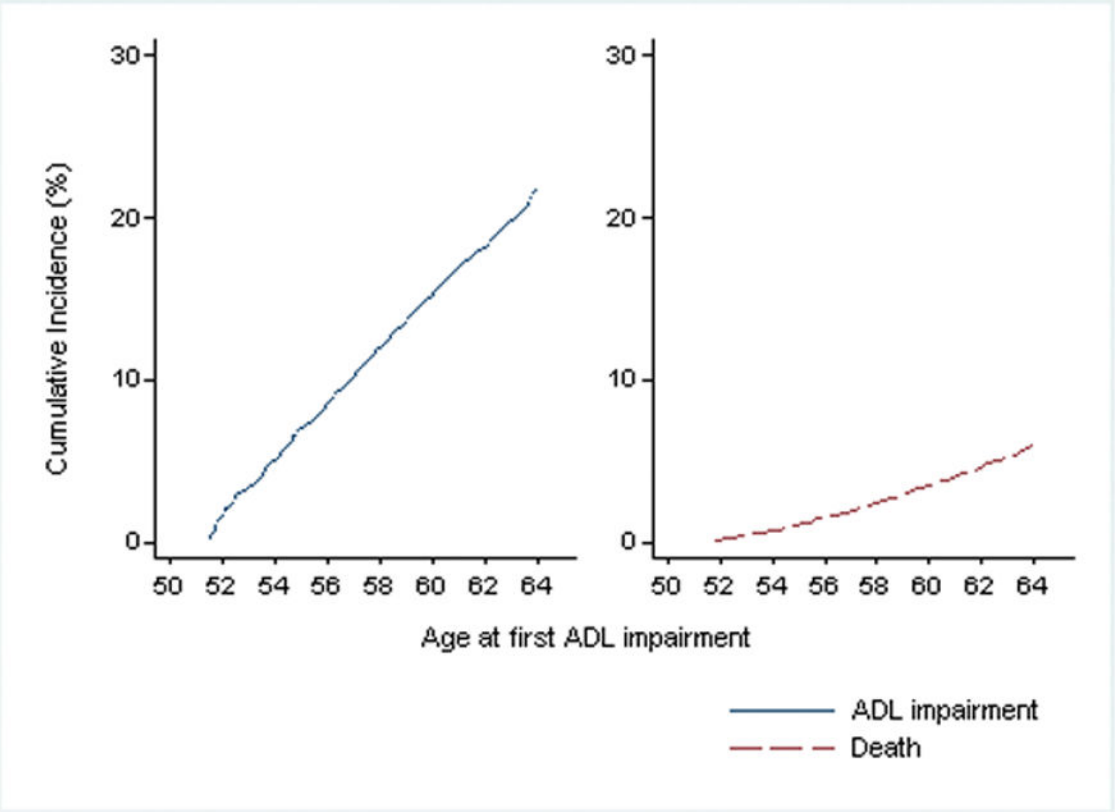

Figure 1. Cumulative Incidence of ADL Impairment and Death Among Middle-Aged Adults

The figure shows the cumulative incidences of ADL impairment (Panel 1) and death (Panel 2) between the ages of 50 and 64, determined using competing risk survival analysis to account for the competing risk of death. Analyses were adjusted to account for the complex survey design.

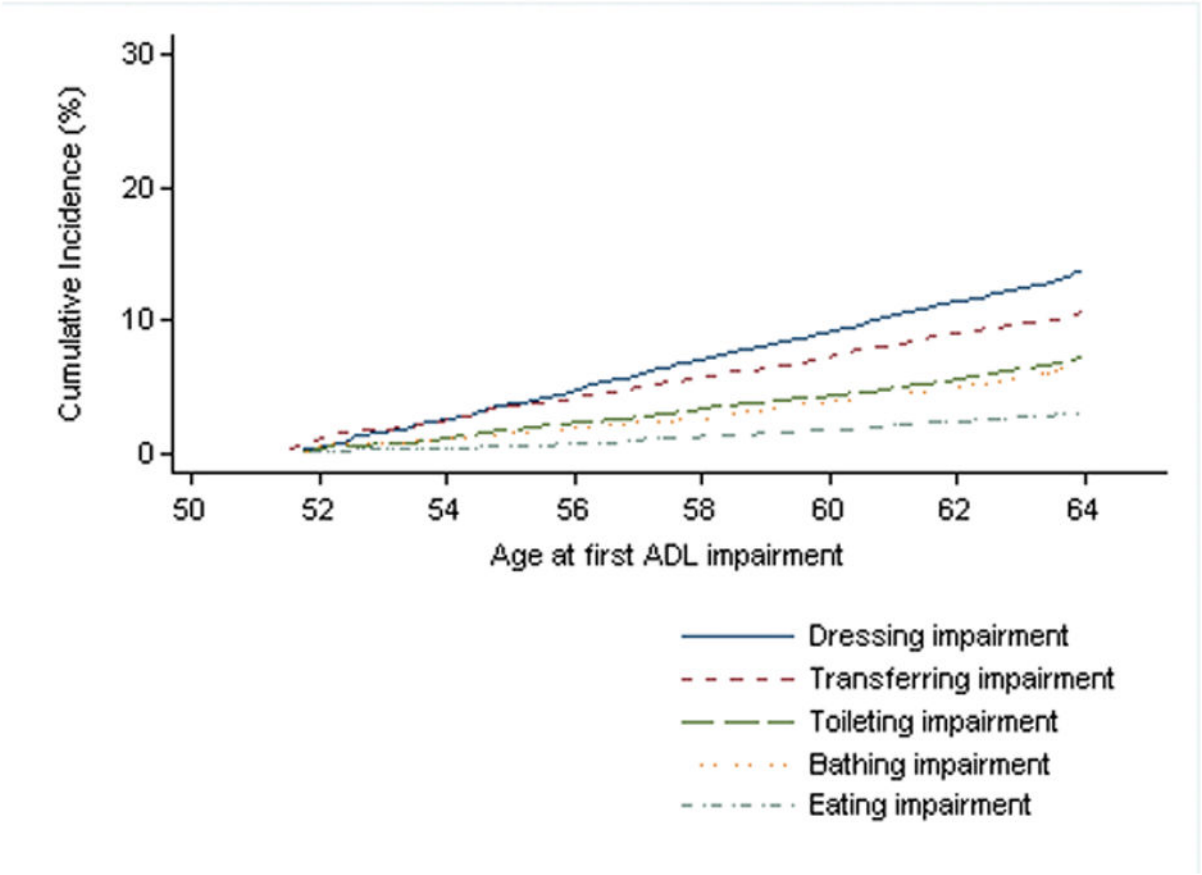

Figure 2. Cumulative Incidence of Impairment in Individual ADLs Among Middle-Aged Adults

The figure shows the cumulative incidences of individual ADL impairments between the ages of 50 and 64, determined using competing risk survival analysis to account for the competing risk of death. Analyses were adjusted to account for the complex survey design.

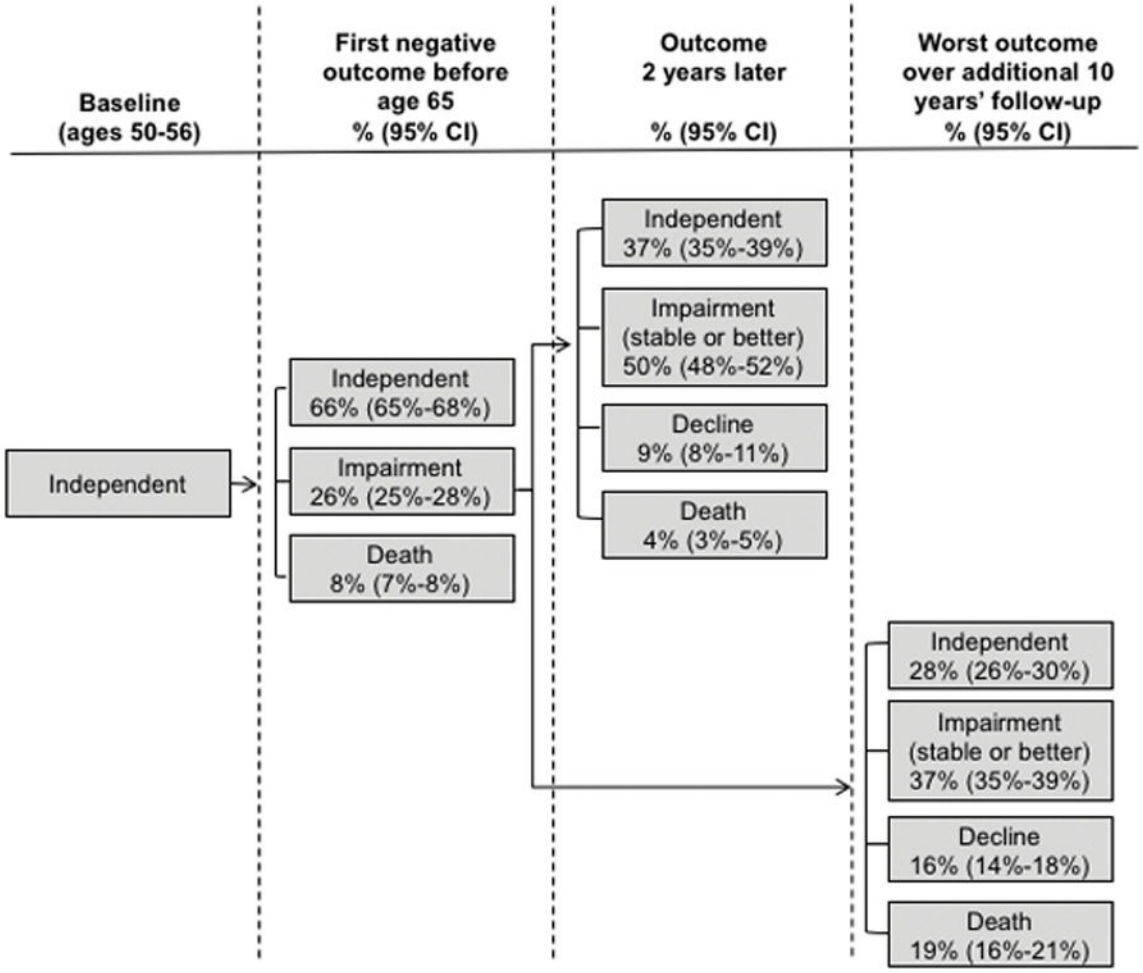

Figure 3. Flow-chart of Predicted Functional Outcomes among Middle-aged Adults

The figure shows the probabilities (and corresponding 95% confidence intervals) of differing functional outcomes among middle-aged adults, estimated using a multi-state model. The predicted probability of experiencing a first episode of ADL impairment in the multistate model (26%) differed slightly from that in the competing risks model (22%).

Table 1

Baseline Characteristics of 6874 Participants with and without Incident ADL Impairment in Middle Age

Characteristic*	All participants (n=6874)	ADL impairment (n=1192)	No ADL impairment (n=5682)	P value
Demographics, %				
Female	46	50	45	.011
Race/ethnicity				<.001
White non-Latino	80	71	82	
Black non-Latino	9	14	9	
Latino	7	11	7	
Other	3	4	3	
Married or partnered	75	68	76	<.001
Socioeconomic status, %				
Less than high school education	15	26%	13%	<.001
Income quartile, $				<.001
Quartile 1	≤32,363	43%	22%	
Quartile 2	32,363, ≤60,000	24%	25%	
Quartile 3	60,000, ≤98,192	20%	26%	
Quartile 4	>98,192	13%	27%	
Net worth quartile, $				<.001
Quartile 1	≤44,500	41%	22%	
Quartile 2	44,500, ≤136,000	26%	25%	
Quartile 3	136,000, ≤345,000	19%	26%	
Quartile 4	>345,000	14%	27%	
Health status, %				
Chronic medical conditions				
Hypertension	29	39%	27%	<.001
Stroke	2	4%	1%	<.001
Diabetes	7	15%	6%	<.001
Cardiac disease	7	11%	7%	<.001
Lung disease	3	6%	2%	<.001
Cancer	4	5%	3%	.016
Arthritis	25	43%	22%	<.001
Other health conditions				
Visual impairment	12	23%	10%	<.001
Hearing impairment	11	16%	10%	<.001
Telephone Interview for Cognitive Status score, mean (SD) †,‡	25.0 (2.9)	24.0 (2.9)	25.1 (2.5)	<.001
Depression	16	27%	13%	<.001
Body mass index				<.001
<18.5	1	1	1	
18.5–24.9	30	22	32	
25–29.9	42	37%	43%	

Characteristic*	All participants (n=6874)	ADL impairment (n=1192)	No ADL impairment (n=5682)	P value
≥30	27	41%	25%	
Health-related behaviors, %				
Alcohol use, ≥3 drinks per day	12	12%	12%	0.95
Current smoker	23	30%	22%	<.001
Infrequent physical activity	60	68%	59%	<.001
Access to health care, %				
Uninsured	11	19%	10%	<.001
Financial barriers to medical care	8	17%	7%	<.001
Physical environment, %				
Fair or poor condition of housing†	11	23%	9%	<.001
Fair or poor safety of neighborhood	9	18%	8%	<.001

Abbreviations: ADL, activities of daily living; SD, standard deviation.

*Results weighted to generate nationally representative estimates and account for the complex survey design.

†Includes only those enrolled in 1998 and 2004, as variable was not available at baseline for participants enrolled in 1992.

‡We report mean scores rather than percentage of participants with cognitive impairment, because no participants met criteria for cognitive impairment at study enrollment.