Education Inequalities in Dual-Function Life Expectancy in the United States

Abstract

Background: This study investigates gender- and education-based inequalities in dual functionality, a new concept that captures a combination of physical and cognitive functioning, both of which are important for independent living and quality of life.

Methods: Using data from the Health and Retirement Study and the National Health Interview Study Linked Mortality Files, we define a measure of dual functionality based on the absence of limitations in activities of daily living and dementia. We estimate dual-function rates (percent free of limitations) and age-50 dual-function expectancy (2FLE) by gender and education.

Results: In their early 50s, only about 65 percent of women with less than a high school degree manifest dual functionality as compared with over 90 percent of women with at least a four-year college degree. A similar pattern holds among men. These education-based gaps in dual functionality remain across later life, even as dual-function rates decline at older ages. The lower dual-function rates among women and men with less education translate into inequalities of 11.6 to 12.9 years in age-50 2FLE between older adults with at least a four-year college degree compared to older adults with less than a high school degree.

Discussion: Older adults, particularly women, with less than a high school degree are estimated to live a smaller percentage of their remaining years with dual functionality compared with older adults with at least a college degree. These inequalities have

implications for the distribution of caregiving resources of individuals, family members, and the broader health care community.

Introduction

People with higher levels of education generally experience better health across an array of indicators than people with lower levels of education. Numerous studies have documented strong relationships between education and physical function. Higher levels of education are associated with lower rates of disability (Montez et al., 2017; Schoeni et al., 2005; Tsai, 2016; Zajacova & Montez, 2017), later onset of functional limitations (Haas, 2008; Haas & Rohlfsen, 2010; Luo & Waite, 2005), and higher disability-free or healthy life expectancy (Cantu et al., 2021; Crimmins & Saito, 2001). For instance, age-standardized disability rates show less than 5 percent of adults with at least a four-year college degree are disabled compared with 21.5 percent of adults with less than a high school degree (Montez et al., 2017). The differences across education levels in the prevalence of disability translate into substantial inequalities in healthy life expectancy. People with a college degree or higher have a healthy age-50 life expectancy about 13 years longer than people with less than a high school degree (Cantu et al., 2021). These education-based inequalities are more pronounced for women than men and have increased among older adults from the 1990s into the mid 2000s (Solé-Auró et al., 2015; Tsai, 2016; Zajacova & Montez, 2017).

A parallel stream of research has examined the relationship between education and cognitive function. Higher levels of education are associated with lower rates of cognitive impairment without dementia (CIND) and dementia (Alley et al., 2007; Crimmins et al., 2018; Walsemann & Ailshire, 2020), potentially slower rates of cognitive decline (Alley et al., 2007), and higher dementia-free or cognitively healthy life expectancy (Crimmins et al., 2018; Farina et al., 2020; Garcia et al., 2021). A snapshot of adults in their mid-60s found roughly 97 percent of people with at least a college degree exhibited no indication of CIND or dementia as compared with roughly 58 percent of people with less than a high school degree (Crimmins et al., 2018). Similar to physical function, such inequalities result in substantial differences in cognitively healthy life expectancy. For instance, adults at age 65 with at least a college degree have a cognitively healthy life expectancy that is about 9 years greater than older adults with a high school degree or less (Crimmins et al., 2018). Studies that stratify by gender find that the gap in cognitively healthy life expectancy across education levels is about one year greater for older women than men (Crimmins et al., 2018; Garcia et al., 2021).

A decline in either physical or cognitive function can have substantial impacts on people's lives. Limitations in either domain may necessitate additional care, render it difficult to remain living independently, and broadly diminish quality of life. This study draws on a new concept, *dual functionality*, that represents a combination of maintaining physical and cognitive function and bridges two separate streams of research (identifying references omitted). We use this concept to document education- and gender-based inequalities in the prevalence of dual functionality among older adults and age-50 dual-function life expectancy (2FLE). Our estimates reveal substantial differences by education in rates of dual functionality and 2FLE that vary by gender and hold noteworthy implications for population health inequalities.

Dual Functionality

Combining physical and cognitive function into a single concept of dual functionality comes with two primary benefits. First, although stemming from, in part, separate etiologies, a reduction in either physical ability or cognitive capacity can lead to similar challenges for an individual and one's family and friends with respect to caregiving and future living arrangements. A notable loss of either physical or cognitive function typically necessitates alterations to residential living spaces or moving to a new residence, arrangements for the provision of care, and a host of changes in social engagement and personal pursuits (Fauth, Elizabeth Braungart et al., 2007; Fingerman et al., 2021). Given the potentially serious individual, familial, social, and community consequences, a focus on dual functionality and its loss provides a new perspective on an important component of population health and population health inequalities.

Second, the concept accords with the way many people think about aging. Research on people's feelings about aging and desires for longevity finds that, not surprisingly, people wish to live to older ages but, at the same time, are less enthusiastic about additional years if they come with physical or cognitive impairments (Lawton et al., 1999). In general, people appear to weigh independent living and quality of life highly when imagining their futures.

Education, Gender, and Dual Functionality

There are well documented relationships between educational attainment and the components of dual functionality—physical and cognitive function—and a number of different mechanisms have been proposed as underlying these relationships for women and men (Zajacova, 2006). With respect to physical function, additional education may lead to less physically demanding occupations, healthier lifestyles, a lower likelihood of exposure to environmental hazards, better access to healthcare, and a reduced risk of developing early chronic conditions that could impede functioning (Cockerham et al., 2020; Mirowsky, 2017; Tsai, 2016; Zajacova & Lawrence, 2018). With respect to cognitive function, many of the same mechanisms likely play a role, but in addition scholars have focused on processes within the brain (Garcia et al., 2021; Walsemann & Ailshire, 2020). Education is thought to generate cognitive reserve, a concept that captures differences in cognitive efficiency, capacity, or flexibility that can render people more or less susceptible to brain pathology (Barulli & Stern, 2013). People with higher cognitive reserve may be able to delay the onset of cognitive impairment (Stern et al., 2020). As a combination of physical and cognitive function, we expect the same set of mechanisms to link education with dual functionality such that people with higher levels of education are more likely to retain dual functionality into older ages.

Studies examining gender inequalities in the education-health gradient propose, and have found some evidence for, differences in the mechanisms linking education and health (Montez et al., 2009; Ross et al., 2012; Zajacova, 2006; Zajacova & Lawrence, 2018). For instance, although on average women earn less than men, women receive greater returns to education on the labor market (DiPrete & Buchmann, 2006). Similarly, the link between education and a variety of health behaviors varies by gender (Cockerham et al., 2017, 2020). Differences in underlying mechanisms may, in part, account for the observed greater inequalities in physical and cognitive function across levels of education for women than men. With respect to dual functionality, we expect different age-adjusted rates by gender due to the well-documented pattern in which women live longer than men but in worse health (Read & Gorman, 2010). Moreover, as dual functionality reflects a combination of physical and cognitive function and each component has multiple underlying mechanisms that vary in strength by gender, we also expect to observe differences in education-based inequalities in dual functionality across women and men.

Methods

Sample

Our analysis draws on two sources of public-use data: (1) the Health and Retirement Study (HRS; Bugliari et al., 2021) and (2) the National Health Interview Study with Linked Mortality Files (NHIS-LMF; Blewett et al., 2019). The HRS is a biennial, longitudinal, nationally representative survey of the non-institutionalized population of US adults ages 50 and older and their spouses. We used a harmonized version of the HRS created by the RAND Corporation merged with measures of cognitive function from the Langa-Weir classification data (Langa et al., 2020).

The NHIS is an annual repeated cross-sectional study, nationally representative of the non-institutionalized adult US population. The National Center for Health Statistics (NCHS) linked respondents from the 1985 through 2014 surveys with the National Death Index (NDI) to include prospective mortality information as of December 31, 2015 (National Center for Health Statistics, 2019).

With the HRS data we constructed an analysis sample with all observations of respondents aged 50 and older beginning in 2000 and concluding 8 waves later in 2016. We chose this time frame due to consistency in the HRS measures of cognitive function and to maximize sample size with rough comparability to the NHIS-LMF mortality data. The baseline sample has 35,158 respondents contributing a total of 170,203 person-year observations. From the baseline sample we dropped person-year observations with zero or missing sample weights (N = 3,826), observations missing data for our component measures of dual functioning (N = 235), and observations missing data for gender or education (N = 29). These sample restrictions result in an analysis sample of 166,113 person-year observations from 34,668 respondents.

We use data from the NHIS-LMF from 1999 to 2014 for 380,497 respondents ages 50 and older that were eligible for NDI linkage. From the baseline sample we dropped respondents with mortality weights of zero (N = 353), a respondent missing information on the date of death (N = 1), and respondents missing data for gender or education (N = 6,800). These sample restrictions result in an analysis sample of 373,343 respondents, 63,068 of whom had a date of death.

Measures

We construct an indicator for dual functionality by combining information from one measure of physical function, activities of daily living (ADLs) limitations, and one measure of cognitive function, dementia status based on a battery of cognitive tests. The HRS includes five ADL tasks – bathing, dressing, eating, getting in or out of bed, and walking across a room – and asks respondents (or their proxies) if they have any difficulty with each task. ADL limitations represent the best measure of physical functioning for dual functionality because they capture an "inability or limitation in performing socially defined activities and roles" (Verbrugge & Jette, 1994). As such, ADL limitations reflect an interaction between a person, the environment, and social roles, whereby a limitation represents a significant challenge to independent living.

For cognitive function, the HRS asks respondents a variant of the Telephone Interview for Cognitive Status (TICS) that includes the immediate and delayed recall of a 10-word list, serial 7s subtraction, and a backward counting task (Brandt et al., 1988; Crimmins et al., 2011). Based on the sum of the items, respondents with a score of 6 or lower are classified as having dementia.

For respondents who were not able to complete a direct interview themselves, proxy reports of memory (0 = excellent to 4 = poor), the number of limitations of instrumental activities of daily living (a count from 0 to 5), and interviewer assessments of the perceived role of cognitive limitations in completing the interview (0 = no cognitive impairment to 2 = has cognitive impairment) were used. After reverse coding the original proxy responses, adults with a total score of 6 or below were classified as having dementia (Crimmins et al., 2011; Langa et al., 2020).

We incorporated proxy reports for ADLs and cognitive function because to exclude them would risk undercounting respondents who lost dual functionality. Seven percent of our person-year observations rely on proxy reports. Based on these two measures of physical and cognitive function respectively, we identified dual functioning respondents at a given age as those with no reported limitations with ADLs and no indication of dementia.

The covariates we use to define our subpopulations are gender and educational attainment (see Table 1). We harmonized information on educational attainment across the HRS and NHIS-LMF to create three categories of attainment: (1) less than a high school degree, (2) a high school degree, a GED, vocational training, or some college, and (3) a four-year college degree or higher degree. Past studies examining disability-free life expectancy or cognitively healthy life expectancy typically define separate categories for a high school degree and GED versus vocational training and some college (Crimmins et al., 2018) or define the highest education level as some college and above (Farina et al., 2020; Garcia et al., 2021). In preliminary analyses we adopted the four-category operationalization for educational attainment and found (1) limited evidence of a difference in dual-function rates between older adults with a high school degree or GED as compared with older adults with vocational training or some college and (2) large standard errors and confidence intervals for estimates of dual-function rates for older age groups of people with vocational training or some college. Therefore, we relied on a three-category educational attainment measure for our primary analyses (analyses based on the four-category educational attainment measure are available upon request).

-- Table 1 about here --

Analyses

To estimate age-interval specific dual-function rates (percentage free of limitations), we fit logit models with indicators for the five-year age intervals for each subpopulation (e.g., a separate model for older women with less than a high school degree). In fitting the logit models, we used the RAND person-level sample weights combined with weights for respondents who entered nursing homes and adjusted for the complex sampling design of the HRS. We then used the model estimates to calculate dual-function rates along with standard errors and confidence intervals for each age interval for each subpopulation.

We used the NHIS-LMF data to estimate mortality rates for five-year age intervals using survival models. To do this we constructed an indicator for mortality (1 = died, 0 = alive as of December 31, 2015) and an exposure measure based on respondents' ages on January 1 of the year of their interview and ages of death based on the year and quarter provided in the NHIS-LMF data. We assigned midpoints for components of dates not included in the data (i.e., day of birth or death is assumed to be 15 and month of death is assumed to be the middle month of the quarter). We fit continuous-time survival models with an exponential distribution and age as a continuous measure for each subpopulation. We use the NHIS-LMF recommended mortality sample weights when fitting the models. We then predict age-group specific mortality rates for each age interval based on the model estimates. Although this is a coarse model for estimating mortality rates, consistent with prior work it performs well and comes quite close to replicating estimates of age-50 life expectancy in 2015 based on US vital statistics (Arias & Xu, 2018; Brown et al., 2019; Lariscy et al., 2015).

We subsequently used Sullivan life tables to calculate age-50 total life expectancy (TLE) and age-50 dual-function life expectancy (2FLE) for subpopulations defined by gender and levels of education (Sullivan, 1971). This is a period or prevalence-based multistate life-table approach in which a synthetic cohort is aged through age-group specific mortality rates and dual function rates. Sullivan life tables have been widely used to document disability-free life expectancy and cognitively healthy life expectancy, particularly when data limitations preclude reliable estimates for incidence-based multistate life table approaches (Cantu et al., 2013; Crimmins et al., 2018; Farina et al., 2020; Garcia et al., 2019, 2021; Hayward et al., 2014). As applied to our analysis, Sullivan life tables have two key inputs: mortality rates and dual-function rates for specific ages or age intervals. Following standard life table conventions, we constructed 5-year age intervals beginning at age 50. Given data sparseness, we treated age 85 and older as our top interval. In preliminary analyses we used 2-year age intervals and obtained nearly identical results. To calculate standard errors for our estimates of life expectancy we implemented a bootstrapping procedure that resamples both the NHIS-LMF and the HRS person-level data in each iteration and used 500 iterations to obtain bootstrap standard errors for our estimates of age-50 TLE and age-50 2FLE (see Garcia et al. [2021, 2019] for a similar approach).

All data preparation and analyses were conducted in R using publicly available data downloaded from IPUMS and the Institute for Social Research (ISR). Replication code is maintained at the Open Science Framework [identifying location omitted for review].

Results

Dual-Function Rates

Figure 1 illustrates the estimated dual-function rates across the age-groups by gender and educational attainment. Beginning with women (Panel A), we find high dual-function rates of 88 to 95 percent that exhibit minimal decline up to age 70 for women with a high school degree/some college and women with at least a four-year degree. The gap between women with a high school degree/some college and women with at least a four-year degree appreciably narrows over this age range. We see a similar steady pattern for women with less than a high school degree through age 70, but at a much lower baseline of 68 percent at ages 50 to 54. We observe sharper declines in dual-function rates beginning around age 70 for all education levels. During this period the differences between women with a high school degree/some college and women with at least a four-year degree further converge and have overlapping confidence intervals. There is less evidence of convergence among older women with less than a high school degree who have an estimated dual-function rate of just over 30 percent for ages 85 and older.

-- Figure 1 about here --

Turning to men (Panel B), we observe a similar pattern of relative stability in dual-function rates through age 65. In contrast to women, however, there is less evidence of convergence among men with at least a four-year degree and men with a high school degree/some college. In addition, the gap between men with less than a high school degree and men with more education is not as large as the gap observed among women. We find a similar pattern of accelerating decline in dual-function rates for men beginning around ages 65 to 70 as observed among women, but the decline is not quite as steep.

Table 2 provides a comparison of the estimates of dual-function rates for men and women across age groups by levels of education. We see significant gender differences in the dual-function rates among older adults with less than a high school degree with men consistently having higher rates of dual functionality than women at all age groups (though the difference is not statistically significant in the age 75 to 79 group). By contrast there is little evidence of differences for women and men with a high school degree/some college except among the 85 and older age group. Similarly, differences in dual-function rates between women and men who have at least a four-year degree are generally small until older ages.

-- Table 2 about here --

Life Expectancy Estimates

Table 3 reports estimates of age-50 total life expectancy (TLE) and age-50 dual-function life expectancy (2FLE) by gender and education. We observe the well-documented education-mortality gradient for both women and men in age-50 TLE as well as the gender gap of about 4 to 4.5 years across all levels of education.

-- Table 3 about here --

For age-50 2FLE, we see education inequalities increase substantially for older adults with less than a high school degree. Among women a gap of about 7 years in age-50 TLE widens to an almost 13-year gap in age-50 2FLE between women with at least a four-year degree and women with less than a high school degree. We observe a similar increase in the gap between these two levels of education for men. For both men and women, the gap between older adults with at least a four-year degree and those with a high school degree/some college in age-50 TLE widen by about a year to a year and a half when considering age-50 2FLE.

From another vantage point, we observe the gender gap in age-50 TLE across levels of education of about 4 to 4.5 years substantially reduces when we consider age-50 2FLE. For older adults with at least a high school degree, the gap between women and men in age-50 2FLE ranges from roughly 1.5 to 2.5 years, about half of the inequalities in age-50 TLE. Among older adults with less than a high school degree, the gender gap in age-50 TLE is virtually eliminated in age-50 2FLE. This pattern reflects the substantially lower rates of dual functionality among older women than men across most age groups.

Finally, the right-most column of Table 3 reveals that women and men with at least a four-year degree experience 84 to 89 percent of their remaining years with dual functionality. In sharp contrast, women and men without a high school degree respectively experience only 61 and 70 percent of their remaining years with dual functionality.

Discussion

This study draws on a new concept, dual functionality, that captures the combination of physical and cognitive function, critical components of independent living and quality of life for many older adults, to investigate education-based population health inequalities. We observe substantial inequalities in dual-function rates by levels of education for both women and men that remain even through ages 85 and older. For instance, women with less than a high school degree have roughly similar rates of dual functionality in their early 50s as women with at least a college degree have in their early 80s. A similar pattern holds for men across different levels of education, albeit at higher baseline rates of dual functionality.

In addition to assessing differences in dual-function rates, this study also analyzed how these rates translate into inequalities in dual-function life expectancy (2FLE). We find significantly larger gaps across levels of education in age-50 2FLE than for age-50 total life expectancy. This is particularly pronounced for women and men with less than a high school degree, a group that comprises almost a fifth of these birth cohorts. Among women and men with a four-year degree or higher, age-50 2FLE represents respectively 84 and 89 percent of their age-50 total life expectancy as compared with 61 and 70 percent for women and men with less than a high school degree. This notable difference reveals that older adults with less than a high school degree are likely to live a substantially higher proportion of their remaining life after losing dual functionality, a prospect that comes with additional costs in caregiving and potential loss of independent living.

Past studies have established a strong negative relationship between education and both physical and cognitive limitations (Crimmins et al., 2018; Montez et al., 2017; Zajacova & Lawrence, 2018). Higher education provides access to greater resources, such as income and access to healthcare, and the opportunity to avoid many risks, such as occupational and environmental hazards, that play a role in retaining physical and cognitive function (Mirowsky, 2017; Zajacova & Lawrence, 2018). These mechanisms likely underlie the educational inequalities we find in dual functionality. By integrating physical and cognitive function into a single concept, we contribute to this line of work by documenting striking inequalities in broad functional capacity across education levels for older women and men. In the context of declining college enrollment following the pandemic (National Student Clearinghouse, 2023), our findings reveal that completing a college degree may come with important health benefits later in life.

Beyond the striking gaps in age-50 2FLE across levels of education, we find that the lower dual-function rates among women lead to a smaller gender gap in age-50 2FLE at all levels of education relative to the gender gap in age-50 total life expectancy. In fact, among older adults with less than a high school degree we estimate less than a third of a year difference in age-50 2FLE between women and men. The substantial reduction or virtual elimination of gender gaps in age-50 2FLE across levels of education provides an important lens on gender differences in the health returns to education that are not as evident when examining physical or cognitive function in isolation (e.g., Farina et al., 2020; Garcia et al., 2021; Solé-Auró et al., 2015).

This study comes with a few limitations that should be kept in mind. First, due to our analytic approach and data limitations, we were only able to stratify by gender in our analyses of education-based inequalities in dual functionality. Differential health returns to education across racial-ethnic groups are well documented (Farmer & Ferraro, 2005; Sims & Coley, 2019; Vable et al., 2018) and future research should investigate this with respect to dual-function rates and 2FLE as well. Second, our estimates of 2FLE from Sullivan life tables rely on stationarity assumptions that the age-interval specific mortality rates and dual-function rates are constant over time (Imai & Soneji, 2007). These assumptions permit the use of contemporary data to examine the experience of a hypothetical cohort that ages through the age-interval specific mortality and dual-function rates. Stationarity assumptions can be relaxed either by adopting a cohort life table approach or multistate life tables that incorporate transition probabilities across states; however, both approaches have substantial data requirements and are often imprecise or unavailable. Third, selective mortality is a potential source of bias in this study due to the sampling procedures of the HRS (sample inclusion criteria based on being age 50 and older) and sample attrition over time. For this study, selective mortality is likely to lead to underestimates of education- and gender-based inequalities in dual functionality as people with lower levels of education and men are more likely to die before age 50 or drop out of the sample. Future research could analyze dual functionality at earlier ages to help address potential bias of this sort.

By drawing on a new concept that unites largely disparate streams of research on physical and cognitive function, this study reveals substantial education- and gender-based inequalities in dual functionality and 2FLE. These inequalities come with significant implications for population health and the allocation of societal resources. Older adults with lower levels of education are likely to live a greater proportion of their lives lacking dual functionality which is likely to require additional resources to provide care. This holds the potential of placing an increased burden on individuals, family members, and the broader residential care and health care communities precisely for the people with the least resources to address these challenges.

References

Alley, D., Suthers, K., & Crimmins, E. (2007). Education and cognitive decline in older Americans: Results from the AHEAD sample. *Research on Aging*, *29*(1), 73–94. https://doi.org/10.1177/0164027506294245

Arias, E., & Xu, J. (2018). *United States life tables, 2015* (National Statistics Vital Reports). National Center for Health Statistics. https://www.cdc.gov/nchs/data/nvsr/nvsr67/nvsr67_07-508.pdf

Barulli, D., & Stern, Y. (2013). Efficiency, capacity, compensation, maintenance, plasticity: Emerging concepts in cognitive reserve. *Trends in Cognitive Sciences*, *17*, 502–509. https://doi.org/10.1016/j.tics.2013.08.012

Blewett, L. A., Rivera Drew, J. A., King, M. L., & Williams, K. C. W. (2019). *IPUMS health surveys: National health interview survey, version 6.4 [dataset]*. IPUMS. https://doi.org/10.18128/D070.V6.4

Brandt, J., Spencer, M., & Folstein, M. (1988). The telephone interview for cognitive status. *Neuropsychiatry Neuropsychol Behav Neurol*, *1*, 111–117. https://doi.org/10.1037/t28542-000

Brown, D. C., Lariscy, J. T., & Kalousová, L. (2019). Comparability of mortality estimates from social surveys and vital statistics data in the United States. *Population Research and Policy Review*, *38*(3), 371–401. https://doi.org/10.1007/s11113-018-9505-1

Bugliari, D., Campbell, N., Chan, C., Hayden, O., Hayes, J., Hurd, M., Karabatakis, A., Main, R., Mallett, J., & McCullough, C. (2021). RAND HRS longitudinal file

2018 (V1) documentation. *RAND Center for the Study of Aging, Santa Monica, CA.* https://doi.org/10.7249/tla2097-1

Cantu, P. A., Hayward, M. D., Hummer, R. A., & Chiu, C.-T. (2013). New estimates of racial/ethnic differences in life expectancy with chronic morbidity and functional loss: Evidence from the National Health Interview Survey. *Journal of Cross-Cultural Gerontology*, *28*, 283–297. https://doi.org/10.1007/s10823-013-9206-5

Cantu, P. A., Sheehan, C. M., Sasson, I., & Hayward, M. D. (2021). Increasing education-based disparities in healthy life expectancy among U.S. non-Hispanic Whites, 2000–2010. *Journals of Gerontology: Series B*, *76*, 319–329. https://doi.org/10.1093/geronb/gbz145

Cockerham, W. C., Bauldry, S., Hamby, B. W., Shikany, J. M., & Bae, S. (2017). A comparison of black and white racial differences in health lifestyles and cardiovascular disease. *American Journal of Preventive Medicine*, *52*, S56–S62. https://doi.org/10.1016/j.amepre.2016.09.019

Cockerham, W. C., D. Wolfe, J., & Bauldry, S. (2020). Health lifestyles in late middle age. *Research on Aging*, *42*, 34–46. https://doi.org/10.1177/0164027519884760

Crimmins, E. M., Kim, J. K., Langa, K. M., & Weir, D. R. (2011). Assessment of cognition using surveys and neuropsychological assessment: The Health and Retirement Study and the Aging, Demographics, and Memory Study. *Journals of Gerontology: Series B*, *66*, i162–i171. https://doi.org/10.1093/geronb/gbr048

Crimmins, E. M., & Saito, Y. (2001). Trends in healthy life expectancy in the United States, 1970–1990: Gender, racial, and educational differences. *Social Science & Medicine*, *52*, 1629–1641. https://doi.org/10.1016/S0277-9536(00)00273-2

Crimmins, E. M., Saito, Y., Kim, J. K., Zhang, Y. S., Sasson, I., & Hayward, M. D. (2018). Educational differences in the prevalence of dementia and life expectancy with dementia: Changes from 2000 to 2010. *Journals of Gerontology: Series B*, *73*, S20–S28. https://doi.org/10.1093/geronb/gbx135

DiPrete, T. A., & Buchmann, C. (2006). Gender-specific trends in the value of education and the emerging gender gap in college completion. *Demography*, *43*(1), 1–24. https://doi.org/10.1353/dem.2006.0003

Farina, M. P., Hayward, M. D., Kim, J. K., & Crimmins, E. M. (2020). Racial and educational disparities in dementia and dementia-free life expectancy. *Journals of Gerontology: Series B*, *75*, e105–e112. https://doi.org/10.1093/geronb/gbz046

Farmer, M. M., & Ferraro, K. F. (2005). Are racial disparities in health conditional on socioeconomic status? *Social Science & Medicine*, *60*(1), 191–204.

Fauth, Elizabeth Braungart, Zarit, S. H., Malmberg, B., & Johansson, B. (2007). Physical, cognitive, and psychosocial variables from the disablement process model predict patterns of independence and the transition into disability for the oldest-old. *The Gerontologist*, *47*, 613–624. https://doi.org/10.1093/geront/47.5.613

Fingerman, K. L., Ng, Y. T., Huo, M., Birditt, K. S., Charles, S. T., & Zarit, S. (2021). Functional limitations, social integration, and daily activities in late life. *Journals of Gerontology: Series B*, *76*, 1937–1947. https://doi.org/10.1093/geronb/gbab014

Garcia, M. A., Downer, B., Chiu, C.-T., Saenz, J. L., Ortiz, K., & Wong, R. (2021). Educational benefits and cognitive health life expectancies: Racial/ethnic, nativity, and gender disparities. *Gerontologist*, *61*, 330–340. https://doi.org/10.1093/geront/gnaa112

Garcia, M. A., Downer, B., Chiu, C.-T., Saenz, J. L., Rote, S., & Wong, R. (2019). Racial/ethnic and nativity differences in cognitive life expectancies among older adults in the United States. *Gerontologist*, *59*(2), 281–289. https://doi.org/10.1093/geront/gnx142

Haas, S. (2008). Trajectories of functional health: The ‘long arm’ of childhood health and socioeconomic factors. *Social Science & Medicine*, *66*, 849–861. https://doi.org/10.1016/j.socscimed.2007.11.004

Haas, S., & Rohlfsen, L. (2010). Life course determinants of racial and ethnic disparities in functional health trajectories. *Social Science & Medicine*, *70*, 240–250. https://doi.org/10.1016/j.socscimed.2009.10.003

Hayward, M. D., Hummer, R. A., Chiu, C.-T., González-González, C., & Wong, R. (2014). Does the Hispanic paradox in US adult mortality extend to disability? *Population Research and Policy Review*, *33*, 81–96. https://doi.org/10.1007/s11113-013-9312-7

Imai, K., & Soneji, S. (2007). On the estimation of disability-free life expectancy: Sullivan’s method and its extension. *Journal of the American Statistical Association*, *102*(480), 1199–1211. https://doi.org/10.1198/016214507000000040

Langa, K. M., Weir, D. R., Kabeto, M., & Sonnega, A. (2020). Langa-Weir classification of cognitive function (1995 Onward). *Survey Research Center Institute for Social Research, University of Michigan*. https://hrsdata.isr.umich.edu/sites/default/files/documentation/data-descriptions/Data_Description_Langa_Weir_Classifications2016.pdf

Lariscy, J. T., Hummer, R. A., & Hayward, M. D. (2015). Hispanic older adult mortality in the United States: New estimates and an assessment of factors shaping the Hispanic paradox. *Demography*, *52*(1), 1–14.

Lawton, M. P., Moss, M., Hoffman, C., Grant, R., Have, T. T., & Kleban, M. H. (1999). Health, valuation of life, and the wish to live. *The Gerontologist*, *39*(4), 406–416. https://doi.org/10.1093/geront/39.4.406

Luo, Y., & Waite, L. J. (2005). The impact of childhood and adult SES on physical, mental, and cognitive well-being in later life. *Journals of Gerontology: Series B*, *60*, S93–S101. https://doi.org/10.1093/geronb/60.2.S93

Mirowsky, J. (2017). *Education, social status, and health*. Routledge.

Montez, J. K., Hayward, M. D., Brown, D. C., & Hummer, R. A. (2009). Why is the educational gradient of mortality steeper for men? *Journals of Gerontology: Series B*, *64*(5), 625–634. https://doi.org/10.1093/geronb/gbp013

Montez, J. K., Zajacova, A., & Hayward, M. D. (2017). Disparities in disability by educational attainment across US states. *American Journal of Public Health*, *107*, 1101–1108. https://doi.org/10.2105/AJPH.2017.303768

National Center for Health Statistics. (2019). *The linkage of national center for health statistics survey data to the national death index–2015 linked mortality file (lmf): Methodology overview and analytic considerations*. Office of Analysis and Epidemiology. https://www.cdc.gov/nchs/data-linkage/mortality.htm

National Student Clearinghouse. (2023). *Current term enrollment estimates (CTEE) expanded edition: Fall 2022 enrollment overview*.

https://public.tableau.com/app/profile/researchcenter/viz/CTEE_Fall2022_Report/CTEEFalldashboard

Read, J. G., & Gorman, B. K. (2010). Gender and health inequality. *Annual Review of Sociology*, *36*, 371–386. https://doi.org/10.1146/annurev.soc.012809.102535

Ross, C. E., Masters, R. K., & Hummer, R. A. (2012). Education and the gender gaps in health and mortality. *Demography*, *49*(4), 1157–1183. https://doi.org/10.1007/s13524-012-0130-z

Schoeni, R. F., Martin, L. G., Andreski, P. M., & Freedman, V. A. (2005). Persistent and growing socioeconomic disparities in disability among the elderly: 1982–2002. *American Journal of Public Health*, *95*(11), 2065–2070. https://doi.org/10.2105/AJPH.2004.048744

Sims, J., & Coley, R. L. (2019). Variations in links between educational success and health: Implications for enduring health disparities. *Cultural Diversity and Ethnic Minority Psychology*, *25*, 32. https://doi.org/10.1037/cdp0000239.supp

Solé-Auró, A., Beltrán-Sánchez, H., & Crimmins, E. M. (2015). Are differences in disability-free life expectancy by gender, race, and education widening at older ages? *Population Research and Policy Review*, *34*, 1–18. https://doi.org/10.1007/s11113-014-9337-6

Stern, Y., Arenaza-Urquijo, E. M., Bartrés-Faz, D., Belleville, S., Cantilon, M., Chetelat, G., Ewers, M., Franzmeier, N., Kempermann, G., & Kremen, W. S. (2020). Whitepaper: Defining and investigating cognitive reserve, brain reserve, and brain maintenance. *Alzheimer's & Dementia*, *16*, 1305–1311. https://doi.org/10.1016/j.jalz.2018.07.219

Sullivan, D. F. (1971). A single index of mortality and morbidity. *HSMHA Health Reports*, *86*(4), 347–354. https://doi.org/10.2307/4594169

Tsai, Y. (2016). Education and disability trends of older Americans, 2000–2014. *Journal of Public Health*, 447–454. https://doi.org/10.1093/pubmed/fdw082

Vable, A. M., Cohen, A. K., Leonard, S. A., Glymour, M. M., dP Duarte, C., & Yen, I. H. (2018). Do the health benefits of education vary by sociodemographic subgroup? Differential returns to education and implications for health inequities. *Annals of Epidemiology*, *28*, 759–766. https://doi.org/10.1016/j.annepidem.2018.08.014

Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Social Science & Medicine*, *38*, 1–14. https://doi.org/10.1016/0277-9536(94)90294-1

Walsemann, K. M., & Ailshire, J. A. (2020). Early educational experiences and trajectories of cognitive functioning among US adults in midlife and later. *American Journal of Epidemiology*, *189*, 403–411. https://doi.org/10.1093/aje/kwz276

Zajacova, A. (2006). Education, gender, and mortality: Does schooling have the same effect on mortality for men and women in the US? *Social Science & Medicine*, *63*, 2176–2190. https://doi.org/10.1016/j.socscimed.2006.04.031

Zajacova, A., & Lawrence, E. M. (2018). The relationship between education and health: Reducing disparities through a contextual approach. *Annual Review of Public Health*, *39*, 273–289. https://doi.org/10.1146/annurev-publhealth-031816-044628

Zajacova, A., & Montez, J. K. (2017). Physical functioning trends among US women and men Age 45–64 by education level. *Biodemography and Social Biology*, *63*(1), 21–30. https://doi.org/10.1080/19485565.2016.1263150

Tables and Figures

Table 1. Descriptive statistics for HRS person-year observations and NHIS-LMF respondents.

	HRS	NHIS-LMF
	N = 166,113	N = 373,343
Women	0.55	0.53
Less than high school	0.17	0.18
High school or some college	0.58	0.57
4-year degree or higher	0.26	0.26
Age	66.12 (10.41)	69.62 (9.24)

Notes: For the HRS, the N is the number of person-year observations. For the NHIS-LMF, the N is the number of respondents. All descriptive statistics are weighted. For gender and education, estimates are proportions. For age, the mean with the standard deviation in parentheses is reported.

Table 2. Differences by gender in dual-function rates across age groups and levels of education.

	Less than high school			High school or some college			4-year degree or higher		
Age group	Women	Men	Difference	Women	Men	Difference	Women	Men	Difference
50-54	0.68 (0.03)	0.77 (0.02)	-0.09*	0.88 (0.01)	0.89 (0.01)	0.00	0.95 (0.01)	0.96 (0.01)	-0.01
55-59	0.67 (0.02)	0.74 (0.02)	-0.07*	0.88 (0.01)	0.87 (0.01)	0.00	0.94 (0.01)	0.96 (0.01)	-0.02
60-64	0.67 (0.02)	0.75 (0.02)	-0.09***	0.86 (0.01)	0.85 (0.01)	0.01	0.93 (0.01)	0.93 (0.01)	0.00
65-69	0.67 (0.01)	0.74 (0.01)	-0.08***	0.87 (0.01)	0.87 (0.01)	0.00	0.92 (0.01)	0.94 (0.01)	-0.02*
70-74	0.65 (0.01)	0.71 (0.01)	-0.06***	0.85 (0.01)	0.85 (0.01)	0.00	0.89 (0.01)	0.91 (0.01)	-0.02
75-79	0.59 (0.02)	0.63 (0.01)	-0.04	0.79 (0.01)	0.80 (0.01)	-0.01	0.82 (0.02)	0.86 (0.01)	-0.04*
80-84	0.50 (0.02)	0.55 (0.01)	-0.05*	0.69 (0.01)	0.70 (0.01)	-0.01	0.74 (0.02)	0.80 (0.01)	-0.06*
85+	0.32 (0.01)	0.41 (0.02)	-0.09***	0.49 (0.01)	0.58 (0.02)	-0.09***	0.55 (0.02)	0.67 (0.02)	-0.12***

Notes: *p < 0.05, ** p < 0.01, *** p < 0.001. Estimates of weighted proportions with standard errors in parentheses.

Table 3. Estimates of age-50 total life expectancy and age 50 dual-function life expectancy.

	Age-50 total life expectancy			Age-50 dual-function life expectancy			% remaining life dual functional
	Est (SE)	Δ Degree+	Δ Gender	Est (SE)	Δ Degree+	Δ Gender	
Women:							
Less than high school	30.52 (0.14)	-7.20	4.36	18.68 (0.25)	-12.85	0.32	61%
High school or some college	34.23 (0.10)	-3.49	4.47	27.23 (0.12)	-4.30	2.70	80%
4-year degree or higher	37.72 (0.31)	-	4.01	31.53 (0.30)	-	1.55	84%
Men:							
Less than high school	26.16 (0.15)	-7.55	-	18.36 (0.23)	-11.62	-	70%
High school or some college	29.76 (0.09)	-3.95	-	24.53 (0.14)	-5.45	-	82%
4-year degree or higher	33.71 (0.15)	-	-	29.98 (0.18)	-	-	89%

Notes: Standard errors based on 500 bootstrap samples. Δ Degree+ is the difference in life expectancy for the given level of education and older adults with a 4-year degree or higher. Δ Gender is the difference in life expectancy between women and men at the same level of education.

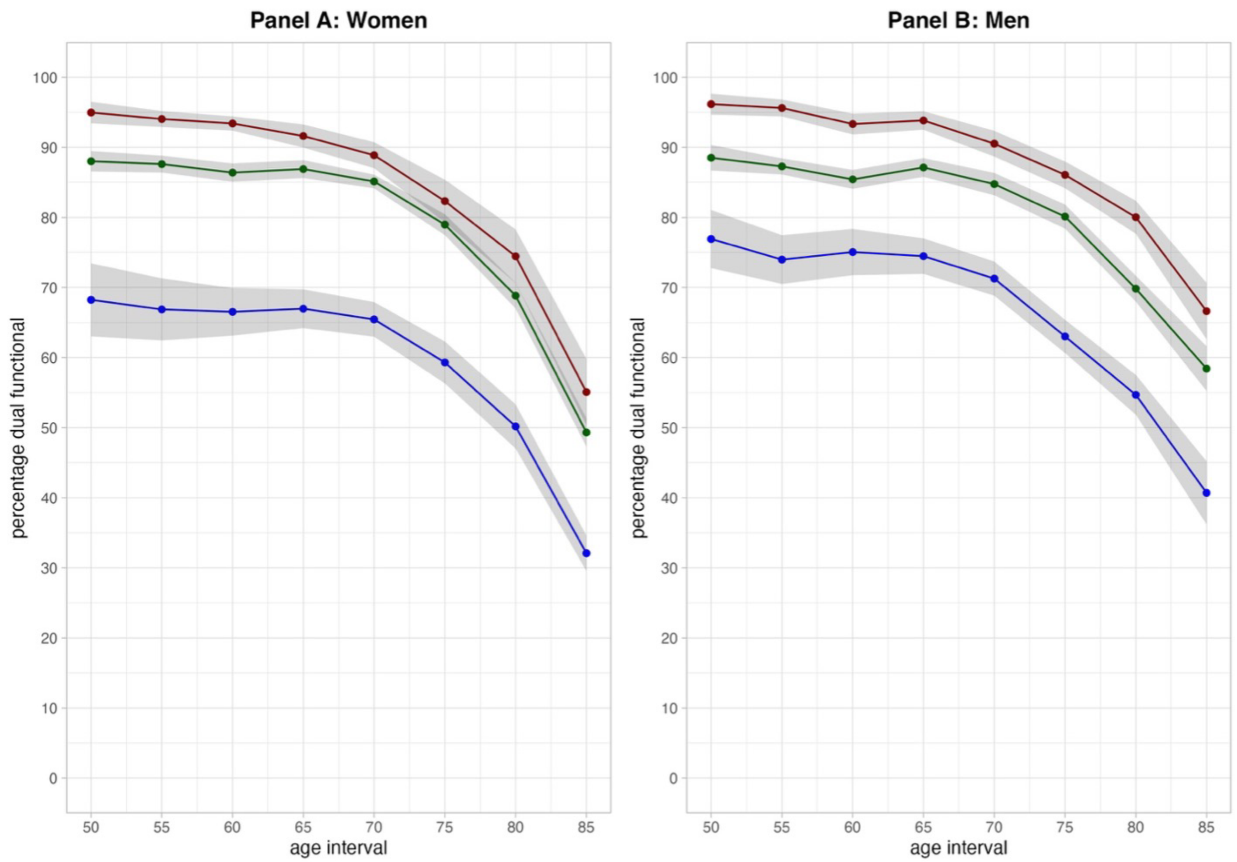

Figure 1. Estimated dual-function rates for women (Panel A) and men (Panel B) by education across five-year age intervals.

The blue line is for older adults with less than a high school education, the green line is for older adults with a high school degree or some college, and the red line is for older adults with a four-year college degree or higher. The shaded areas are 95% confidence regions.