SSM - Population Health 15 (2021) 100921

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

# Socioeconomic status across the life course and dementia-status life expectancy among older Americans

Hyungmin Cha[a,*,1], Mateo P. Farina[b,1,**], Mark D. Hayward[a]

[a] Department of Sociology and Population Research Center, The University of Texas at Austin, USA
[b] Andrus School of Gerontology, The University of Southern California, USA

ARTICLE INFO

*Keywords:*
Dementia
Life expectancy
Mortality
Socioeconomic status

ABSTRACT

This study examines how socioeconomic status (SES) across the life course is associated with individuals' lifetime dementia experience – the years of life persons can expect to live and without with dementia. Conceptually, dementia-free life expectancy reflects the ability to postpone dementia onset while dementia life expectancy reflects the average lifetime period with the condition. How SES across the life course contributes to dementia-status life expectancy is the focus of this study. We assess whether persons who are advantaged in their lifetime SES live the most years without dementia and the fewest years with dementia compared to less advantaged persons. Using the Health and Retirement Study (2000–2016), we examine these questions for U.S. adults aged 65 and older using multistate life tables and a microsimulation approach. The results show that higher SES persons can expect to live significantly more years of life without dementia and that the period of life with dementia is compressed compared to less advantaged persons. The results also underscore that importance of cumulative exposure, showing that adults from disadvantaged childhoods who achieve high education levels often have dementia experiences that are similar to or better than those of adults from advantaged childhoods who achieved low education levels.

## 1. Introduction

Dementia is one of the most feared diseases in the United States. Nearly half of middle aged Americans report being afraid of developing dementia (Maust et al., 2015), which is higher than rates for other age-related chronic conditions such as cardiovascular disease and diabetes. This trepidation partly stems from a common perception that dementia is an inevitable consequence of old age, yet empirical work documents that dementia can be avoided even at very old ages (Andersen-Ranberg et al., 2001; Qiu & Fratiglioni, 2018). The fear also stems from the high level of dependency associated with the condition. Dementia is frequently associated with heightened psychological distress, deterioration in cognitive functioning, and a substantial decline in physical functioning (Livingston et al., 2020). The amount of time people live with dementia can thus have a broad and enduring impact on individual, familial and government resources. In this study, we gain new insights into individuals' lifetime dementia experiences by assessing how the expected years of life with and without dementia are linked to socioeconomic status (SES) from childhood spanning into later adulthood.

The expected years of life with and without dementia (i.e., dementia-status life expectancy and dementia-free life expectancy) reflect the intersection of two demographic processes: dementia onset and mortality. The underlying force of dementia onset, referred to as the risk of dementia in this manuscript, determines when in the life course the period of life with dementia begins. A lower risk of dementia would signify that onset is expected at later ages, which would minimize the number of years that people are expected to spend with dementia if mortality were to remain the stable. Relatedly, the force of dementia-status specific mortality also structures life expectancy with and without dementia across various groups; lower mortality risk in each state signifies more years lived in that state.

Although dementia risk is sometimes thought of as an inevitable consequence of aging, the risk is not evenly distributed in the older

* Corresponding author. Department of Sociology, Center on Aging and Population Sciences and Population Research Center, University of Texas at Austin, 305 E. 23rd Street / RLP 2.406A, Austin, TX, 78712-1699, USA.
** Corresponding author. Andrus School of Gerontology, The University of Southern California, 3715 McClintock Ave, Los Angeles, CA, 90089, USA.
*E-mail addresses:* hyungmin.cha@utexas.edu (H. Cha), mfarina@usc.edu (M.P. Farina).
[1] Names are listed alphabetically; both authors contributed equally to this work.

https://doi.org/10.1016/j.ssmph.2021.100921
Received 11 July 2021; Received in revised form 24 August 2021; Accepted 8 September 2021
Available online 12 September 2021

population. A number of studies document that dementia is tightly linked to social and behavioral "risks" over the life course – that is, the condition is highly socially patterned with significant differences in risk within the population (James & Bennett, 2019; Livingston et al., 2020). In this study, we focus on one of the most prominent "risk factors," socioeconomic status, to better understand how conditions from different parts of the life course potentially combine, for example, to influence the postponement of dementia onset as well as shortening the period of life with dementia. Socioeconomic conditions across the life course are associated with cognitive development in early life as well as modifiable risk factors in adulthood that may trigger neuropathological processes (e.g., smoking, physical activity, obesity, excessive alcohol consumption, hypertension, diabetes, loneliness, exposure to air pollution, and sleep) (Glymour et al., 2012; Livingston et al., 2020; Lövdén et al., 2020; Sutin et al., 2019). This points to the importance of considering SES as a "fundamental cause" of dementia—a social risk factor that will be continued to be associated with dementia across time and place due to the impact SES has knowledge, money, power, prestige, and beneficial social connections that can be used to avoid risk and maximize rewards (Link & Phelan, 1995). Because SES differences in life expectancy are usually smaller in magnitude than SES differences in life free of major cognitive and physical health problems (Crimmins et al., 2018; Farina et al., 2020; Montez & Hayward, 2014), our orienting hypothesis is that higher SES persons will experience a compressed period of living with dementia and longer lives without dementia compared to persons who are more socioeconomically disadvantaged.

Although much is unclear about the ways in which dementia risk as well as dementia-status mortality, the inputs to the life table model of dementia status life expectancy, are linked to life course socioeconomic status, considerable evidence points to the importance of specific indicators of socioeconomic status *across* the life course for dementia risk. Here, the indicators are benchmarked using measures of childhood socioeconomic adversity, educational attainment, and later-life wealth. For example, prior studies have documented that cognitive development and impairment over the life course are associated with childhood socioeconomic adversities, preschool education, education in childhood and adolescence, and financial resources in adulthood (Cadar et al., 2018; Luo & Waite, 2005; Walsemann & Ailshire, 2020; Zhang et al., 2019). Some studies have reported a direct effect from early life socioeconomic conditions on dementia, even when adult conditions were accounted for (Glymour et al., 2012; Luo & Waite, 2005; Melrose et al., 2015; Zhang et al., 2019). People with worse childhood socioeconomic conditions not only have a greater likelihood of dementia in older adulthood, but also experience it at younger ages (Marden et al., 2017; Pudrovska, 2014). In addition to early life socioeconomic conditions, adulthood socioeconomic conditions appear to independently contribute to the risk of dementia or moderate/severe cognitive impairment (Lövdén et al., 2020; Marden et al., 2017; Zhang et al., 2016). People with lower levels of education and lower income or wealth are more likely to experience dementia or cognitive impairment compared to persons with more socioeconomic resources (Crimmins et al., 2018; Marden et al., 2017; Zhang et al., 2016).

Although the evidence points to the importance of considering socioeconomic exposures across the life course as influencing cognitive function and dementia risk, few studies have assessed how early life conditions combine with adult conditions throughout the life course in a cumulative fashion to influence heterogeneity in cognitive health in the older population. We draw on the cumulative exposure concept to assess the role of lifetime socioeconomic status more holistically—as reflected in childhood socioeconomic adversity, educational attainment and later-life wealth–documenting the unique and joint contributions of these life course socioeconomic exposures to later-life cognitive health.

In this spirit, two main concerns motivate this study. The first main concern is how socioeconomic status at three periods across the life course (childhood, young adult, and later life) influences dementia-status life expectancies. Prior research examining health status life expectancies in the older American population generally report that higher SES persons live longer lives, live longer healthy lives, and experience a compressed period of morbidity or disability compared to less advantaged persons (Crimmins & Saito, 2001; Montez & Hayward, 2014). Framed in these terms, we expect that a lifetime of socioeconomic advantage will be associated with people living significantly longer lives compared to persons with fewer lifetime advantages, while also experiencing a compression in dementia life expectancy. Longer life is thus expected to be reflected in terms of better lifetime cognitive health.

The second concern is whether the consequences of childhood socioeconomic disadvantage can be overcome through advantages experienced in later life; here, measured in terms of educational attainment and wealth. More generally, this is a question of how these socioeconomic exposures over the life course combine to impact dementia status life expectancy. For example, does early life adversity lead to significantly greater years of life with dementia regardless of adulthood socioeconomic achievement? Or do early life conditions combine with adult socioeconomic conditions in a cumulative exposure fashion to influence dementia status life expectancy? Can higher levels of education and wealth compensate for childhood SES disadvantages?

## 2. Data and methods

We use the Health and Retirement Study (HRS) from 2000 to 2016 to examine how socioeconomic status at three life periods influences dementia-status life expectancy. The HRS is a nationally representative longitudinal study designed to examine the health and well-being of U.S. adults aged 50 and older (HRS, 2019). The present study uses the RAND HRS Longitudinal File 2016 (V2), which is a cleaned and consolidated file of all 1992–2016 survey waves developed by the RAND Center for the Study of Aging and supported by the National Institute on Aging and the Social Security Administration (RAND, 2020). The file contains adults who are representative of cohorts born between 1892 and 1950 and their spouses. The present study begins with the 2000 wave because consistent cognitive health information for both community-dwelling and nursing home residents aged 65 years and older first became available in 2000 (Crimmins et al., 2011). The age-eligible sample includes all respondents in 2000, 65 years of age and older, as well as HRS respondents who became age-eligible from 2002 to 2016: HRS respondents are allowed to age into the analytic sample when they turn 65. The analytic sample for the present study includes aged 65 + 18,201 non-Hispanic White and Black adults (Table 1).

HRS provides a comprehensive assessment of lifetime socioeconomic indicators to evaluate our study's objectives. In addition, the HRS

**Table 1**
Weighted Descriptive Statistics at Baseline (percentages, except for age) (N = 18,201).

| | % or Mean | S.E. |
|---|---|---|
| Age (in years) | 70.98 | .06 |
| Female | 55.73 | |
| Childhood Family Poor | 30.57 | |
| Ever Received Help from Relatives | 11.80 | |
| Ever Moved for Financial Reasons | 17.29 | |
| Number of Childhood SES Disadvantages | | |
| 3 | 10.83 | |
| 2 | 21.21 | |
| 1 | 24.33 | |
| 0 | 43.62 | |
| Education | | |
| Less than HS | 23.31 | |
| High school grad | 35.37 | |
| Some college | 20.11 | |
| College | 21.21 | |
| Logged Equivalized Wealth (in 2000 constant dollars) | 13.44 | .01 |

*Note*: Totals may not add to 100.0 because of rounding.

provides longitudinal information on the cognitive status which have been validated using clinical diagnoses and survey scores in the HRS Aging, Demographics, and Memory Study (Crimmins et al., 2011). Vital status information is provided at each wave based on the HRS tracker file allowing us to measure mortality incidence. The individual observations on survival for persons in the HRS can be considered accurate and representative (Weir, 2016).

### 2.1. Dementia status

We use proxy and self-reports to assess dementia because people who experience dementia may struggle with completing self-reported measures of cognitive status. We take the Langa-Weir classification approach which is used widely to assess dementia status at the population level among respondents aged 65 and older (Crimmins et al, 2011, 2018; Farina et al., 2020; Hayward et al., 2021; Langa et al, 2008, 2017). For HRS respondents who could not participate in the survey due to health issues, the interviews were conducted through proxies (spouses or children). For proxy respondents (about 10% of the interviews), we measure proxy-reported dementia status based on a rating of respondent's current memory from excellent to poor (0–4); assessments of limitations of five instrumental activities of daily living including using the phone, managing money, taking a medication, preparing hot meals, and shopping for groceries (0–5); and the interviewer's assessment of difficulty in completing the interview due to cognitive limitation (0–2), which sum to 11. Respondents who receive a score of 6 or higher on the proxy measurement are coded as having dementia. For HRS self-respondents, we measure self-reported dementia status using a summary score of immediate word recall (0-10), delayed word recall (0-10), serial subtraction of 7s (0–5), and backward counting from 20 (0–2). The score ranges from 0 to 27. We code self-respondents who score 6 or lower as having dementia.

### 2.2. Early-life socioeconomic experiences, education, and late-life wealth

We use a scale of cumulative socioeconomic adversity in early life, a categorical variable of education, and late-life wealth as indicators of life course socioeconomic status. The scale of early life socioeconomic adversity is based on information about mother's education, father's education, and overall childhood socioeconomic status because socioeconomic exposures tend to cluster (Green et al., 2010; Montez & Hayward, 2014). We dichotomize each individual measure: mother's education (1 = less than 8 years); father's education (1 = less than 8 years); respondent's perception of whether their childhood family was "pretty well-off financially, average, or poor" (1 = poor). Adding three variables provides a summary score that ranges from 0 to 3. Although this measure assumes the disadvantages are additive and have equal weight, this measure is beneficial for estimating potential dose-response—an increase in risk associated with each increase in level—and threshold effects. (see Montez & Hayward, 2014 for detail).

We create a categorical measure of educational attainment based on reported years of education (without a high school diploma, a high school diploma or GED, some college, or a bachelor's degree or higher). Our primary measure of late-life socioeconomic status is self-reported household wealth at age 65. The wealth variable is provided by the RAND Center for the Study of Aging, which consistently imputed missing data across waves (Bugliari et al., 2020). Because income varies from year to year, wealth is often the preferred marker of later-life SES when evaluating the SES and health relationship (Bond Huie et al., 2003; Marden et al., 2017; Zhang et al., 2016). Net household wealth represents the value of household assets minus debts. We adjust the household wealth by 2000 dollars using Consumer Price Index to balance the inflation over time. We then recode the household wealth by adding constants to eliminate negative values and divide by the square root of household size and log the value following previous studies (Glymour & Manly, 2008; Zhang et al., 2016). After adjusting the wealth measurement, we create quartiles to capture the relative wealth ranking for each respondent adjusted for inflation and household size. There are 3592 adults who were aged older than 65 before 2000 (the first wave of the study). We impute their wealth values by extrapolating the earliest observation from 1992 (when the HRS starts).

### 2.3. Covariates

A continuous measurement of age is included in our model as a covariate to estimate the age-specific risks of dementia and mortality. We measure age by subtracting the interview date from the self-reported date of birth in order to provide a more precise measurement that also accounts for months whereas whole age does not. We do not adjust for other covariates because these add significant complexity to our estimation approach described below. Thus, our estimates should be thought of as the average for the 2000–2016 period which centers on 2008. The parsimonious models are necessary to make use of microsimulation and bootstrapping in estimating the life tables. We do not estimate the models by race because when counting the numbers of health state transitions, the numbers are modest in some combinations of life course socioeconomic status (see Appendix for numbers of all respondents by the combination of socioeconomic status). In addition, we tested the sensitivity of our results to the lack of control for sociodemographic variables such as birth cohort and race. Based on multivariate hazard models, models with and without cohort and race show very similar effects for the socioeconomic indicators (see Appendix). All statistical modeling is stratified by sex, and separate life tables are calculated for males and females. Table 1 provides the weighted statistics on age, gender, childhood socioeconomic adversity, education, and wealth.

### 2.4. Analytic strategy

To address how early life socioeconomic disadvantage, education, and wealth combine to predict dementia-status life expectancy, we conduct the analysis in two steps. First, we use multivariate hazard models to estimate health state transition rates for each possible transition reflecting the potential health state transitions (No Dementia-Dementia, No Dementia-Death, Dementia-No Dementia, Dementia-Death). Second, using the health state transition rates, we simulate the life histories of a 100,000-person cohort to calculate expected years with and without dementia.

The first step involves estimating discrete-time hazard models based on a file of exposure intervals using the 18,201 respondents from HRS 2000–2016. Exposure intervals refer to the time between observation waves in the HRS. The calculation of exposure intervals is crucial because the parameter estimates from the hazard models are used to calculate the transition probabilities, which are the inputs of the multistate life tables. These are sensitive to the exposure calculations (Cai et al., 2010; Gill et al., 2005; Wolf & Gill, 2009).

We calculate the interval consistent with prior research (Crimmins et al., 1994; Montez & Hayward, 2014). If an interval ends with death, because we know the exact age at the beginning of the interval and the death date from the HRS dataset, we calculate exposure based on the difference between age at the beginning and death date. If an interval ends with censoring, we assume that censoring occurs in the middle of the interval. We convert bi-annual to annual to get a person-year file. The respondents with censoring are assigned 0.5 year (Cai et al., 2010). We take the age at the beginning of the interval and add half of the average exposure for the exposure interval between the two appropriate observation annual waves. If an interval ends with any dementia event, exposure should be equal to the entire observation interval, regardless of the direction of the transition. To avoid missing pieces of exposure for "survivors," all alive events are assumed to occur at the end of the interval.

The statistical model has the following general form.

$$ln\mu_{ij}(t) = a_{ij} + b_{ij}*Age + c_{ij}*Z'$$

where $\mu ij$ is the transition rate in the tth interval from current state $i$ (e.g., no dementia) to state $j$ (e.g., dementia), Age references the age at the beginning of the exposure interval, and $Z'$ references the three measures of socioeconomic status. As a check on our assessment of cumulative exposure, we assessed the interaction between early life SES, education, and wealth. For men and women, the transition from no dementia to dementia did not contain any statistically significant interaction at $p < .05$ and it did not improve the model fit according to the Bayesian information criterion, suggesting that the influences of life course socioeconomic status on dementia are additive rather than multiplicative. We assume that the variation in transition rates between states within an exposure interval can be described by an exponential survival distribution (i.e., the risk was constant within the exposure interval). We also assume that a Markov process governs the transition rates (e.g., no duration dependence within a cognitive status) and use exact age at the beginning of an observation interval to estimate age-dependency (Crimmins et al., 1994; Montez & Hayward, 2014).

Based on the estimated transition parameters, a microsimulation approach (i.e., SPACE (the Stochastic Population Analysis for Complex Events) allows us to simulate the life path for each member of the life table population with a given combination of SES characteristics (Cai et al., 2010). The simulation procedure is repeated 1 year at time for each person until his or her death. This generates simulated lifelines for the entire life table cohort. By averaging over the lifelines, we calculate the life table functions. For example, we compute years with dementia using the average number of years lived with dementia for the simulated cohort. Then, in order to test the socioeconomic group differences in multistate life table functions, we estimate bootstrapped standard errors using the rescaling bootstrap method developed specifically for complex surveys ($N = 300$) (Cai et al., 2010). This allows us to conduct significance tests regarding years with dementia across life course socioeconomic combinations.

**Table 2**
Results of parametric hazard models of childhood SES disadvantages, education, and later-life wealth on dementia onset.

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
|---|---|---|---|---|---|---|---|
| Panel A. Male | | | | | | | |
| Age | 1.06*** | 1.06*** | 1.05*** | 1.06*** | 1.05*** | 1.05*** | 1.05*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Childhood Disadvantages (ref. None) | | | | | | | |
| 3 SES Disadvantages | 1.87*** | | | 1.16 | 1.72*** | | 1.14 |
| | (0.15) | | | (0.10) | (0.14) | | (0.10) |
| 2 SES Disadvantages | 1.56*** | | | 1.10 | 1.45*** | | 1.09 |
| | (0.11) | | | (0.08) | (0.11) | | (0.08) |
| 1 SES Disadvantage | 1.18* | | | 0.99 | 1.14 | | 0.99 |
| | (0.09) | | | (0.07) | (0.08) | | (0.07) |
| Education (ref. Less than HS) | | | | | | | |
| High school grad | | 0.46*** | | 0.48*** | | 0.47*** | 0.49*** |
| | | (0.03) | | (0.03) | | (0.03) | (0.03) |
| Some college | | 0.37*** | | 0.39*** | | 0.38*** | 0.40*** |
| | | (0.03) | | (0.04) | | (0.03) | (0.04) |
| College | | 0.29*** | | 0.31*** | | 0.31*** | 0.32*** |
| | | (0.02) | | (0.03) | | (0.03) | (0.03) |
| Wealth quartile (ref. <25th) | | | | | | | |
| 25-50th | | | 0.85 | | 0.89 | 1.01 | 1.02 |
| | | | (0.07) | | (0.08) | (0.09) | (0.09) |
| 50-75th | | | 0.67*** | | 0.73*** | 0.92 | 0.93 |
| | | | (0.06) | | (0.07) | (0.09) | (0.09) |
| >75th | | | 0.53*** | | 0.60*** | 0.85 | 0.86 |
| | | | (0.05) | | (0.06) | (0.08) | (0.09) |
| Panel B. Female | | | | | | | |
| Age | 1.07*** | 1.07*** | 1.05*** | 1.06*** | 1.05*** | 1.06*** | 1.06*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Childhood Disadvantages (ref. None) | | | | | | | |
| 3 SES Disadvantages | 1.97*** | | | 1.38*** | 1.77*** | | 1.33*** |
| | (0.13) | | | (0.10) | (0.12) | | (0.09) |
| 2 SES Disadvantages | 1.58*** | | | 1.24*** | 1.46*** | | 1.21** |
| | (0.09) | | | (0.07) | (0.08) | | (0.07) |
| 1 SES Disadvantage | 1.21** | | | 1.09 | 1.16* | | 1.07 |
| | (0.07) | | | (0.07) | (0.07) | | (0.07) |
| Education (ref. Less than HS) | | | | | | | |
| High school grad | | 0.58*** | | 0.63*** | | 0.60*** | 0.64*** |
| | | (0.03) | | (0.03) | | (0.03) | (0.03) |
| Some college | | 0.43*** | | 0.48*** | | 0.46*** | 0.50*** |
| | | (0.03) | | (0.03) | | (0.03) | (0.04) |
| College | | 0.37*** | | 0.42*** | | 0.42*** | 0.46*** |
| | | (0.03) | | (0.04) | | (0.04) | (0.04) |
| Wealth quartile (ref. <25th) | | | | | | | |
| 25-50th | | | 0.92 | | 1.00 | 1.06 | 1.08 |
| | | | (0.05) | | (0.06) | (0.06) | (0.06) |
| 50-75th | | | 0.67*** | | 0.74*** | 0.84* | 0.86* |
| | | | (0.05) | | (0.05) | (0.06) | (0.06) |
| >75th | | | 0.49*** | | 0.58*** | 0.67*** | 0.69*** |
| | | | (0.04) | | (0.04) | (0.05) | (0.05) |

*Note*: Standard errors in parentheses. ***$p < .001$, **$p < .01$, *$p < .05$. 31,527 person-years (Male). 43,557 person-years (Female) from 18,201 respondents from HRS 2000–2016.

## 3. Results

Summary characteristics of the sample are shown in Table 1. The mean age of the respondents at baseline is 70.98. 56% of the sample are women. Around 57% of the sample experienced at least one early-life socioeconomic adversities. In addition, around 23% of the sample didn't graduate high school. The average logged equivalized wealth in 2000 constant dollars is 13.44, on par with median household wealth in 2008 (Gottschalck et al., 2014).

Before addressing our main research aims about dementia status life expectancy, we examine how life course socioeconomic status is associated with dementia incidence (see Appendix for results of mortality and other transitions). We estimate how early-life socioeconomic status, educational attainment, and later life wealth predict the dementia onset, using a nested approach to better understand the potential independent and pathway associations of the socioeconomic indicators with dementia-status life expectancy. Table 2 shows the results of these models by sex. Panel A and B refer to male and female stratified models, respectively.

For males, Model 1 provides evidence of a dose-response relationship between childhood adversity and risk of dementia (i.e., the incidence of onset). As the number of childhood adversities increases, dementia risk also increases substantially. The risks of dementia for those with three disadvantages and two disadvantages are 87% ($p < .001$), and 56% ($p < .001$) higher, respectively, than those with no socioeconomic disadvantages during childhood. Compared to those who did not experience childhood socioeconomic adversity, the risk of dementia is 18% ($p < .001$) higher for respondents with 1 socioeconomic disadvantage during childhood. Model 2 shows a substantial decrease in dementia risk for those with greater levels of education, as expected given prior research showing negative relationship between dementia and education. Compared to those without a high school diploma, high school graduation is associated with 54% lower risk ($p < .001$), some college has a 63% lower risk ($p < .001$), and bachelor's degree holders have a 71% lower risk ($p < .001$). We also observe a lower risk of dementia with increased levels of wealth in Model 3. Compared to those in the lowest wealth quartile, being in the 2nd highest wealth quartile is associated with a 33% lower risk of dementia risk ($p < .001$) and being in the highest wealth quartile is associated with a 47% lower risk ($p < .001$). Overall, these first three models point to increasing dementia risk with greater socioeconomic adversity at childhood, early adulthood, and mid to later life. While the effect sizes for education and wealth at 65 are smaller for women, we find that the socioeconomic gradients are similar to those for men.

How do socioeconomic indicators across the life course predict risk of dementia, net of each other? In Models 4 and 5, we show that the inclusion of education and wealth at 65, respectively, attenuates the association of higher dementia risk with greater childhood socioeconomic adversity, although the association remains significant for women. The coefficients for education (Model 4) and wealth at 65 (Model 5) are also modestly attenuated but remain statistically significant. In Model 6, we find that the inclusion of education attenuates the association of lower dementia risk with higher wealth quartile for women. When all SES indicators are included (Model 7), the findings point to both their robust independent associations net of each other and some overlap between socioeconomic conditions at early and later adulthood for women.

Overall, we find that these socioeconomic experiences fairly independently shape dementia transitions for the respondents included in the analysis. Experiencing childhood disadvantages has a significant role on dementia but it is explained by the inclusion of education and wealth among men. For women, experiencing childhood disadvantages has a statistically significant role in explaining the onset of dementia with the inclusion of education and wealth, suggesting that socioeconomic status at three life course periods additively affects the risk of dementia. Education plays a major role explaining the effect of childhood disadvantages on dementia risk, and wealth at later life explains a modest part of the association between childhood disadvantages and dementia risk.

### *3.1. To what extent are childhood disadvantage, educational attainment, and later-life wealth associated with dementia-status life expectancy?*

Next, we evaluate the differences of socioeconomic status at three periods across the life course on dementia-life expectancy at age 65. These results are presented in Table 3. Overall, the patterns are consistent with the results shown in Table 2 for dementia risk. Lower SES is associated with more years with dementia, fewer years dementia-free, and lower total life expectancy. For males, for example, having three childhood SES disadvantages is associated with 1.82 years of dementia life expectancy, while dementia life expectancy is about one year less for men with no adversities. Note also that the absolute differences in dementia-free life expectancy are substantial for the lowest and highest group (14.85 years compared to 17.56 years). Childhood SES disadvantages are associated with a shorter dementia-free life and a relatively extended period of life with dementia. Phrased in the context of total life expectancy, the longer lives of advantaged men are accompanied by a highly compressed period of life with dementia. Looking at the association with education, men with no high school diploma are expected to live 2.07 years with dementia, whereas men with a college degree are expected to live 0.63 years (8 months) with dementia (1.5-year difference). For adjusted household wealth at 65, we find the smallest differences, but they still are stark. Men in the bottom 25% are expected to live 1.54 years with dementia, while men in the upper 75% are estimated to live 0.95 years (11 months) with dementia: 0.6-year (7 months) difference. Again, the same pattern of advantaged men's longer lives with a compressed period of life with dementia is evident.

One additional issue to consider is where in the distributions of the SES indicators we observe the greatest differences for dementia-free and dementia life expectancy. Note, for example, how the values for the dementia-status life expectancies change across levels of attainment. The biggest difference in dementia life expectancy is found for men with less than a high school education compared to men who are high school graduates. Although the difference in dementia life expectancy between high school and college graduates is statistically significant, substantively the differences are relatively small: 0.82 years (10 months) for high school graduates compared to 0.63 years (8 months) for college graduates. In contrast, the gains in dementia-free life expectancy associated with a high school education and then a college education are both quite large (13.41 years compared to 16.40 years and 16.40 years compared to 19.75 years), pointing to the importance of education's association with mortality risk throughout the entire distribution of educational attainment. More generally, these patterns point to the need to integrate the dementia process with the mortality process to better understand the lifetime experience of dementia in the older population.

We can see similar socioeconomic gradients in dementia-status expectancy among older women, but the gaps are larger than those shown for men. These findings consistently show that socioeconomic disadvantages at every point in the life course are associated with shorter lives, shorter lives free of dementia and longer lives with dementia. These results also point to the importance of education, in that the largest differences in dementia expectancy are found for bottom and top levels of educational attainment. Similar to our findings among men, the association between education and dementia life expectancy is stronger at the lower part of the education distribution, while the association with dementia-free life expectancy was evidence for the entire distribution of education.

**Table 3**
Dementia, dementia-free, total life expectancy at age 65 by gender for childhood, young adult, and late-life socioeconomic status.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Dementia | Dementia-free | Total | % of Years Impaired | Dementia | Dementia-free | Total | % of Years Impaired |
| Life Course SES (Child, Young Adult, Late-life) Numbers of childhood SES disadvantages | | | | | | | | |
| 3 | 1.82 | 14.85 | 16.67 | 10.90 | 2.66 | 16.54 | 19.20 | 13.86 |
| | (0.16) | (0.42) | (0.40) | | (0.19) | (0.36) | (0.42) | |
| 2 | 1.24 | 15.02 | 16.26 | 7.62 | 1.92 | 17.77 | 19.69 | 9.77 |
| | (0.09) | (0.30) | (0.31) | | (0.12) | (0.39) | (0.43) | |
| 1 | 0.98 | 16.67 | 17.65 | 5.58 | 1.71 | 19.10 | 20.81 | 8.20 |
| | (0.07) | (0.28) | (0.28) | | (0.14) | (0.35) | (0.40) | |
| 0 | 0.86 | 17.56 | 18.42 | 4.66 | 1.52 | 19.96 | 21.48 | 7.07 |
| | (0.08) | (0.26) | (0.28) | | (0.11) | (0.25) | (0.24) | |
| Education | | | | | | | | |
| Less than HS | 2.07 | 13.41 | 15.48 | 13.35 | 2.72 | 15.92 | 18.63 | 14.59 |
| | (0.12) | (0.25) | (0.27) | | (0.15) | (0.26) | (0.33) | |
| HS Grad | 0.82 | 16.40 | 17.22 | 4.76 | 1.62 | 18.88 | 20.50 | 7.89 |
| | (0.07) | (0.25) | (0.26) | | (0.10) | (0.22) | (0.23) | |
| Some College | 0.70 | 16.62 | 17.31 | 4.02 | 1.43 | 20.36 | 21.79 | 6.58 |
| | (0.10) | (0.35) | (0.34) | | (0.17) | (0.35) | (0.37) | |
| College | 0.63 | 19.75 | 20.37 | 3.09 | 1.04 | 21.30 | 22.34 | 4.65 |
| | (0.11) | (0.41) | (0.41) | | (0.17) | (0.54) | (0.58) | |
| Wealth quartile at age 65 | | | | | | | | |
| >25% | 1.54 | 13.51 | 15.05 | 10.22 | 2.10 | 17.48 | 19.58 | 10.71 |
| | (0.15) | (0.45) | (0.45) | | (0.16) | (0.34) | (0.34) | |
| 25–50% | 1.28 | 14.75 | 16.03 | 7.97 | 1.91 | 17.80 | 19.70 | 9.69 |
| | (0.08) | (0.29) | (0.29) | | (0.12) | (0.28) | (0.31) | |
| 50–75% | 1.06 | 16.32 | 17.38 | 6.10 | 1.91 | 19.25 | 21.16 | 9.02 |
| | (0.11) | (0.28) | (0.29) | | (0.15) | (0.33) | (0.35) | |
| <75% | 0.95 | 18.09 | 19.04 | 4.99 | 1.29 | 20.05 | 21.34 | 6.05 |
| | (0.10) | (0.31) | (0.33) | | (0.14) | (0.34) | (0.35) | |

*Note*: 18,201 respondents (7807 Male and 10,394 Female adults) from HRS 2000–2016. Results from 100,000 Simulations are shown. Bootstrapped standard errors are in parentheses.

### *3.2. How do early-life socioeconomic experiences combine with educational attainment and late-life wealth to predict years dementia-status life expectancy?*

Lastly, we then turn to how life course socioeconomic conditions combine to evaluate the degree to which later life socioeconomic achievement might compensate for childhood disadvantages. Table 4 lays out the worst- and best-case scenarios (low education and low wealth compared to college education and highest wealth quartile) by level of childhood SES. For example, for men with three SES childhood disadvantages, subsequent SES disadvantages (less than a high school education and the lowest wealth quartile) are associated with 2.62 years of dementia expectancy and 11.82 years of life without dementia. However, for men who are disadvantaged in childhood but have a college education and wealth in the top quartile, dementia life expectancy is highly compressed: only 0.84 years (10 months) of dementia expectancy while dementia-free life expectancy is quite lengthy (20.15 years). The results are consistent with the idea that improvements in SES after childhood can play an important compensatory role in reducing the lifetime burden of dementia while expanding years of life free of dementia.

The results in Table 4 also show how a lifetime of disadvantage compared to a lifetime of advantage defines the extremes in dementia-status life expectancy and this applies to both men and women. For example, dementia life expectancy at age 65 among men ranged from 2.62 years for the most disadvantaged lifetime (3 childhood SES adversities, low education and low wealth) to 0.6 years (7 months) for the most advantaged (0 childhood SES adversities, high education and high wealth).

We find these same patterns for women but with more years of dementia regardless of life course SES circumstances. For example, the most disadvantaged women are expected to live 3.06 years with dementia and the most advantaged women are expected to live 0.86 years (10 months) with dementia. These are more years of life with dementia than men, but the simulations also suggest a substantial decrease in dementia with improvements in SES circumstances after childhood. Altogether, these findings suggest that improvements in SES after childhood can substantially ameliorate the negative consequences of childhood disadvantage. In other words, upward socioeconomic mobility can play an important role in reducing the lifetime burden of dementia and enhancing the length of life without dementia.

## 4. Discussion

This study makes clear that dementia risk and years of life with dementia are highly modifiable; it reflects exposures over a lifetime. In this study, we have documented a significant connection between socioeconomic status across the life course and dementia risk with lower socioeconomic status associated with higher rates of cognitive impairment and dementia (Glymour et al., 2012; Glymour & Manly, 2008; Luo & Waite, 2005; Zhang et al, 2008, 2016). However, few researchers have considered that socioeconomic status throughout life may be associated with dementia risk and the amount of time spent living with and without dementia—a useful approach to understand SES disparities in individual lifetime experiences of this syndrome. This study is among the first to consider how SES status in childhood, early adulthood, and later life and their combinations shape disparities in years of life with and without dementia, highlighting another critical aspect to consider when evaluating cognitive health of the population and important sociodemographic differences. We uncover three notable findings: 1) each life course period contributes to dementia risk and appears to be additive, 2) a clear socioeconomic gradient in life with and without dementia was evident for all three life periods, and 3) while each life course period contributed to the number of years an individual can expect to live and without dementia, educational attainment appears to be the most important socioeconomic life course factor associated with dementia-status life expectancy.

Our finding that worse socioeconomic exposures at different life

**Table 4**
Dementia, dementia-free, total life expectancy at age 65 by gender for combinations of early-life, young adult, and later-life socioeconomic status.

| | N | Dementia | Dementia-free | Total | % of Years Impaired. |
|---|---|---|---|---|---|
| Male | | | | | |
| 3 SES Disadvantages | | | | | |
| Less than HS, <25th wealth quartile | 133 | 2.62 | 11.82 | 14.44 | 0.18 |
| | | (0.29) | (0.57) | (0.54) | (0.02) |
| College, >75th wealth quartile | 35 | 0.84 | 20.15 | 20.99 | 0.04 |
| | | (0.20) | (0.72) | (0.74) | (0.01) |
| 2 SES Disadvantages | | | | | |
| Less than HS, <25th wealth quartile | 161 | 2.07 | 11.68 | 13.76 | 0.15 |
| | | (0.26) | (0.45) | (0.46) | (0.02) |
| College, >75th wealth quartile | 107 | 0.68 | 19.53 | 20.21 | 0.03 |
| | | (0.16) | (0.62) | (0.64) | (0.01) |
| 1 SES Disadvantage | | | | | |
| Less than HS, <25th wealth quartile | 84 | 1.93 | 12.65 | 14.58 | 0.13 |
| | | (0.22) | (0.50) | (0.49) | (0.01) |
| College, >75th wealth quartile | 271 | 0.62 | 20.48 | 21.10 | 0.03 |
| | | (0.14) | (0.59) | (0.59) | (0.01) |
| 0 SES Disadvantage | | | | | |
| Less than HS, <25th wealth quartile | 65 | 1.95 | 12.45 | 14.40 | 0.14 |
| | | (0.30) | (0.52) | (0.53) | (0.02) |
| College, >75th wealth quartile | 865 | 0.60 | 20.53 | 21.13 | 0.03 |
| | | (0.12) | (0.55) | (0.54) | (0.01) |
| Female | | | | | |
| 3 SES Disadvantages | | | | | |
| Less than HS, <25th wealth quartile | 285 | 3.06 | 15.03 | 18.09 | 0.17 |
| | | (0.28) | (0.42) | (0.48) | (0.01) |
| College, >75th wealth quartile | 27 | 1.19 | 20.02 | 21.22 | 0.06 |
| | | (0.25) | (0.75) | (0.81) | (0.01) |
| 2 SES Disadvantages | | | | | |
| Less than HS, <25th wealth quartile | 361 | 2.57 | 15.62 | 18.19 | 0.14 |
| | | (0.24) | (0.48) | (0.52) | (0.01) |
| College, >75th wealth quartile | 69 | 0.90 | 20.80 | 21.70 | 0.04 |
| | | (0.18) | (0.85) | (0.92) | (0.01) |
| 1 SES Disadvantage | | | | | |
| Less than HS, <25th wealth quartile | 161 | 2.55 | 16.24 | 18.79 | 0.14 |
| | | (0.28) | (0.40) | (0.45) | (0.01) |
| College, >75th wealth quartile | 205 | 0.85 | 21.56 | 22.42 | 0.04 |
| | | (0.19) | (0.68) | (0.75) | (0.01) |
| 0 SES Disadvantage | | | | | |
| Less than HS, <25th wealth quartile | 98 | 2.58 | 16.40 | 18.98 | 0.14 |
| | | (0.29) | (0.38) | (0.44) | (0.01) |
| College, >75th wealth quartile | 747 | 0.86 | 21.92 | 22.78 | 0.04 |
| | | (0.15) | (0.59) | (0.61) | (0.01) |

*Note*: 18,201 respondents (7807 Male and 10,394 Female adults) from HRS 2000–2016. Results from 100,000 Simulations are shown. Bootstrapped standard errors are in parentheses.

periods are associated with worse cognitive health is consistent with other work. Several studies have shown that poor childhood SES circumstances, lower levels of education, and lower levels of wealth in adulthood are associated with increased rates of dementia and cognitive impairment (Cadar et al., 2018; James & Bennett, 2019; Marden et al., 2017; Zhang et al., 2016). We build on this work by providing a more detailed understanding of how socioeconomic status across the life course combines to influence later life dementia incidence risk and life with and without dementia. Our main finding that each life course stage impacts dementia risk and shapes years of life with and without dementia, points to the importance of socioeconomic conditions throughout life and their additive nature when understanding dementia risk. Put differently, dementia risk is not only shaped by more proximately socioeconomic conditions in adulthood, but also by the socioeconomic conditions that are experienced decades before onset. The continued importance of childhood socioeconomic conditions may indicate how childhood environment can shape risk at an early important developmental period that is then carried forward, which is reflected in both the greater risk of dementia and greater years of life lived with dementia. However, while a disadvantaged childhood cannot be fully overcome, upward mobility as evidenced through greater levels education and wealth can significantly reduce both risk and years of life spent in that dependent state. This finding suggests that while socioeconomic circumstances are additive, the magnitude of their impact on cognitive health risk may differ, which will be important for future research to consider.

Whereas other studies have evaluated the influence of socioeconomic status on dementia risk or mortality, separately, our study observes how both processes combine to impact years of life with and without dementia as well as total amount of years, which lets us observe compression of morbidity—another important dimension of cognitive health. Similar to other health studies, we find that socioeconomically advantaged groups are expected to have more years of life without dementia and fewer years of life with dementia. However, the underlying processes were not clearly understood. In this study, we find that the most disadvantaged group (low SES throughout life) has greater risk of dementia and mortality at older ages, but not to the point that mortality offsets dementia risk to curtail the number of years spent with dementia (i.e., the mortality did not occur so early to limit the number of years that disadvantaged group had with dementia). Instead, we find that SES resources impact both processes. Lower SES older adults are doubly disadvantaged and spend almost four times more time with dementia than the most advantaged group, even though they live significantly shorter lives. Therefore, socioeconomic conditions throughout life impact dementia and mortality risk and compress morbidity for the most advantaged.

The importance of SES across all three periods of the life course point to distinct pathways or mechanisms that link each period to dementia risk. Because we find that lifetime SES factors are additive, our study provides evidence that each period ought to have pathways or mechanisms that connect it to later life cognitive health that are not fully explained by other life course SES factors. For example, early life socioeconomic circumstances may be closely associated with exposure to other social and biological risk factors (such as poor childhood health, exposure to pathogens, etc.) that impede cognitive development, directly impacting later life cognitive health (Seifan et al., 2015; Zhang et al., 2019). While early life circumstances may be connected to educational attainment (in that people born into a life of socioeconomic adversity are less likely to obtain higher levels of education) (Jackson, 2009), it was not fully attenuated in our models, which suggests some other pathways and/or mechanisms that link early life SES to later life cognitive health are not associated with educational attainment or later life socioeconomic circumstances. The same argument can be applied to the other life course periods that were investigated since they are also have independent effects on dementia risk and dementia life expectancy. Future research should evaluate how life course pathways and mechanisms are associated to SES across each period, which would provide further insight into how SES shapes later life cognitive health and can be modified to lower dementia risk resulting in fewer years of life with dementia.

When comparing all three lifetime socioeconomic conditions, we find that education (in particular, being a high school graduate vs. not being a high school graduate) has the largest impact on dementia life expectancy. However, despite the importance of education in these data, future work should be careful to consider how life course processes are shaped by historical ones. Public health scholars and demographers often point to the importance of cohorts in understanding population health related changes (Bhatta, 2020). In fact, recent work has found that cognitive functioning among older adults is declining in more recent cohorts even though educational attainment has continued to increase (since the early-Baby Boomers) (Zheng, 2020). This unfavorable trend suggests that the effect of education may have important limitations when being translated into cognitive health advantage that are in part influenced by life course context. For example, a high school diploma among older adults in our study may have led to stable employment during adulthood due to the rapid industrialization and economic growth in the post-war period for the United States (Breen & Jonsson, 2005). However, since the 1970s, the United States has experienced rampant growth in economic inequality that has been coupled with an erosion of working-class jobs, meaning a high school diploma cannot be translated into the same economic and social resources today as had been found in the earlier part of the century (Kalleberg, 2009). As such, the large decline in dementia risk and years of life with dementia between people with and without a high school diploma may be less stark in the near future because the social and economic conditions for high school diploma holders may more closely aligned to less educated counterparts. Future work evaluating dementia risk and socioeconomic conditions throughout the life course should consider how larger societal shifts may have impacted the associations between covariates.

This study has some important limitations. First, our measure of dementia is based on cognitive tests and proxy reports rather than clinical diagnosis. Previous research using the HRS has demonstrated that cognitive tests and proxy tests correctly classify 88% and 75% of respondents in having dementia or not, respectively (Crimmins et al., 2011). Nonetheless, the issue of misclassification cannot be ignored. Second, although we systematically add SES at three different life periods to evaluate how early life SES changes, our analysis cannot determine causality. Early life may be tied to other confounding factors also associated with education. Future studies should more explicitly investigate how early life SES shapes adult SES to impact cognitive health in older age. Finally, due to data limitations, we are unable to evaluate distinct race/ethnic differences. We know that race/ethnicity in the United States structures risks and rewards, which may lead to similar differences as had been observed for men and women. The data we used is primarily composed of white older adults (85% of the sample). As more data becomes available, future studies should evaluate how SES across the life course impacts dementia experiences for Hispanics, Blacks, Native Americans, and Asians.

## 5. Conclusion

Despite these limitations, the current study makes important contributions to the literature on cognitive health and socioeconomic adversity throughout life. Our study identifies the overall influence of SES on dementia status life expectancies, helping to inform both research on modifiable factors as well as research considering biological pathways. Drawing on a nationally representative sample based on 16 years of data, we find clear patterns in greater dementia risk and individual burden (years of life with dementia) for adults with lower SES at each life periods and throughout life. But similar to other studies that have emphasized the role of education, we find that educational attainment appears to be the most consequential life course SES measure for dementia: high school graduates regardless of early life adversity or wealth at 65 have by far the lowest risk and fewest years of life lived with dementia. This implication is crucial because it emphasizes the largely cumulative risk of dementia that is tied to socioeconomic conditions throughout life. However, the associations themselves may be amenable based on larger sociopolitical contexts (Hayward et al., 2015). Future work should further explore the complexities that tie dementia risk and burden to socioeconomic conditions, while considering gendered, racial, or cohort patterns that may elucidate how these processes are shaped and influenced by the world in which people live.

Lastly, our research also speaks to the uneven burden of dementia in population, which may inform future health policy. We found that lower SES corresponded to greater years of dementia, especially for those with lower levels of education. This suggests that those with the fewest resources will likely be spending the most amount of time in this highly dependent state, which has significant implications for healthcare and caregiving costs. Research has found that the average lifetime costs for dementia is $321,780 (2015 dollars), which may be higher for people with lower SES status who live more years with dementia on average. While the U.S. provides universal health coverage for adults 65 years and older, it only covers approximately 30% of the costs (Medicare and Medicaid), leaving 70% to the families (Jutkowitz et al., 2017). As a result, family members of people with fewer SES resources will have to cover the gap, which may result in them providing caregiving themselves and/or shoulder the burden of paying for the necessary medical care outside of Medicaid and Medicare coverage to help maintain quality of life for the person experiencing dementia. While our research does not evaluate costs directly, it provides a basis for understanding the stark inequalities in later life dementia experiences that go beyond the individual but may impact families, communities, and healthcare systems.


## Acknowledgements

This research received support from a grant by the National Institute on Aging (R5605778, PI: Mark Hayward), infrastructure grants from the National Institute on Aging (P30AG066614) and from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (P2CHD042849 and T32HD007081) awarded to the Population Research Center at the University of Texas at Austin, and infrastructure grants from the National Institute on Aging (T32AG000037, P30AG066589, P30AG043073) awarded to School of Gerontology, Center for Advancing Sociodemographic and Economic Study of Alzheimer's Disease and Related Dementias, and the USC Resource Center for Minority Aging Research, respectively, at the University of Southern California. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.


## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2021.100921.

## Author statement

Hyungmin Cha: Conceptualization, Methodology, Formal Analysis, Writing, Reviewing, and Editing., Mateo Farina: Conceptualization, Supervising analysis, Methodology, Writing, Reviewing, and Editing., Mark Hayward: Conceptualization, Supervising analysis, Writing, Reviewing, and Editing.

## References


Andersen-Ranberg, K., Vasegaard, L., & Jeune, B. (2001). Dementia is not inevitable: A population-based study of Danish centenarians. *Journal of Gerontology: Series B, 56*, P152–P159. https://doi.org/10.1093/geronb/56.3.P152

Bhatta, T. R. (2020). Intercohort variations in the education–health gradient: Sociohistorical changes in early-life selection mechanisms in the United States. *Journal of Gerontology: Series B gbaa, 100*. https://doi.org/10.1093/geronb/gbaa100

Bond Huie, S. A., Krueger, P. M., Rogers, R. G., & Hummer, R. A. (2003). Wealth, race, and mortality. *Social Science Quarterly, 84*, 667–684. https://doi.org/10.1111/1540-6237.8403011

Breen, R., & Jonsson, J. O. (2005). Inequality of opportunity in comparative perspective: Recent research on educational attainment and social mobility. *Annual Review of Sociology, 3*, 223–243.

Bugliari, D., Carroll, J., Hayden, O., Hayes, J., Hurd, M., Karabatakis, A., Main, R., Marks, J., McCullough, C., Meijer, E., Moldoff, M., Pantoja, P., Rohwedder, S., & StClair, P. (2020). *RAND HRS detailed imputations file 2016 (V2) documentation*.

Cadar, D., Lassale, C., Davies, H., Llewellyn, D. J., Batty, G. D., & Steptoe, A. (2018). Individual and area-based socioeconomic factors associated with dementia incidence in England: Evidence from a 12-year follow-up in the English longitudinal study of ageing. *JAMA Psychiatr., 75*, 723–732. https://doi.org/10.1001/jamapsychiatry.2018.1012

Cai, L., Hayward, M., Saito, Y., Lubitz, J., Hagedorn, A., & Crimmins, E. (2010). Estimation of multi-state life table functions and their variability from complex survey data using the SPACE Program. *DemRes, 22*, 129–158. https://doi.org/10.4054/DemRes.2010.22.6

Crimmins, E. M., Hayward, M. D., & Saito, Y. (1994). Changing mortality and morbidity rates and the health status and life expectancy of the older population. *Demography, 31*, 159. https://doi.org/10.2307/2061913

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: Psychological Sciences and Social Sciences, 66B*, 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: Psychological Sciences and Social Sciences, 73*, S20–S28. https://doi.org/10.1093/geronb/gbx135

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: Psychological Sciences and Social Sciences*. https://doi.org/10.1093/geronb/gbz046

Gill, T. M., Allore, H., Hardy, S. E., Holford, T. R., & Han, L. (2005). Estimates of active and disabled life expectancy based on different assessment intervals. *Journal of Gerontology: Series A, 60*, 1013–1016. https://doi.org/10.1093/gerona/60.8.1013

Glymour, M. M., & Manly, J. J. (2008). Lifecourse social conditions and racial and ethnic patterns of cognitive aging. *Neuropsychology Review, 18*, 223–254. https://doi.org/10.1007/s11065-008-9064-z

Glymour, M. M., Tzourio, C., & Dufouil, C. (2012). Is cognitive aging predicted by one's own or one's parents' educational level? Results from the three-city study. *American Journal of Epidemiology, 175*, 750–759. https://doi.org/10.1093/aje/kwr509

Gottschalck, A., Vornovytskyy, M., & Smith, A. (2014). *Household wealth in the U.S.: 2000 to 2011*.

Green, J. G., McLaughlin, K. A., Berglund, P. A., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2010). Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication I: Associations with first onset of DSM-IV disorders. *Archives of General Psychiatry, 67*, 113–123. https://doi.org/10.1001/archgenpsychiatry.2009.186

Hayward, M. D., Farina, M. P., Zhang, Y. S., Kim, J. K., & Crimmins, E. M. (2021). The importance of improving educational attainment for dementia prevalence trends from 2000-2014, among older non-hispanic Black and white Americans. *Journal of Gerontology: Series B*. https://doi.org/10.1093/geronb/gbab015

Hayward, M. D., Hummer, R. A., & Sasson, I. (2015). Trends and group differences in the association between educational attainment and U.S. adult mortality: Implications for understanding education's causal influence. *Social Science & Medicine, Special Issue: Educational Attainment and Adult Health: Contextualizing Causality, 127*, 8–18. https://doi.org/10.1016/j.socscimed.2014.11.024

HRS. (2019). *Health and retirement study 2016 tracker early, version 3.0*.

Jackson, M. I. (2009). Understanding links between adolescent health and educational attainment. *Demography, 46*, 671–694. https://doi.org/10.1353/dem.0.0078

James, B. D., & Bennett, D. A. (2019). Causes and patterns of dementia: An update in the era of redefining alzheimer's disease. *Annual Review of Public Health, 40*, 65–84. https://doi.org/10.1146/annurev-publhealth-040218-043758

Jutkowitz, E., Kane, R. L., Gaugler, J. E., MacLehose, R. F., Dowd, B., & Kuntz, K. M. (2017). Societal and family lifetime cost of dementia: Implications for policy. *Journal of the American Geriatrics Society, 65*, 2169–2175. https://doi.org/10.1111/jgs.15043

Kalleberg, A. L. (2009). Precarious work, insecure workers: Employment relations in transition. *American Sociological Review, 74*, 1–22.

Langa, K. M., Larson, E. B., Crimmins, E. M., Faul, J. D., Levine, D. A., Kabeto, M. U., & Weir, D. R. (2017). A comparison of the prevalence of dementia in the United States in 2000 and 2012. *JAMA Intern Med, 177*, 51–58. https://doi.org/10.1001/jamainternmed.2016.6807

Langa, K. M., Larson, E. B., Karlawish, J. H., Cutler, D. M., Kabeto, M. U., Kim, S. Y., & Rosen, A. B. (2008). Trends in the prevalence and mortality of cognitive impairment in the United States: Is there evidence of a compression of cognitive morbidity? *Alzheimer's and Dementia, 4*, 134–144. https://doi.org/10.1016/j.jalz.2008.01.001

Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior, 35*, 80. https://doi.org/10.2307/2626958

Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., Brayne, C., Burns, A., Cohen-Mansfield, J., Cooper, C., Costafreda, S. G., Dias, A., Fox, N., Gitlin, L. N., Howard, R., Kales, H. C., Kivimäki, M., Larson, E. B., Ogunniyi, A., … Mukadam, N. (2020). Dementia prevention, intervention, and care: 2020 report of the lancet commission. *The Lancet*. https://doi.org/10.1016/S0140-6736(20)30367-6. S0140673620303676.

Lövdén, M., Fratiglioni, L., Glymour, M. M., Lindenberger, U., & Tucker-Drob, E. M. (2020). Education and cognitive functioning across the life span. *Psychological Science in the Public Interest, 21*, 6–41. https://doi.org/10.1177/1529100620920576

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: Psychological Sciences and Social Sciences, 60*, S93–S101. https://doi.org/10.1093/geronb/60.2.S93

Marden, J. R., Tchetgen Tchetgen, E. J., Kawachi, I., & Glymour, M. M. (2017). Contribution of socioeconomic status at 3 life-course periods to late-life memory function and decline: Early and late predictors of dementia risk. *American Journal of Epidemiology, 186*, 805–814. https://doi.org/10.1093/aje/kwx155

Maust, D. T., Kim, H. M., Seyfried, L. S., Chiang, C., Kavanagh, J., Schneider, L. S., & Kales, H. C. (2015). Antipsychotics, other psychotropics, and the risk of death in patients with dementia: Number needed to harm. *JAMA Psychiatr., 72*, 438–445. https://doi.org/10.1001/jamapsychiatry.2014.3018

Melrose, R. J., Brewster, P., Marquine, M. J., MacKay-Brandt, A., Reed, B., Farias, S. T., & Mungas, D. (2015). Early life development in a multiethnic sample and the relation to late life cognition. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 70*, 519–531. https://doi.org/10.1093/geronb/gbt126

Montez, J. K., & Hayward, M. D. (2014). Cumulative childhood adversity, educational attainment, and active life expectancy among U.S. Adults. *Demography, 51*, 413–435. https://doi.org/10.1007/s13524-013-0261-x

Pudrovska, T. (2014). Early-life socioeconomic status and mortality at three life course stages: An increasing within-cohort inequality. *Journal of Health and Social Behavior, 55*, 181–195. https://doi.org/10.1177/0022146514531986

Qiu, C., & Fratiglioni, L. (2018). Aging without dementia is achievable: Current evidence from epidemiological research. *JAD, 62*, 933–942. https://doi.org/10.3233/JAD-171037

RAND. (2020). *RAND HRS longitudinal file 2016 (V2)*.

Seifan, A., Schelke, M., Obeng-Aduasare, Y., & Isaacson, R. (2015). Early life epidemiology of alzheimer's disease - a critical review. *NED, 45*, 237–254. https://doi.org/10.1159/000439568

Sutin, A. R., Stephan, Y., Luchetti, M., & Terracciano, A. (2019). Loneliness and risk of dementia. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*. https://doi.org/10.1093/geronb/gby112

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

Weir, D. R. (2016). *Validating mortality ascertainment in the health and retirement study* (Vol. 19).

Wolf, D. A., & Gill, T. M. (2009). Modeling transition rates using panel current-status data: How serious is the bias? *Demography, 46*, 371–386. https://doi.org/10.1353/dem.0.0057

Zhang, Z., Gu, D., & Hayward, M. D. (2008). Early life influences on cognitive impairment among oldest old Chinese. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 63*, S25–S33. https://doi.org/10.1093/geronb/63.1.S25

Zhang, Z., Hayward, M. D., & Yu, Y.-L. (2016). Life course pathways to racial disparities in cognitive impairment among older Americans. *Journal of Health and Social Behavior, 57*, 184–199. https://doi.org/10.1177/0022146516645925

Zhang, Z., Liu, H., & Choi, S. (2019). Early-life socioeconomic status, adolescent cognitive ability, and cognition in late midlife: Evidence from the Wisconsin Longitudinal Study. *Social Science & Medicine, 112575*. https://doi.org/10.1016/j.socscimed.2019.112575

Zheng, H. (2020). A new look at cohort trend and underlying mechanisms in cognitive functioning. *Journal of Gerontology: Series B*. https://doi.org/10.1093/geronb/gbaa107