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Racial, Ethnic, Nativity, and Educational Disparities in Cognitive Impairment and Activity Limitations in the United States, 1998–2016

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ABSTRACT Despite extensive research on cognitive impairment and limitations in basic activities of daily living, no study has investigated the burden of their co-occurrence (co-impairment). Using the Health and Retirement Study data and incidence-based multistate models, we study the population burden of co-impairment using three key indicators: mean age at onset, lifetime risk, and health expectancy. We examine patterns by gender, race, ethnicity, nativity, education, and their interactions for U.S. residents aged 50–100. Furthermore, we analyze what fractions of racial, ethnic, and nativity disparities in co-impairment are attributable to inequalities in educational attainment. Results reveal that an estimated 56% of women and 41% of men aged 50 will experience co-impairment in their remaining life expectancy. Men experience an earlier onset of co-impairment than women (74 vs. 77 years), and women live longer in co-impairment than men (3.4 vs. 1.9 years). Individuals who are Black, Latinx, and lower educated, especially those experiencing intersecting disadvantages, have substantially higher lifetime risk of co-impairment, earlier co-impairment onset, and longer life in co-impairment than their counterparts. Up to 75% of racial, ethnic, and nativity disparity is attributable to inequality in educational attainment. This study provides novel insights into the burden of co-impairment and offers evidence of dramatic disparities in the older U.S. population.

KEYWORDS Health disparities • Cognitive impairment • ADLs • Social stratification • Multistate models

Introduction

The lengthening of life expectancies has made maintaining older individuals' health and well-being a public health priority in high-income countries. Healthy cognitive function and the ability to perform basic activities of daily living (ADLs), such as walking, dressing, and eating, without limitations are two important components of healthy aging. Extensive research has explored the burden of cognitive impairment (Crimmins et al. 2016; Reuser et al. 2011) and ADL limitations (Freedman and Spillman 2016; Ostchega et al. 2000; Zaninotto et al. 2020) among the older U.S.

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population. However, there is a lack of research focusing on the burden from the simultaneous occurrence of cognitive impairment and activity limitations, which is likely to have substantially greater ramifications for affected adults and their caregivers than either condition alone (Riffin et al. 2017).

This study is the first to quantify the population burden of the co-occurrence of cognitive impairment and ADL limitations (henceforth, *co-impairment*), and it contributes to population health research in three key ways. First, using incidence-based, discrete-time Markov chain multistate models and data from the Health and Retirement Study, a high-quality panel survey representative of U.S. residents older than 50, we estimate three key indicators: (1) mean age at onset, (2) lifetime risk, and (3) life expectancy in co-impairment. These indicators together provide a more nuanced understanding of the burden of co-impairment among the older U.S. population than any single indicator.

Second, we investigate how this burden differs by intersecting life course (dis)advantages, including gender, race, ethnicity, nativity, and educational attainment. Identifying subpopulations that experience greater burden will also help identify which caregiver subgroups are at higher risk of poor health from bearing this burden.

Third, we incorporate a counterfactual framework focusing on educational attainment, given that it is a fundamental and potentially modifiable health determinant. We examine what fractions of the racial, ethnic, and nativity disparities in co-impairment are attributable to educational inequalities by estimating a counterfactual that eliminates racial, ethnic, and nativity inequalities in the distribution of educational attainment.

This study builds on research on cognitive impairment and ADL limitations. Using advanced statistical methods, we extend knowledge on the burden of their co-occurrence—*co-impairment*—and racial, ethnic, nativity, and educational disparities in co-impairment among the older U.S. population. In addition to using the widely used indicators of life and health expectancies, we calculate indicators of lifetime risk and mean age at co-impairment onset, providing a more comprehensive picture of the burden of co-impairment. Furthermore, the flexibility of multistate modeling allows us to incorporate a counterfactual framework to clarify the role of educational attainment inequalities in driving racial, ethnic, and nativity disparities in co-impairment.

Background

Life expectancy at older ages has increased in the United States, contributing to the expansion of the older population (World Health Organization 2017). Adults aged 65 and older constituted 17% (56 million individuals) of the total U.S. population in 2020 but are expected to represent 22% (81 million individuals) of the population by 2040 (Vespa et al. 2018). Population aging poses a challenge because cognitive function and the ability to carry out basic ADLs decline as adults age, often preventing independent living.

In the United States, an estimated 18 million older individuals experienced cognitive impairment in 2020 (Rajan et al. 2021), and ADL limitations translated to a loss of 432,224 years of healthy life for adults aged 50 and older in 1998–2014 (McGrath et al. 2019). One projection predicts that the number of older adults with cognitive impairment will increase to more than 35 million by 2060 (Rajan et al. 2021), although whether prevalence in the United States is increasing or decreasing is a matter of ongoing debate (e.g., Hale, Schneider, Gampe et al. 2020; Langa et al. 2017; Lee et al. 2021). The hefty emotional, social, and economic burden of Alzheimer's disease and related dementias makes cognitive impairment an important public health issue (Alzheimer's Association 2011, 2022).

Similarly, the odds of experiencing ADL limitations have increased significantly in recent decades in the older U.S. population (Tsai 2017), with one U.S. study identifying more than 1 million community-dwelling older adults with co-impairment (Riffin et al. 2017). Although extensive research has examined cognitive impairment and activity limitations, no study has investigated the probability of ever experiencing co-impairment, when in the life course individuals experience it, and how long they expect to live in the highly disadvantaged state of co-impairment.

Addressing the burden of co-impairment in population health research is urgently needed because the number of adults experiencing co-impairment will likely increase as a result of population aging and other health trends. Both cognitive impairment and ADL limitations share many common risk factors, and the risks of cognitive impairment (Robitaille et al. 2018) and ADL limitations (Jacob et al. 2018) increase substantially with age. These health conditions share a range of morbidities (e.g., diabetes, stroke, and hypertension) as risk factors (Caskie et al. 2010; Crichton et al. 2016; Hankey et al. 2002; Langa et al. 2017; Skoog and Gustafson 2006; Verruca et al. 1996; Wong et al. 2013). These morbidities are projected to become more prevalent in the coming years in the United States (Heidenreich et al. 2011; Lin et al. 2018; Ovbiagele et al. 2013).

Cognitive impairment is itself a significant risk factor for activity limitations and *vice versa* (Fauth et al. 2013; Hajek and König 2016; Sauvaget et al. 2002). Individuals with mild cognitive impairment or dementia are considerably more likely to experience ADL limitations than those not cognitively impaired (Andrews et al. 2016; Thomas 2001). Furthermore, activity limitations are a significant risk factor for incident cognitive impairment, and their onset often signals an acceleration of cognitive decline (Fauth et al. 2013; Rajan et al. 2013). These factors are likely to increase cases of co-impairment.

Cognitive impairment and ADL limitations exert a considerable burden on affected adults and are associated with reduced quality of life and an increased risk of death (Alzheimer's Association 2021; Ankuda et al. 2020; Gobbens 2018; Langa et al. 2008; Marengoni et al. 2009). Compared with only cognitive impairment or ADL limitations, co-impairment is more detrimental to independent living because the compounding of adverse health conditions means greater dependence on caregivers (Riffin et al. 2017). Co-impaired adults also experience a substantially greater mortality risk than adults with only one of these health conditions (Yu et al. 2017). In the United States, most adults with ADL limitations or cognitive impairment receive care in the community (Freedman and Spillman 2014; Lepore et al. 2017). Caregiving for adults with co-impairment is taxing. The percentage of caregivers reporting physical, emotional, and financial difficulties and social participation restrictions associated with care provision is higher for caregivers of co-impaired adults than for caregivers of adults with only cognitive impairment or only activity limitations (Riffin et al. 2017). These difficulties are associated with adverse health consequences for caregivers (Fratiglioni et al. 2000).

Exacerbating caregiving challenges, the burden of these health conditions is not uniform across the older U.S. population. For instance, relative to men, women are more likely to experience cognitive impairment (Hale, Schneider, Mehta et al. 2020; Suthers et al. 2003) and activity limitations (Wang et al. 2021) and spend more years in these health states (Crimmins et al. 2016; Hale, Schneider, Mehta et al. 2020; Suthers et al. 2003; Zaninotto et al. 2020). Compared with Whites, Blacks and Latinx (both U.S.-born and foreign-born) have a significantly higher likelihood of cognitive impairment and poorer cognitive health expectancies, even after education and other health conditions are controlled (Garcia et al. 2019; Reuser et al. 2011). These subpopulations also have a higher risk of, and longer expectancies in, activity limitations than Whites (Freedman and Spillman 2016; Garcia et al. 2017; Ostchega et al. 2000; Zsembik et al. 2000). Among these disadvantaged subpopulations, foreign-born Latinx live the longest with cognitive impairment and activity limitations (Garcia et al. 2019; Hayward et al. 2014). Lower educated adults have a significantly higher risk of cognitive impairment (Reuser et al. 2011) and activity limitations (Carmona-Torres et al. 2019), net of other sociodemographic risk factors, and live longer in these health states (Crimmins et al. 2018; Lièvre et al. 2008; Solé-Auró et al. 2014). Within each racial and ethnic subgroup, those with lower education live a greater proportion of their lives with cognitive impairment (Farina et al. 2020) and activity limitations (Crimmins et al. 1996) than their higher educated counterparts. Blacks with the lowest education experience a greater burden of activity limitations and cognitive impairment than the lowest educated Whites. However, the burden of co-impairment for these subpopulations has yet to be studied.

The proportion of Latinx and Blacks, who constituted 29% of the U.S. population in 2010, is expected to reach 43% by 2060 (Jones et al. 2021; Vespa et al. 2018). These subgroups are socioeconomically disadvantaged and experience a greater burden of chronic morbidities (Ferdinand and Nasser 2015; Whitson et al. 2011), which are risk factors of cognitive impairment and ADL limitations and therefore may place these groups at a higher risk of co-impairment (Langa et al. 2017; Wong et al. 2013). Because the U.S. adult population is becoming much more racially diverse, understanding how racial, ethnic, and nativity subgroups have shaped the burden of co-impairment is essential. Also important is examining how these important social risk factors—namely, race, ethnicity, nativity, and educational attainment—combine to differentiate the experience of co-impairment in the older U.S. population. Carepartner pairs belonging to more disadvantaged populations are likely to bear the considerable strain of co-impairment caregiving longer, exacerbating adverse consequences. Therefore, identifying subpopulations with a greater burden of co-impairment will not only help identify subgroups in need of support resources (tertiary prevention) but may also help target appropriate interventions for vulnerable caregivers (primary prevention).

The significant variations in cognitive functioning and performance in ADLs among Whites, Blacks, and Latinx have garnered attention in population health research. Several studies have argued that educational attainment inequalities across these racial and ethnic subpopulations are responsible for a sizable portion of the racial and ethnic disparities in these health domains (Fuller-Thomson et al. 2009; Garcia, Saenz et al. 2018; Lin et al. 2014; Schwartz et al. 2004; Yaffe et al. 2013). Educational attainment is a risk factor that is modifiable through appropriate policy interventions. Therefore, it is important to assess the extent to which increasing educational attainment would minimize racial, ethnic, and nativity disparities in cognitive function and performance in ADLs.

Data and Methods

Data

This study uses data from the Health and Retirement Study (HRS), a biennial, nationally representative survey of U.S. adults older than 50 and their spouses of any age. The survey is conducted by the Institute for Social Research at the University of Michigan and is funded by the National Institute on Aging (NIA U01AG009740) and the Social Security Administration (National Institute on Aging and Social Security Administration 2019). Additional details of the HRS can be found elsewhere (Fisher and Ryan 2018). We use the RAND HRS longitudinal file 2016 (V2) from 1998–2016, which includes imputed cognitive scores for self-respondents with missing cognitive data (McCammon et al. 2019). Our analytic sample comprises study participants and their spouses aged 50–100 who have cognitive function and ADL scores in at least two waves.[1] The unit of analysis in the multistate calculation is a transition. To be included in the multistate calculation, an individual needs to have been in the survey for at least two waves, which are fielded an average of two years apart. Less than one fifth of 1% of any of the predictors are missing.

Measures

Dependent Variable

The dependent variable has five states. Four are transient states, from which recovery is possible: *healthy* (no cognitive impairment and no ADL limitations), *only cognitive impairment*, *only ADL limitation(s)*, and *co-impairment* (cognitive impairment and ADL limitation(s)). The fifth one—*death*—is an absorbing state, verified through the National Death Index. These five states form the state space of the Markov model (see Figure 1).

ADL Limitation(s)

ADLs are the fundamental skills usually required to manage basic daily needs (Mlinac and Feng 2016). Self-reported ADL limitations are the measures most commonly used in research and clinical settings (Bravell et al. 2011) and are assessed via questions from the ADL scale (Katz et al. 1963). The HRS asks respondents whether they experience difficulty in dressing, walking, bathing, eating, and getting in or out

[1] Table S1 (online appendix) shows the HRS birth cohorts included in our analytic sample.

of bed because of a health or memory problem. We classify respondents as having ADL limitation(s) if they report difficulty with at least one ADL, as is common in the literature (Bardenheier et al. 2016; Mehta and Myrskylä 2017; Payne 2022). For the 8% of our analytic sample for whom a proxy responded on behalf of the respondent, we use proxy responses for assessing ADL limitation(s) and cognitive impairment (Sonnega et al. 2014).

Although subjective reports and proxy responses may introduce some bias (Li et al. 2015; Todorov and Kirchner 2000), other available ADL assessments (*use of equipment* or *gets help*) are asked for select ADLs or to meet a narrower definition of disability (Bugliari et al. 2020; Gill et al. 1998). Furthermore, because our focus is on how difficulties in ADLs combined with cognitive impairment result in a greater burden of co-impairment, subjective experience is also important. To address the likely proxy bias, we include response status in our models. The practice effects adjustment (discussed in the Independent Variables section) accounts for self-reports versus proxy responses.

Cognitive Impairment

We use information from self-respondents and proxies to determine whether a person is cognitively impaired. For self-respondents, the HRS uses a modified version of the Telephone Interview for Cognitive Status (TICS) test. The TICS test scores range from 0 to 27 points and include four tasks: immediate (0–10 points) and delayed word recall (0–10 points), serial-7s (0–5 points), and counting backward (0–2 points). The cut points (cognitive impairment, 0–11; no cognitive impairment, 12–27) were already validated against the Aging Demographics and Memory Study (ADAMS), a substudy of the HRS with an in-depth neuropsychological examination (Crimmins et al. 2011; Langa et al. 2005).

For respondents requiring a proxy, we follow Langa and Weir to define cognitive health states (Langa et al. 2017). We use a nine-point scale for the 1998 wave, which includes the proxy's direct assessment of (1) the respondent's memory (0 = excellent, 4 = poor) and (2) the respondent's limitations in five instrumental ADLs: managing money, taking medication, preparing hot meals, using the phone, and shopping for groceries (0–5). The total score ranges from 0 to 9 (0–2 indicates no cognitive impairment, and 3–9 indicates cognitive impairment). From 2000 onward, another measure is added: (3) the proxy's assessment of the respondent's difficulty completing the interview for cognitive limitations, creating an 11-point scale (0–2 indicates no cognitive impairment, and 3–11 indicates cognitive impairment). The addition of this measure did not significantly affect our results. The cut points we use for proxies are ADAMS-validated (Crimmins et al. 2011; Langa et al. 2005).

Independent Variables

Age is a continuous variable measured in completed years. The HRS reports gender as a binary variable (1 = woman). Race and ethnicity are self-reported. Small sample sizes restrict us to studying the categories White, Black, and other, with ethnicity categorized as Hispanic or non-Hispanic. We create a joint variable of race and ethnicity, categorized as non-Latinx White, Latinx Black, non-Latinx Black, non-Black Latinx, and non-Latinx other. We combine Latinx Black with non-Latinx Black because these groups have health outcomes more similar to non-Latinx Black than to non-Black Latinx (Chinn and Hummer 2016). Importantly, Latinx Blacks are a distinct subpopulation of the Latinx population. The Hispanic paradox of better health for immigrants relative to natives does not extend to Latinx Blacks (Elo et al. 2011), who experience greater health disadvantages than White Latinx, more similar to those of non-Latinx Blacks (Borrell 2006; Borrell and Crawford 2006; Chinn and Hummer 2016; Cuevas et al. 2016). Latinx Blacks are also much more socioeconomically comparable to non-Latinx Blacks than to non-Black Latinx and are more likely to share neighborhoods (Denton and Massey 1989; Fears 2003; Logan 2004).

Our categorization combines very few (60) Latinx Blacks with the roughly 6,000 non-Latinx Blacks in our analytic sample. We then disaggregate non-Black Latinx into non-Black U.S.-born Latinx and non-Black foreign-born Latinx. We include *non-Latinx other* in the analyses, but we do not show the results because of small sample sizes at older ages. Henceforth, we refer to non-Latinx White as *White*, Latinx Black and non-Latinx Black as *Black*, non-Black U.S.-born Latinx as *U.S.-born Latinx*, and non-Black foreign-born Latinx as *foreign-born Latinx*.

We measure educational attainment categorically to account for the nonlinear association between education and health outcomes (see, e.g., Montez et al. 2012). Because of the low average educational attainment for these early to mid-twentieth-century cohorts—especially for women and Black and Latinx subpopulations—we combine some college with high school diploma/general equivalency degree (GED) and consider the highest education to be an associate's degree or higher. For more recent cohorts, we could define higher education by creating a category for bachelor's degree or higher. However, for Blacks and Latinx in the earlier cohorts, bachelor's degree attainment is rare. Only 242 U.S.-born Latinas (vs. roughly 15,000 White women) in our analytic sample have a bachelor's degree or higher education. Such small sample sizes will lead to unstable estimates. For the earlier cohorts for whom further education was rarer (see Hendi 2017)—especially for women, Blacks, and Latinx—an associate's degree is a significant achievement. The final educational categories are less than high school, high school/GED/some college, and an associate's degree or higher.

To account for practice effects, we adjust for the number of cognitive tests taken, measured categorically as the (1) first, (2) second, (3) third to sixth, or (4) seventh or higher cognitive assessment test taken (Goldberg et al. 2015). A fifth category identifies respondents with a proxy.

Statistical Analysis

Multistate Modeling

As noted earlier, we employ incidence-based multistate methods instead of the more widely used prevalence-based Sullivan method for exploring the population burden of morbidity or poor health (e.g., Crimmins et al. 2016; Freedman and Spillman 2016;

Garcia et al. 2019; Jagger et al. 2016; Suthers et al. 2003; Tom et al. 2015). Because the Sullivan approach is based on the prevalence of a health condition, it reflects a portion of the past risk of that condition in the population. The method does not allow recovery from poor health, nor does it allow mortality to vary by health status. In contrast, because the multistate method relies on incidence data, it measures the current risk of the health condition in the population. It allows recovery (e.g., transition back from unhealthy to healthy) and allows mortality to vary by health state. In other words, the multistate approach more accurately estimates contemporary population health dynamics. Therefore, when the data allow, researchers often choose to use multistate methods (e.g., Cai and Lubitz 2007; Crimmins et al. 2009; Majer et al. 2013; Payne and Kobayashi 2022).

For example, in a recent U.S.-based study, Payne (2022) compared partial cohort life expectancies and expectancies in states of ADL limitations, chronic morbidities, and self-reported poor health across successive birth cohorts. The multistate method has also been applied to examine variations in life expectancies and disability-free life expectancies with and without specific diseases, such as cancer (Payne and Kobayashi 2022). Cai and Lubitz (2007) used this approach to examine three theories of population aging: morbidity compression, morbidity expansion, and dynamic equilibrium. In recent years, there have been methodological advances in the Markov chain multistate literature, including calculating additional metrics (e.g., Caswell and Zarulli 2018; Dudel 2021). For instance, Dudel (2021) expanded the Markov chain toolbox by presenting methods for waiting times, helping us understand the timing of events under study (e.g., the average age at first entry into a state and leaving a state).

In this study, we apply discrete-time Markov chain multistate models to understand the dynamics of co-impairment in the older U.S. population. In addition to calculating expectancy in co-impairment, we also calculate the lifetime risk and mean age at onset of co-impairment from multistate models. The lifetime risk of a condition is the probability of ever experiencing that condition before dying (Kemeny and Snell 1983). Because individual life courses are only partially observed in the HRS, the calculation of lifetime risk (and mean age at onset) cannot be based only on individual trajectories. Therefore, we use established demographic multistate methods (Dudel 2021; Kemeny and Snell 1983; Mehta and Myrskylä 2017) to calculate lifetime risk and mean age at co-impairment onset.

The Markov chain multistate models are based on the probabilities of transitions across the states in the Markov state space. Figure 1 illustrates the states from the Markov state space and the transitions across the states. To estimate these transition probabilities, we use multinomial logistic regression models (Allison 1982), as is common in applied multistate research (Bardo and Lynch 2021; Cai and Lubitz 2007; Dudel 2021; Hale et al. 2021; Mehta and Myrskylä 2017; Payne 2022). We estimate four multinomial logistic regression models, all stratified by gender.

To estimate transition probabilities for the overall population, we use Model 1, which takes the form

$$\log \frac{p_{ij}}{p_{iH}} = a_{ij} + b_{1,ij} Age + b_{2,ij} Age^2 + \gamma_{ij}^T PE,$$

where p_{ij} is the transition probability from state i to state j that also includes the state *death*; H indicates the reference state, *healthy*; a_{ij} is the intercept; *Age* is the age

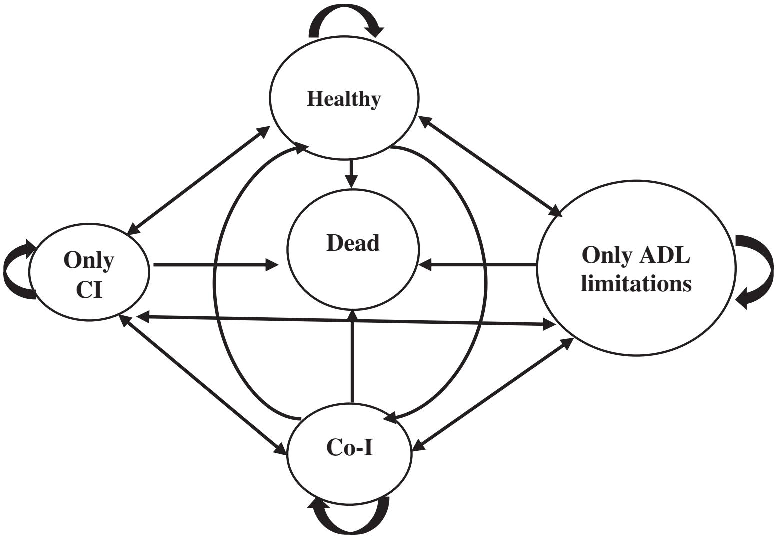

Fig. 1 Markov state space along with transitions across the states denoted by the arrows. We estimate probabilities of these transitions by age, gender, race, ethnicity, nativity, education, and their interactions. Co-I = co-impairment. CI = cognitive impairment. ADL = activities of daily living.

during the follow-up at mid-interview; and γ_{ij} is the coefficient vector related to the practice effects categories.

Model 2 adds race, ethnicity, and nativity to Model 1 to estimate the transition probabilities by race, ethnicity, and nativity (e.g., for foreign-born Latinx). Model 3 adds education to Model 1 (without race, ethnicity, and nativity) to estimate the transition probabilities by education (e.g., for an associate's degree or more education). The primary goal of our study is to understand the burden of co-impairment for Whites, Blacks, and Latinx with varying educational levels and for educational subgroups with different racial and ethnic compositions as they exist in the older U.S. population. Notably, this approach differs from approaches aiming to assess mechanisms. In Models 2 and 3, we allow the full set of interactions between the predictors.

Model 4 estimates transition probabilities for all combinations of race, ethnicity, nativity, and education (e.g., foreign-born Latinx with an associate's degree or more) as follows:

$$\log \frac{p_{ij}}{p_{iH}} = a_{ij} + b_{1,ij} Age + b_{2,ij} Age^2 + \gamma_{ij}^T PE + \delta_{ij}^T DEMOGR,$$

where δ_{ij} is a coefficient vector related to the variables in *DEMOGR*; it includes race, ethnicity, nativity, education, and the full set of interactions.

To obtain the age-specific transition probabilities for the overall population from Model 1, we set practice effects to the second interview. To obtain the age-specific transition probabilities for a specific subgroup—for example, Whites in Model 2, an associate's degree or more in Model 3, and Whites with an associate's degree or more in Model 4—we set the corresponding categorical variable(s) to 1 and practice effects to the second interview.

The probability that an adult who is in state *i* at age *x* will be in state *j* at age *x* + 2, $p(j|x, i)$, is then arranged in a Markov transition matrix, $\mathbf{M^T} = [\boldsymbol{pji}]$, for each of the subgroups analyzed—one for the total population, one for overall Blacks, one for Blacks with associate's degree or more, and so on.

By performing matrix operations on the Markov transition matrix, $\mathbf{M^T}$, we obtain the metrics of lifetime risk of co-impairment, mean age at onset of co-impairment, and life expectancy in co-impairment. Section 2 of the online appendix provides a detailed description of the estimation procedure. In brief, to estimate the expectancies, we follow the standard approach of first estimating the conditional expectancies and then calculating weighted averages across conditional expectancies. Weights are the starting state distribution at age 50. For each of the subpopulations, we use its own starting state distribution at age 50. To avoid small sample noise, we calculate starting state over ages 50–60 during 1998–2016. We use survey weights from the HRS to account for the complex survey design and nonresponse. We estimate confidence intervals using the bootstrap procedure suggested by Cameron and Trivedi (2005) based on 500 replications, as applied in multistate research (Dudel and Myrskylä 2017). We resample health trajectories at the individual level, mimicking the survey's complex sampling process and accounting for the cohort structure and oversampling (Dudel and Myrskylä 2017). We conduct all analyses using R.

In this article, we focus on the state of *co-impairment*. However, in Tables S2 and S3 in the online appendix, we present the expectancy estimates for all health states in the Markov state space. Furthermore, in Table S4, we present the estimates of mean age at onset for *only cognitive impairment* and *only ADL limitations*.

Counterfactual Model

We examine what fractions of racial, ethnic, and nativity disparities in co-impairment are attributable to inequalities in the distribution of educational attainment by estimating a counterfactual that eliminates these educational inequalities. We first calculate, for each racial, ethnic, and nativity subgroup, co-impairment expectancies by educational attainment (e.g., co-impairment expectancies for Blacks with less than high school, Blacks with high school/GED/some college, and Blacks with associate's degree or more).

Next, for Blacks and U.S.- and foreign-born Latinx, we aggregate the respective co-impairment expectancies by educational attainment using weights to obtain the counterfactual co-impairment expectancy. The weights are the distribution of educational attainment for Whites. In other words, we estimate the counterfactual co-impairment expectancies for Blacks and U.S.- and foreign-born Latinx by assigning them the same educational distribution as their more advantaged White counterparts.

This counterfactual allows us to estimate potential racial, ethnic, and nativity disparities in co-impairment expectancy, absent those that can be attributed to the considerable racial, ethnic, and nativity inequalities in the distribution of educational attainment. Furthermore, the online appendix (section 5) provides an example of the calculation of counterfactual expectancies.

Table 1 Descriptive characteristics of the sample

	Individuals	%	Transitions	%	% Transition to Co-impairment
Overall	32,697	100	195,491	100	7
Men	14,507	44.4	83,601	42.8	6
Women	18,190	55.6	111,890	57.2	8
White	22,451	68.7	139,476	71.3	6
Black	5,836	17.8	31,818	16.3	11
U.S.-born Latinx	1,389	4.2	8,046	4.1	10
Foreign-born Latinx	2,113	6.5	11,284	5.8	11
Less Than High School	8,353	25.5	46,312	23.7	16
High School/GED/Some College	16,606	50.8	101,663	52.0	5
Associate's Degree+	7,738	23.7	47,516	24.3	2

Source: 1998–2016 Health and Retirement Study.

Results

Descriptive Statistics

Table 1 provides the sociodemographic characteristics of the sample during 1998–2016. The total sample size is 32,697 individuals, and the analysis is based on 195,491 transitions. Sample sizes for women, Whites, and adults with high school/GED/some college education are higher than those for their counterparts. Blacks and U.S.- and foreign-born Latinx are nearly two times as likely to experience a transition to co-impairment as Whites. The lowest educated adults are eight times as likely to experience a transition to co-impairment than the highest educated.

Lifetime Risk of Co-impairment

In Table 2, we present the lifetime risk of co-impairment for the total population and separately by race, ethnicity, nativity, and education. Overall, 56% of women and 41% of men aged 50 are predicted to experience co-impairment in their remaining life expectancy. We find considerable disparities by race, ethnicity, nativity, and education.

U.S.- and foreign-born Latinx and Blacks experience a substantially greater lifetime risk of co-impairment than Whites, irrespective of gender. The likelihood of co-impairment for foreign- and U.S.-born Latinas and Black women is, respectively, 30 (=81% – 51%), 20, and 18 percentage points higher than for White women. The corresponding numbers for men are 28, 17, and 19 percentage points. The lifetime risk of co-impairment for the lowest educated women and men is, respectively, 28 and 31 percentage points greater than for the highest educated.

Table 3 shows the lifetime risk for White, Black, and Latinx subpopulations by educational attainment. The most disadvantaged subpopulations are lower educated Blacks and Latinx—particularly foreign-born Latinas, who experience an

Table 2 Lifetime risk (%) of co-impairment for the total population and by race, ethnicity, nativity, and education in the United States, 1998–2016, with 95% confidence intervals shown in parentheses

	Women	Men
	Lifetime Risk (%)	Lifetime Risk (%)
Total	56 (53, 59)	41 (38, 44)
White	51 (48, 54)	36 (32, 39)
Black	69 (65, 73)	55 (51, 60)
U.S.-born Latinx	71 (64, 77)	53 (44, 61)
Foreign-born Latinx	81 (76, 86)	64 (55, 71)
Less Than High School	72 (69, 75)	58 (54, 63)
High School/GED/Some College	50 (47, 54)	37 (33, 40)
Associate's Degree+	44 (38, 49)	27 (24, 32)

Source: 1998–2016 Health and Retirement Study.

Table 3 Lifetime risk (%) of co-impairment for interactions of gender, race, ethnicity, nativity, and education in the United States, 1998–2016, with 95% confidence intervals shown in parentheses

		Women	Men
		Lifetime Risk (%)	Lifetime Risk (%)
White	Less than high school	61 (56, 65)	51 (46, 57)
	High school/GED/some college	48 (45, 52)	34 (30, 37)
	Associate's degree+	43 (38, 49)	27 (23, 31)
Black	Less than high school	80 (76, 83)	65 (60, 71)
	High school/GED/some college	62 (57, 68)	52 (46, 59)
	Associate's degree+	52 (42, 60)	34 (22, 46)
U.S.-born Latinx	Less than high school	78 (71, 83)	65 (55, 74)
	High school/GED/some college	60 (48, 71)	44 (30, 57)
	Associate's degree+	52 (14, 80)	21 (3, 44)
Foreign-born Latinx	Less than high school	87 (83, 91)	71 (62, 79)
	High school/GED/some college	60 (48, 72)	41 (27, 54)
	Associate's degree+	31 (0, 54)	41 (23, 61)

Source: 1998–2016 Health and Retirement Study.

87% lifetime risk of co-impairment. For each racial and ethnic subpopulation, the likelihood of co-impairment increases as the level of educational attainment decreases. For example, for the lowest educated U.S.-born Latinas and Latinos, the penalty for not having a higher education is a lifetime risk of co-impairment that is, respectively, at least 18 and 21 percentage points higher. However, racial and ethnic disparities persist at all levels of educational attainment. Notably, the confidence intervals for lifetime risk of U.S.- and foreign-born Latinx with an associate's degree or more are too wide (reflecting small sample sizes) to draw clear conclusions for these subpopulations. However, in this article, we are mainly interested in identifying the highly disadvantaged subpopulations, and the estimates for Black and Latinx adults with the lowest education indicate a greater burden of co-impairment with high precision.

Table 4 The mean age at co-impairment onset and life expectancy at age 50 in co-impairment for the total population and by race, ethnicity, nativity, and education in the United States, 1998–2016, with 95% confidence intervals shown in parentheses

	Women	Men	Women	Men
	Mean Age	Mean Age	Years Co-impaired	Years Co-impaired
Total	77 (76, 78)	74 (73, 75)	3.4 (3.0, 3.8)	1.9 (1.6, 2.2)
White	79 (78, 80)	76 (75, 77)	2.7 (2.4, 3.1)	1.5 (1.3, 1.8)
Black	70 (69, 72)	69 (67, 70)	5.1 (4.5, 5.9)	3.1 (2.6, 3.7)
U.S.-born Latinx	73 (71, 75)	70 (68, 73)	5.5 (4.4, 6.7)	2.5 (1.9, 3.3)
Foreign-born Latinx	71 (69, 72)	73 (71, 75)	7.9 (6.5, 9.5)	4.0 (3.1, 5.2)
Less Than High School	69 (68, 70)	67 (66, 69)	5.6 (5.0, 6.4)	3.3 (2.9, 3.9)
High School/GED/Some College	79 (78, 80)	74 (73, 75)	2.7 (2.3, 3.1)	1.6 (1.3, 1.9)
Associate's Degree+	83 (82, 84)	80 (79, 81)	2.1 (1.7, 2.5)	1.0 (0.8, 1.3)

Source: 1998–2016 Health and Retirement Study.

Mean Age at Onset of Co-impairment

Table 4 shows the mean age at onset of co-impairment for the total population and separately by race, ethnicity, nativity, and education. On average, women become co-impaired at age 77, and men are 3 years younger at onset. Black women and men are 9 and 7 years younger at onset than White women and men, respectively. The educational gradient is even steeper than the racial, ethnic, and nativity gradient. The lowest educated women and men are, respectively, 14 and 13 years younger at onset than their highest educated counterparts.

Table 5 shows the estimates of the mean age at onset of co-impairment for White, Black, and Latinx subpopulations by educational attainment. For each racial, ethnic, and nativity subgroup, the mean age at onset decreases with decreasing educational attainment. Black women and men pay the highest penalty for having the lowest education and are the youngest at co-impairment onset (age 64). This penalty results in dramatic disparities in mean age at first co-impairment incidence relative to the highest educated White women and men: 20 (= 84 – 64) years for Black women and 17 years for Black men.

Life Expectancy in Co-impairment at Age 50

Total life expectancy at age 50 was 33 years for women and 28.4 years for men,[2] reflecting women's mortality advantage (Tables S2 and S3, online appendix). Despite being socioeconomically disadvantaged, foreign-born Latinx have longer life expectancy than their White counterparts (Cantu et al. 2013; Garcia et al. 2019), reflecting the Hispanic paradox (Markides and Eschbach 2011). Women and

[2] Our life expectancy estimates are similar to the U.S. National Vital Statistics life expectancy estimates of 32.7 for women and 29.0 for men in the reference year 2007 (Arias 2011).

Table 5 The mean age at onset of co-impairment for interactions of gender, race, ethnicity, nativity, and education in the United States, 1998–2016, with 95% confidence intervals shown in parentheses

		Women	Men
		Mean Age	Mean Age
White	Less than high school	72 (71, 73)	69 (68, 71)
	High school/GED/some college	80 (79, 81)	75 (74, 76)
	Associate's degree+	84 (83, 85)	81 (79, 82)
Black	Less than high school	64 (62, 65)	64 (62, 66)
	High school/GED/some college	73 (72, 75)	70 (68, 72)
	Associate's degree+	78 (76, 80)	75 (72, 78)
U.S.-born Latinx	Less than high school	68 (65, 71)	65 (62, 68)
	High school/GED/some college	79 (76, 81)	73 (70, 77)
	Associate's degree+	78 (73, 84)	77 (72, 82)
Foreign-born Latinx	Less than high school	68 (66, 70)	71 (69, 73)
	High school/GED/some college	78 (76, 80)	77 (74, 80)
	Associate's degree+	80 (77, 85)	79 (75, 84)

Source: 1998–2016 Health and Retirement Study.

men with less than a high school education live 6 fewer years than those with an associate's degree or more.

Table 4 shows the number of years expected to live in co-impairment at age 50 for the total population and separately by race, ethnicity, nativity, and education. On average, women live 1.5 more years co-impaired than men. Compared with White women, foreign- and U.S.-born Latinx and Black women live 5.2, 2.8, and 2.4 more years in co-impairment; respective figures for men in these racial and ethnic subgroups (relative to White men) are 2.5, 1.0, and 1.6 years. The lowest educated men and women live, respectively, 2.3 and 3.5 more years in co-impairment than the highest educated.

Table 6 shows life expectancies in co-impairment for all racial and ethnic subpopulations by educational levels. In each racial and ethnic subpopulation, the lowest educated have the longest life expectancy in co-impairment. Black and Latinx adults with the lowest education are substantially disadvantaged. The lowest educated foreign-born Latinx live the longest co-impaired (5.0 years for men and 9.7 years for women), followed by Blacks. Further, the educational gradients are greater for Black and Latinx adults, especially for the two Latinx subpopulations, compared with Whites. For instance, having at least an associate's degree is associated with fewer years lived in co-impairment: 8.6 years for foreign-born Latinas and 3.2 years for U.S.-born Latinos. In contrast, the difference in co-impairment expectancies between the lowest and highest educated White men (women) is only 1.6 years.

Counterfactual: Eliminating Inequalities in the Distribution of Educational Attainment

In panels a (women) and b (men) of Figure 2, the bars represent the racial, ethnic, and nativity disparities in co-impairment expectancy in the empirical and counterfactual scenarios. For instance, in the empirical scenario, Black women live 2.4 (= 5.1 – 2.7) years

Table 6 Life expectancy in co-impairment at age 50 for interactions of gender, race, ethnicity, nativity, and education in the United States, 1998–2016, with 95% confidence intervals shown in parentheses

		Women	Men
		Years Co-impaired	Years Co-impaired
White	Less than high school	3.7 (3.2, 4.3)	2.6 (2.0, 3.1)
	High school/GED/some college	2.5 (2.1, 2.8)	1.4 (1.1, 1.7)
	Associate's degree+	2.1 (1.7, 2.4)	1.0 (0.8, 1.2)
Black	Less than high school	7.5 (6.3, 8.7)	4.1 (3.3, 4.9)
	High school/GED/some college	4.0 (3.3, 4.8)	2.9 (2.2, 3.7)
	Associate's degree+	2.7 (1.8, 4.0)	1.4 (0.7, 2.4)
U.S.-born Latinx	Less than high school	6.9 (5.4, 8.5)	3.8 (2.7, 5.2)
	High school/GED/some college	3.5 (2.2, 5.1)	1.8 (1.0, 2.9)
	Associate's degree+	3.0 (0.3, 9.1)	0.6 (0.1, 1.8)
Foreign-born Latinx	Less than high school	9.7 (8.1, 11.4)	5.0 (3.7, 6.5)
	High school/GED/some college	3.5 (2.2, 5.1)	1.7 (1.0, 2.8)
	Associate's degree+	1.1 (0.0, 3.0)	1.8 (0.7, 4.4)

Source: 1998–2016 Health and Retirement Study.

longer in co-impairment than White women. Compared with the empirical scenario, the differences between White, Black, and Latinx subpopulations' co-impairment expectancies are reduced in the counterfactual scenario. Black men and women experience a reduction of 31% and 33%, respectively. Even more dramatically, respective reductions for U.S.-born Latinos and Latinas are 70% and 54%, and those for foreign-born Latinos and Latinas are 68% and 75%.

Tables S5 and S6 (online appendix) present the counterfactual expectancies for all the health states and total life expectancies for Blacks and U.S.- and foreign-born Latinx, along with the empirical estimates. These tables show that eliminating educational inequalities reduces disparities in healthy life expectancy considerably, especially for Latinx subgroups, but has a mostly negligible effect on total life expectancies. In other words, eliminating inequalities in the distribution of educational attainment would likely compress morbidity among Blacks and Latinx.

Discussion

Being either cognitively impaired or having ADL limitations poses serious disadvantages for the affected adults, their family members, their caregivers, and the wider society. However, research on the dynamics of the co-occurrence of these adverse health conditions has been lacking. The present study contributes to population health research by being the first to assess the burden of co-impairment. Using three key metrics derived from incidence-based, discrete-time Markov chain multistate models and drawing on a nationally representative sample of adults living in the United States, we reveal four major findings.

First, we estimate the lifetime risk of experiencing co-impairment at age 50, finding a significantly higher lifetime risk for women than for men. This disadvantage is partly attributable to women's greater longevity, which increases their years of

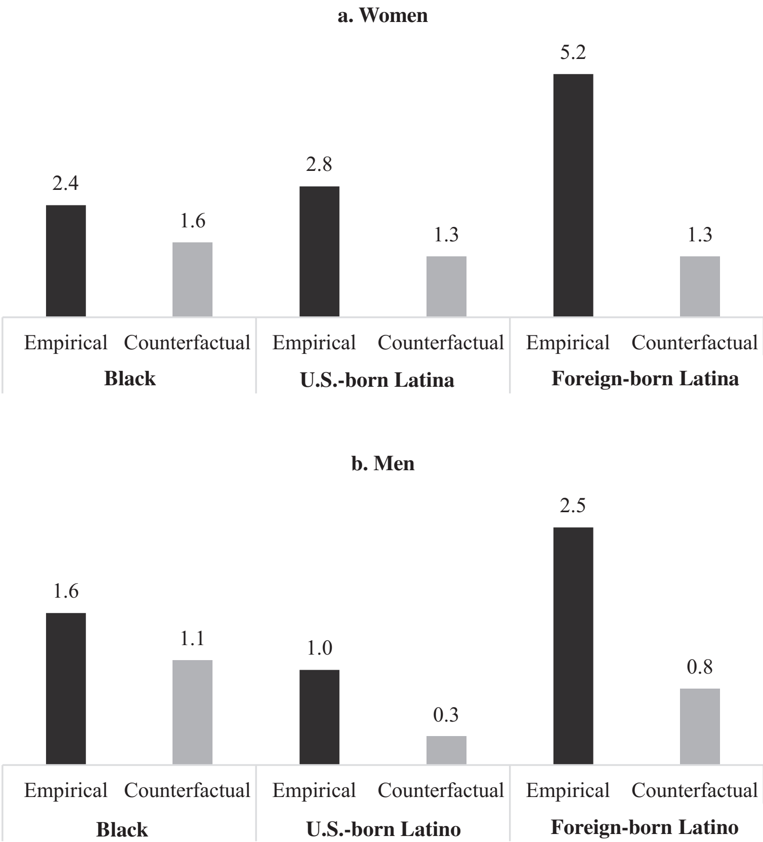

Fig. 2 Racial, ethnic, and nativity disparities in co-impairment expectancy in the empirical versus counterfactual scenario for U.S. women (panel a) and men (panel b), 1998–2016. *Source*: 1998–2016 Health and Retirement Study.

exposure in higher risk age groups. Blacks,[3] U.S.- and foreign-born Latinx, and lower educated adults have a substantially higher likelihood of co-impairment than Whites and the higher educated.

Second, because lifetime risk does not clarify when in the life course co-impairment is experienced, we estimate the mean age at co-impairment onset. On average, men experience an earlier onset of co-impairment than women. Irrespective of gender, Blacks and the lowest educated, especially those at the intersection, are the most disadvantaged: they experience the earliest onset of co-impairment among all the subpopulations examined.

Third, we estimate how many years an adult aged 50 can expect to live co-impaired. Men aged 50 have fewer years co-impaired than women. Compared with older Whites

[3] As a reminder: White includes only non-Latinx White; Black includes Latinx Black and non-Latinx Black; and U.S.-born Latinx and foreign-born Latinx are both non-Black.

and the higher educated, older Blacks, U.S.- and foreign-born Latinx, and the lower educated live significantly more years co-impaired.

The combination of two of the social risk factors for poor health reveals large disparities. For instance, the highest educated White men aged 50 can expect to live only one year in co-impairment, whereas the lowest educated foreign-born Latinas aged 50 can expect to live 9.7 years co-impaired. A difference of almost nine years indicates the dramatic disparity between disadvantaged and advantaged subpopulations.

Fourth, our sample aged 50–100 displays considerable racial, ethnic, and nativity inequalities in educational attainment. For instance, only 18% of Whites have less than a high school education, compared with 34% of Black individuals, 43% of U.S.-born Latinx, and 62% of foreign-born Latinx. Our findings reveal that eliminating these inequalities in educational attainment substantially reduces racial, ethnic, and nativity disparities in co-impairment. The disparity reduction is greater for Latinx subgroups than for Blacks. This counterfactual exercise underscores the importance of educational attainment interventions for narrowing future racial and ethnic disparities in health. However, such interventions are not applicable to the cohorts under analysis or even to contemporary cohorts who have completed their education.

In our sample, 82% of Whites have at least a high school education, compared with 66% of Blacks, 57% of U.S.-born Latinx, and 38% of foreign-born Latinx. However, even by 2021, the percentage of those aged 50 and older with at least a high school education was 94% for Whites, 87% for Blacks, and 67% for Latinx (including foreign-born Latinx; U.S. Census Bureau 2022). For even more recent cohorts, educational attainment has increased differentially, such that the racial and ethnic inequalities in educational attainment have narrowed substantially among young adults aged 18–29 (U.S. Census Bureau 2022). Although education levels among more recent cohorts for all racial, ethnic, and nativity subgroups increased relative to those of older birth cohorts, the rate of increase is greater for U.S.- and foreign-born Latinx (Everett et al. 2011). Variation also exists within the Latinx subgroup: U.S.-born Latinx have higher levels of education than foreign-born Latinx (Everett et al. 2011).

Although increasing educational attainment and narrowing educational inequalities may decrease the racial, ethnic, and nativity disparities in co-impairment in the older U.S. population in the coming decades, we may also need to consider other factors, such as educational quality. Recent evidence suggests that equality in educational attainment does not lead to racial and ethnic equality in healthy aging (McLaughlin et al. 2020). Evidence shows racial and ethnic disparities in the quality of education, with Black and Latinx subgroups lying at the disadvantaged end (Glymour and Manly 2008; Sisco et al. 2015). Indeed, racial disparities in educational quality explain a substantial portion of the racial disparities in cognitive function among adults matched on educational level (Manly et al. 2002). Therefore, both levels and quality of education are likely essential for narrowing or eliminating the racial, ethnic, and nativity disparities in the burden of co-impairment in the coming decades.

Blacks and Latinx are also substantially disadvantaged in markers of socioeconomic status other than education, for instance, wealth and income (Bhutta et al. 2020; Iceland 2019; U.S. Census Bureau 2020). These disadvantages only partially explain racial and ethnic disparities in health. Other exposures are likely to perpetuate health disparities, such as differential access to health care and stress caused by individual and structural racism. Research has found that the greater discrimination Blacks and Latinx experience partially explains racial and ethnic disparities in health (e.g., Colen et al. 2018; Williams et al. 2008). Counterintuitively, Colen and colleagues (2018) showed that an increase in socioeconomic status for Blacks and Latinx adults might lead to even more exposure to discrimination, further indicating that eliminating racial and ethnic inequalities in socioeconomic status may not eliminate health disparities. Understanding the role of these factors in disparities in the co-impairment burden is a potential avenue for future research.

Our research highlights that the most disadvantaged subpopulations, which are likely to be the least economically resourced, bear the greatest burden of co-impairment. Thus, policy implications include not just interventions on proximate determinants of health, such as promoting positive health contexts (e.g., increasing social connectedness), but also providing support for these vulnerable populations (e.g., expanding coverage of health and long-term care insurance).

Because of the lack of research on co-impairment, direct comparison with previous studies is not possible. Previous research on cognitive impairment (Garcia et al. 2019) and activity limitations (Hayward et al. 2014) reported a higher burden for Blacks and Latinx, especially for foreign-born Latinx. Another study found a considerable reduction in disparities in the odds of cognitive impairment for foreign-born Latinx after eliminating educational inequalities (Garcia, Saenz et al. 2018). However, the study found risk reduction to be lower for Black individuals.

The current study provides a detailed overview of disparities in co-impairment across population subgroups but does not attempt to explain the mechanisms behind these disparities. The underlying mechanisms are likely multifaceted. For instance, relative to Whites, Blacks and Latinx experience higher rates of chronic morbidities, such as diabetes (Ferdinand and Nasser 2015; Whitson et al. 2011), which is associated with poor cognitive health and ADL limitations (Langa et al. 2017; Wong et al. 2013). Black and Latinx adults have higher odds of experiencing discrimination than Whites (Colen et al. 2018), for example, in health care, employment, and police interactions, as well as through microaggressions and racial slurs (Bleich et al. 2019). Many studies show that racial and ethnic discrimination is associated with poorer physical and cognitive health outcomes (e.g., Coogan et al. 2020; Williams et al. 2008). Prior research indicates that the advantage in ADL limitations among younger foreign-born Latinx over Whites (the healthy immigrant effect) does not hold in later life (Melvin et al. 2014). Foreign-born Latinx most often come to the United States for employment, which often involves low-paid, physically demanding work (Tienda et al. 2006). The cumulative toll of physically taxing (and sometimes hazardous) jobs, such as in the construction or meatpacking industry (Kochhar 2008), may place them in a particularly vulnerable position in terms of health in later life.

The greater burden of chronic morbidities and discrimination experienced by Blacks and Latinx, when combined with low educational attainment, might create an even greater burden for those with intersecting disadvantages, which may partially explain the substantially greater lifetime risks, younger onsets, and longer years in co-impairment for lower educated Black and Latinx subgroups. Prior evidence also points to a greater health disadvantage for lower educated Blacks than higher educated Blacks (Farina et al. 2020; Reuser et al. 2011).

The results may provide insight into the continuing discourse on the future prospects for morbidity compression or expansion. We observe that for educational categories not accounting for race and ethnicity, as levels of education increase, total life expectancies increase; however, life expectancies in co-impairment decrease. Also, for racial and ethnic subpopulations, with increasing educational levels, the number of co-impairment years decreases. In other words, advantaged subpopulations have longer life expectancies but shorter co-impaired years. These findings are promising in light of the continued debate about whether increasing life expectancy implies increases in morbid years (Steensma et al. 2017).

Furthermore, our findings may also help to identify the highly vulnerable caregiver subgroups who may need additional support. Family members or other caregivers often provide home care to adults with poor health as long as possible, meaning caregivers of co-impaired adults are particularly vulnerable because they carry the greatest caregiving burden (Freedman and Spillman 2014; Lepore et al. 2017; Riffin et al. 2017). In particular, relative to White adults, Black and Latinx adults are more dependent on their family members for caregiving support (Rote and Moon 2018). Our findings show that Blacks, Latinx, and socioeconomically disadvantaged adults live substantially longer in co-impairment than Whites and the highly educated. As a result, their caregivers are at greater risk of poor health outcomes because of the substantial strain of the longer duration of co-impairment caregiving. In addition, Black caregivers[4] are less likely to use respite services and tend to use fewer formal services for caregiving (Chow et al. 2010; Crist et al. 2009; Parker and Fabius 2020). All these factors raise concerns about the caregivers of co-impaired adults, especially for Black and Latinx, immigrant, and socioeconomically disadvantaged subgroups.

The severity of co-impairment is likely to increase with age (Yu et al. 2017), which may lead to co-impaired adults being transitioned to institutional care. In recent decades, the length of stay in institutional care and the number and percentage of adults using nursing homes have increased for Blacks and Latinx compared with Whites (Feng, Fennell et al. 2011; Freedman and Spillman 2016). Such transitions can be particularly disadvantageous for socioeconomically disadvantaged subgroups as nursing home costs have increased in recent decades (Stewart et al. 2009), and older Blacks and Latinx are more likely to reside in less-resourced nursing homes with lower staffing ratios, fewer financial resources, and poor care (Fennell et al. 2010; Smith et al. 2007).

The United States has experienced significant population aging, and the population is also becoming racially more diverse. The shares of Latinx and Blacks are expected to increase from 18% and 13% to 28% and 15%, respectively, between 2016 and 2060 (Vespa et al. 2018). In such a situation, the considerably higher burden of co-impairment for these subgroups, who are also disadvantaged in terms of socioeconomic perspectives, presents a serious challenge for policymakers and may adversely impact national health indicators in the years to come.

This study has some limitations that could be characterized as issues with (1) measurement, (2) sampling, and (3) estimation. First, regarding measurement, categorizing

[4] A high proportion of couples in these cohorts are in racially homogamous partnerships—for example, 97% for those married by 1967 and 90% of individuals in couples of any age (Livingston and Brown 2017)—so most familial caregivers for Blacks and Latinx are also Blacks or Latinx, respectively.

cognitive function into two standard categories of no cognitive impairment and cognitive impairment results in a loss of information: it does not distinguish between mild and severe impairment. Unfortunately, the two-category measurement is a necessary simplification for this analysis, as using three cognition states, two ADL states, and death led to zero transitions across many states, making the model inestimable.

Another issue with measurement is that the HRS assessment of ADLs might misclassify respondents with activity limitations. To reduce respondent burden, from Wave 3 onward, for respondents self-reporting no difficulty with any of the tasks asked before the ADLs, all the ADL questions are skipped and set to *no difficulty*. From Wave 4 forward, for respondents self-reporting *no difficulty* in dressing and reporting difficulty with only one of the tasks asked before the ADLs, the remaining ADL questions are skipped and set to *no difficulty*—the assumption being that *no difficulty* in the initial questions would lead to *no difficulty* with the subsequent skipped questions (Bugliari et al. 2020). However, this is not necessarily a safe assumption and would result in the misclassification of those with ADL limitations as not limited.

Another reason ADLs (and co-impairment) could be misclassified is that cognitively impaired adults may overrate their performance, (mis)reporting having no difficulties with ADLs (Puente et al. 2014). They could therefore be misclassified as having only cognitive impairment instead of co-impairment, leading to biased estimates of the transitions. Most problematically, the bias might overestimate the probabilities of transitioning from only cognitive impairment to death and underestimate the transition probabilities from co-impairment to death (because having ADL limitations is a risk factor for accelerated cognitive decline and death) (Ankuda et al. 2020; Fauth et al. 2013; Rajan et al. 2013). Furthermore, the ADL questions ask respondents to exclude any limitation expected to last less than three months. This time frame constraint adds further complexity to the ADL measures, especially for adults with poorer cognitive function, which may contribute to their misreporting.

Despite these elements likely contributing to the underestimation of ADLs and co-impairment, there is a high degree of concordance among self-rated, medically diagnosed, and performance-based measures of basic functional ability (Bravell et al. 2011; Wu et al. 2016). Furthermore, a large body of literature has used these ADL measures from the HRS (Bardenheier et al. 2016; Mehta and Myrskylä 2017; Payne 2022; Payne and Kobayashi 2022; Raymo and Wang 2022; Sauerberg and Canudas-Romo 2022).

Second, another limitation relates to sampling: although all the calculations are based on survey weights to account for the complex survey design and nonresponse, we do not consider primary sampling units or strata in the estimations because of the analytic complexity involved in doing so. Therefore, the estimated standard errors may be underestimated. However, our confidence interval calculations are based on established multistate research that resamples health trajectories at the individual level, mimicking the complex sampling process of the survey and accounting for the cohort structure and oversampling (Dudel and Myrskylä 2017).

Third, the study has estimation limitations. The counterfactual estimates for foreign-born Latinas may be partially based on imprecise estimates. Foreign-born Latinas are mainly concentrated in the lowest educational category, resulting in small cell sizes for foreign-born Latinas with higher educational attainment. Furthermore, although this study is based on quality longitudinal data spanning nearly two decades, information on health states is available only at waves of data collection, conducted two years apart. Thus, the health states develop in discrete steps from Wave 4/year 1998 to Wave 13/year 2016 at two-year intervals, and we do not have information on health states between any two waves.

Finally, our findings do not correspond to any particular birth cohort in the HRS. The results reflect the burden of co-impairment in a synthetic cohort if the cognitive impairment and ADL limitations observed during the years 1998–2016 hold throughout that synthetic cohort's ages 50–100 (period perspective).

Conclusion

This study provides novel insights into the burden of the co-occurrence of cognitive impairment and limitations in basic ADLs and offers evidence of dramatic co-impairment disparities in the older U.S. population. Our findings call attention to the importance of considering cognitive impairment and activity limitations simultaneously in assessing the health of older individuals in the United States. The considerable disparities across subpopulations indicate that the country has a long way to go to attain health equity. Further research should use traditional regression-based approaches or causal inference modeling to examine the mechanisms driving the racial, ethnic, nativity, and educational disparities in co-impairment. ■

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References

Allison, P. D. (1982). Discrete-time methods for the analysis of event histories. *Sociological Methodology, 13,* 61–98.

Alzheimer's Association. (2011). 2011 Alzheimer's disease facts and figures. *Alzheimer's & Dementia, 7,* 208–244.

Alzheimer's Association. (2021). Alzheimer's disease facts and figures. *Alzheimer's & Dementia, 17,* 327–406.

Alzheimer's Association. (2022). Alzheimer's disease facts and figures. *Alzheimer's & Dementia, 18,* 700–789.

Andrews, J. S., Desai, U., Kirson, N. Y., Enloe, C. J., Ristovska, L., King, S., . . . Kahle-Wrobleski, K. (2016). Functional limitations and health care resource utilization for individuals with cognitive impairment without dementia: Findings from a United States population-based survey. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring, 6,* 65–74.

Ankuda, C. K., Levine, D. A., Langa, K. M., Ornstein, K. A., & Kelley, A. S. (2020). Caregiving, recovery, and death after incident ADL/IADL disability among older adults in the United States. *Journal of Applied Gerontology, 39,* 393–397.

Arias, E. (2011). *United States life tables, 2007* (National Vital Statistics Reports, Vol. 59 No. 9). Hyattsville, MD: National Center for Health Statistics.

Bardenheier, B. H., Lin, J., Zhuo, X., Ali, M. K., Thompson, T. J., Cheng, Y. J., & Gregg, E. W. (2016). Compression of disability between two birth cohorts of U.S. adults with diabetes, 1992–2012: A prospective longitudinal analysis. *Lancet: Diabetes & Endocrinology, 4,* 686–694.

Bardo, A. R., & Lynch, S. M. (2021). Cognitively intact and happy life expectancy in the United States. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 76,* 242–251.

Bhutta, N., Chang, A. C., Dettling, L. J., & Hsu, J. W. (2020). *Disparities in wealth by race and ethnicity in the 2019 Survey of Consumer Finances* (FEDS Notes report). Washington, DC: Board of Governors of the Federal Reserve System. https://doi.org/10.17016/2380-7172.2797

Bleich, S. N., Findling, M. G., Casey, L. S., Blendon, R. J., Benson, J. M., SteelFisher, G. K., . . . Miller, C. (2019). Discrimination in the United States: Experiences of Black Americans. *Health Services Research, 54*(Suppl. 2), 1399–1408.

Borrell, L. N. (2006). Self-reported hypertension and race among Hispanics in the National Health Interview Survey. *Ethnicity & Disease, 16,* 71–77.

Borrell, L. N., & Crawford, N. D. (2006). Race, ethnicity, and self-rated health status in the Behavioral Risk Factor Surveillance System Survey. *Hispanic Journal of Behavioral Sciences, 28,* 387–403.

Bravell, M. E., Zarit, S. H., & Johansson, B. (2011). Self-reported activities of daily living and performance-based functional ability: A study of congruence among the oldest old. *European Journal of Ageing, 8,* 199–209.

Bugliari, D., Carroll, J., Hayden, O., Hayes, J., Hurd, M., Karabatakis, A., . . . St. Clair, P. (2020). *RAND HRS longitudinal file 2016 (V2) documentation*. RAND Center for the Study of Aging. Retrieved from https://hrsdata.isr.umich.edu/sites/default/files/documentation/codebooks/randhrs1992_2016v2.pdf

Cai, L., & Lubitz, J. (2007). Was there compression of disability for older Americans from 1992 to 2003? *Demography, 44,* 479–495.

Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: Methods and applications*. New York, NY: Cambridge University Press.

Cantu, P. A., Hayward, M. D., Hummer, R. A., & Chiu, C.-T. (2013). New estimates of racial and 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.

Carmona-Torres, J. M., Rodríguez-Borrego, M. A., Laredo-Aguilera, J. A., López-Soto, P. J., Santacruz-Salas, E., & Cobo-Cuenca, A. I. (2019). Disability for basic and instrumental activities of daily living in older individuals. *PloS One, 14,* e0220157. https://doi.org/10.1371/journal.pone.0220157

Caskie, G. I., Sutton, M. C., & Margrett, J. A. (2010). The relation of hypertension to changes in ADL/IADL limitations of Mexican American older adults. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 65B,* 296–305.

Caswell, H., & Zarulli, V. (2018). Matrix methods in health demography: A new approach to the stochastic analysis of healthy longevity and DALYs. *Population Health Metrics, 16,* 8. https://doi.org/10.1186/s12963-018-0165-5

Chinn, J. J., & Hummer, R. A. (2016). Racial disparities in functional limitations among Hispanic women in the United States. *Research on Aging, 38,* 399–423.

Chow, J. C. C., Auh, E. Y., Scharlach, A. E., Lehning, A. J., & Goldstein, C. (2010). Types and sources of support received by family caregivers of older adults from diverse racial and ethnic groups. *Journal of Ethnic & Cultural Diversity in Social Work, 19,* 175–194.

Colen, C. G., Ramey, D. M., Cooksey, E. C., & Williams, D. R. (2018). Racial disparities in health among nonpoor African Americans and Hispanics: The role of acute and chronic discrimination. *Social Science & Medicine, 199,* 167–180.

Coogan, P., Schon, K., Li, S., Cozier, Y., Bethea, T., & Rosenberg, L. (2020). Experiences of racism and subjective cognitive function in African American women. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring, 12,* e12067. https://doi.org/10.1002/dad2.12067

Crichton, S. L., Bray, B. D., McKevitt, C., Rudd, A. G., & Wolfe, C. D. (2016). Patient outcomes up to 15 years after stroke: Survival, disability, quality of life, cognition and mental health. *Journal of Neurology, Neurosurgery, and Psychiatry, 87,* 1091–1098.

Crimmins, E. M., Hayward, M. D., Hagedorn, A., Saito, Y., & Brouard, N. (2009). Change in disability-free life expectancy for Americans 70 years old and older. *Demography, 46,* 627–646.

Crimmins, E. M., Hayward, M. D., & Saito, Y. (1996). Differentials in active life expectancy in the older population of the United States. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 51,* S111–S120.

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, 66*(Suppl. 1), i162–i171.

Crimmins, E. M., Saito, Y., & Kim, J. K. (2016). Change in cognitively healthy and cognitively impaired life expectancy in the United States: 2000–2010. *SSM—Population Health, 2,* 793–797.

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*(Suppl. 1), S20–S28.

Crist, J. D., McEwen, M. M., Herrera, A. P., Kim, S.-S., Pasvogel, A., & Hepworth, J. T. (2009). Caregiving burden, acculturation, familism, and Mexican American elders' use of home care services. *Research and Theory for Nursing Practice, 23,* 165–180.

Cuevas, A. G., Dawson, B. A., & Williams, D. R. (2016). Race and skin color in Latino health: An analytic review. *American Journal of Public Health, 106,* 2131–2136.

Denton, N. A., & Massey, D. S. (1989). Racial identity among Caribbean Hispanics: The effect of double minority status on residential segregation. *American Sociological Review, 54,* 790–808.

Dudel, C. (2021). Expanding the Markov chain toolbox: Distributions of occupation times and waiting times. *Sociological Methods & Research, 50,* 401–428.

Dudel, C., & Myrskylä, M. (2017). Working life expectancy at age 50 in the United States and the impact of the Great Recession. *Demography, 54,* 2101–2123.

Elo, I. T., Mehta, N. K., & Huang, C. (2011). Disability among native-born and foreign-born Blacks in the United States. *Demography, 48,* 241–265.

Everett, B. G., Rogers, R. G., Hummer, R. A., & Krueger, P. M. (2011). Trends in educational attainment by race and ethnicity, nativity, and sex in the United States, 1989–2005. *Ethnic and Racial Studies, 34,* 1543–1566.

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, 75,* e105–e112.

Fauth, E. B., Schwartz, S., Tschanz, J. T., Østbye, T., Corcoran, C., & Norton, M. C. (2013). Baseline disability in activities of daily living predicts dementia risk even after controlling for baseline global cognitive ability and depressive symptoms. *International Journal of Geriatric Psychiatry, 28,* 597–606.

Fears, D. (2003, July 14). Race divides Hispanics, report says. *The Washington Post*, p. A03.

Feng, Z., Fennell, M. L., Tyler, D. A., Clark, M., & Mor, V. (2011). The care span: Growth of racial and ethnic minorities in U.S. nursing homes driven by demographics and possible disparities in options. *Health Affairs, 30,* 1358–1365.

Fennell, M. L., Feng, Z., Clark, M. A., & Mor, V. (2010). Elderly Hispanics more likely to reside in poor-quality nursing homes. *Health Affairs, 29,* 65–73.

Ferdinand, K. C., & Nasser, S. A. (2015). Racial and ethnic disparities in prevalence and care of patients with type 2 diabetes mellitus. *Current Medical Research and Opinion, 31,* 913–923.

Fisher, G. G., & Ryan, L. H. (2018). Overview of the Health and Retirement Study and introduction to the special issue. *Work, Aging and Retirement, 4,* 1–9.

Fratiglioni, L., Wang, H. X., Ericsson, K., Maytan, M., & Winblad, B. (2000). Influence of social network on occurrence of dementia: A community-based longitudinal study. *Lancet, 355,* 1315–1319.

Freedman, V. A., & Spillman, B. C. (2014). Disability and care needs among older Americans. *Milbank Quarterly, 92,* 509–541.

Freedman, V. A., & Spillman, B. C. (2016). Active life expectancy in the older U.S. population, 1982–2011: Differences between Blacks and Whites persisted. *Health Affairs, 35,* 1351–1358.

Fuller-Thomson, E., Nuru-Jeter, A., Minkler, M., & Guralnik, J. M. (2009). Black–White disparities in disability among older Americans: Further untangling the role of race and socioeconomic status. *Journal of Aging And Health, 21,* 677–698.

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

Garcia, M. A., Downer, B., Crowe, M., & Markides, K. S. (2017). Aging and disability among Hispanics in the United States: Current knowledge and future directions. *Innovation in Aging, 1,* igx020. https://doi.org/10.1093/geroni/igx020

Garcia, M. A., Saenz, J., Downer, B., & Wong, R. (2018). The role of education in the association between race, ethnicity, nativity, cognitive impairment, and dementia among older adults in the United States. *Demographic Research, 38,* 155–168. https://doi.org/10.4054/DemRes.2018.38.6

Gill, T. M., Robison, J. T., & Tinetti, M. E. (1998). Difficulty and dependence: Two components of the disability continuum among community-living older persons. *Annals of Internal Medicine, 128,* 96–101.

Glymour, M. M., & Manly, J. J. (2008). Lifecourse social conditions and racial and ethnic patterns of cognitive aging. *Neuropsychology Review, 18,* 223–254.

Gobbens, R. J. (2018). Associations of ADL and IADL disability with physical and mental dimensions of quality of life in people aged 75 years and older. *PeerJ: Life and Environment, 6,* e5425. https://doi.org/10.7717/peerj.5425

Goldberg, T. E., Harvey, P. D., Wesnes, K. A., Snyder, P. J., & Schneider, L. S. (2015). Practice effects due to serial cognitive assessment: Implications for preclinical Alzheimer's disease randomized controlled trials. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring, 1,* 103–111.

Hajek, A., & König, H. H. (2016). Longitudinal predictors of functional impairment in older adults in Europe—Evidence from the Survey of Health, Ageing and Retirement in Europe. *PloS One, 11,* e0146967. https://doi.org/10.1371/journal.pone.0146967

Hale, J. M., Dudel, C., & Lorenti, A. (2021). Cumulative disparities in the dynamics of working poverty for later career U.S. workers (2002–2012). *Socius, 7*. https://doi.org/10.1177/2378023120987332

Hale, J. M., Schneider, D. C., Gampe, J., Mehta, N. K., & Myrskylä, M. (2020). Trends in the risk of cognitive impairment in the United States, 1996–2014. *Epidemiology, 31,* 745–754.

Hale, J. M., Schneider, D. C., Mehta, N. K., & Myrskylä, M. (2020). Cognitive impairment in the U.S.: Lifetime risk, age at onset, and years impaired. *SSM—Population Health, 11,* 100577. https://doi.org/10.1016/j.ssmph.2020.100577

Hankey, G. J., Jamrozik, K., Broadhurst, R. J., Forbes, S., & Anderson, C. S. (2002). Long-term disability after first-ever stroke and related prognostic factors in the Perth Community Stroke Study, 1989–1990. *Stroke, 33,* 1034–1040.

Hayward, M. D., Hummer, R. A., Chiu, C. T., González-González, C., & Wong, R. (2014). Does the Hispanic paradox in U.S. adult mortality extend to disability? *Population Research and Policy Review, 33,* 81–96.

Heidenreich, P. A., Trogdon, J. G., Khavjou, O. A., Butler, J., Dracup, K., Ezekowitz, M. D., . . . Woo, Y. J. (2011). Forecasting the future of cardiovascular disease in the United States: A policy statement from the American Heart Association. *Circulation, 123,* 933–944.

Hendi, A. S. (2017). Trends in education-specific life expectancy, data quality, and shifting education distributions: A note on recent research. *Demography, 54,* 1203–1213.

Iceland, J. (2019). Racial and ethnic inequality in poverty and affluence, 1959–2015. *Population Research and Policy Review, 38,* 615–654.

Jacob, M. E., Marron, M. M., Boudreau, R. M., Odden, M. C., Arnold, A. M., & Newman, A. B. (2018). Age, race, and gender factors in incident disability. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences, 73,* 194–197.

Jagger, C., Matthews, F. E., Wohland, P., Fouweather, T., Stephan, B. C., Robinson, L., . . . Brayne, C. (2016). A comparison of health expectancies over two decades in England: Results of the Cognitive Function and Ageing Study I and II. *Lancet, 387,* 779–786.

Jones, N., Marks, R., Ramirez, R., & Rios-Vargas, M. (2021, August 12). *2020 census illuminates racial and ethnic composition of the country*. U.S. Census Bureau. Retrieved from https://www.census.gov/library/stories/2021/08/improved-race-ethnicity-measures-reveal-united-states-population-much-more-multiracial.html

Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A., & Jaffe, M. W. (1963). Studies of illness in the aged—The index of ADL: A standardized measure of biological and psychosocial function. *JAMA, 185,* 914–919.

Kemeny, J. G., & Snell, J. L. (1983). *Finite Markov chains* (3rd printing). New York, NY: Springer-Verlag.

Kochhar, R. (2008). *Latino workers in the ongoing recession: 2007 to 2008* (Report). Washington, DC: Pew Hispanic Center.

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 Internal Medicine, 177,* 51–58.

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 & Dementia, 4,* 134–144.

Langa, K. M., Plassman, B. L., Wallace, R. B., Herzog, A. R., Heeringa, S. G., Ofstedal, M. B., . . . Willis, R. J. (2005). The Aging, Demographics, and Memory Study: Study design and methods. *Neuroepidemiology, 25,* 181–191.

Lee, M., Halpern-Manners, A., & Warren, J. R. (2021). The prevalence of cognitive impairment is not increasing in the United States: A critique of Hale et al. (2020). *Epidemiology, 32,* 712–716.

Lepore, M., Ferrell, A., & Wiener, J. M. (2017). *Living arrangements of people with Alzheimer's disease and related dementias: Implications for services and supports* (Issue brief). Washington, DC: Research Summit on Dementia Care, U.S. Department of Health and Human Services. Retrieved from https://aspe.hhs.gov/sites/default/files/migrated_legacy_files/177276/LivingArran.pdf

Li, M., Harris, I., & Lu, Z. K. (2015). Differences in proxy-reported and patient-reported outcomes: Assessing health and functional status among Medicare beneficiaries. *BMC Medical Research Methodology, 15,* 62. https://doi.org/10.1186/s12874-015-0053-7

Lièvre, A., Alley, D., & Crimmins, E. M. (2008). Educational differentials in life expectancy with cognitive impairment among the elderly in the United States. *Journal of Aging and Health, 20,* 456–477.

Lin, J., Thompson, T. J., Cheng, Y. J., Zhuo, X., Zhang, P., Gregg, E., & Rolka, D. B. (2018). Projection of the future diabetes burden in the United States through 2060. *Population Health Metrics, 16,* 9. https://doi.org/10.1186/s12963-018-0166-4

Lin, S. F., Beck, A. N., & Finch, B. K. (2014). Black–White disparity in disability among U.S. older adults: Age, period, and cohort trends. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 69,* 784–797.

Livingstone, G., & Brown, A. (2017). *Intermarriage in the U.S. 50 years after Loving v. Virginia* (Report). Washington, DC: Pew Research Center. Retrieved from https://www.pewresearch.org/social-trends/2017/05/18/intermarriage-in-the-u-s-50-years-after-*loving*-v-virginia/

Logan, J. R. (2004). How race counts for Hispanic Americans. *Sage Race Relations Abstracts, 29*(1), 7–19.

Majer, I. M., Stevens, R., Nusselder, W. J., Mackenbach, J. P., & van Baal, P. H. (2013). Modeling and forecasting health expectancy: Theoretical framework and application. *Demography, 50,* 673–697.

Manly, J. J., Jacobs, D. M., Touradji, P., Small, S. A., & Stern, Y. (2002). Reading level attenuates differences in neuropsychological test performance between African American and White elders. *Journal of the International Neuropsychological Society, 8,* 341–348.

Marengoni, A., Von Strauss, E., Rizzuto, D., Winblad, B., & Fratiglioni, L. (2009). The impact of chronic multimorbidity and disability on functional decline and survival in elderly persons. A community-based, longitudinal study. *Journal of Internal Medicine, 265,* 288–295.

Markides, K. S., & Eschbach, K. (2011). Hispanic paradox in adult mortality in the United States. In R. G. Rogers & E. M. Crimmins (Eds.), *International handbooks of population: Vol. 2. International handbook of adult mortality* (pp. 227–240). Dordrecht, the Netherlands: Springer Science+Business Media.

McCammon, R. J., Fisher, G. G., Hassan, H., Faul, J. D., Rogers, W. L., & Weir, D. R. (2019). *Health and Retirement Study imputation of cognitive functioning measures: 1992–2016 (Version 1.0): Data description*. Ann Arbor: Survey Research Center, University of Michigan. Retrieved from http://hrsonline.isr.umich.edu/modules/meta/xyear/cogimp/desc/COGIMP9216_dd.pdf

McGrath, R., Al Snih, S., Markides, K., Hackney, K., Bailey, R., & Peterson, M. (2019). The burden of functional disabilities for middle-aged and older adults in the United States. *Journal of Nutrition, Health & Aging, 23,* 172–174.

McLaughlin, S. J., Kim, S., Li, L. W., & Zhang, J. (2020). Educational differences in trajectories and determinants of healthy ageing in midlife and older Americans. *Maturitas, 134,* 21–28.

Mehta, N., & Myrskylä, M. (2017). The population health benefits of a healthy lifestyle: Life expectancy increased and onset of disability delayed. *Health Affairs, 36,* 1495–1502.

Melvin, J., Hummer, R. A., Elo, I. T., & Mehta, N. (2014). Age patterns of racial, ethnic, and nativity differences in disability and physical functioning in the United States. *Demographic Research, 31,* 497–510. https://doi.org/10.4054/DemRes.2014.31.17

Mlinac, M. E., & Feng, M. C. (2016). Assessment of activities of daily living, self-care, and independence. *Archives of Clinical Neuropsychology, 31,* 506–516.

Montez, J. K., Hummer, R. A., & Hayward, M. D. (2012). Educational attainment and adult mortality in the United States: A systematic analysis of functional form. *Demography, 49,* 315–336.

National Institute on Aging, & Social Security Administration. (2019). *The Health and Retirement Study*. Retrieved from https://hrs.isr.umich.edu/welcome-health-and-retirement-study

Ostchega, Y., Harris, T. B., Hirsch, R., Parsons, V. L., & Kington, R. (2000). The prevalence of functional limitations and disability in older persons in the U.S.: Data from the National Health and Nutrition Examination Survey III. *Journal of the American Geriatrics Society, 48,* 1132–1135.

Ovbiagele, B., Goldstein, L. B., Higashida, R. T., Howard, V. J., Johnston, S. C., Khavjou, O. A., . . . Trogdon, J. G. (2013). Forecasting the future of stroke in the United States: A policy statement from the American Heart Association and American Stroke Association. *Stroke, 44,* 2361–2375.

Parker, L. J., & Fabius, C. D. (2020). Racial differences in respite use among Black and White caregivers for people living with dementia. *Journal of Aging and Health, 32,* 1667–1675.

Payne, C. F. (2022). Expansion, compression, neither, both? Divergent patterns in healthy, disability-free, and morbidity-free life expectancy across U.S. birth cohorts, 1998–2016. *Demography, 59,* 949–973.

Payne, C. F., & Kobayashi, L. C. (2022). Changes in life expectancy and disability-free life expectancy in successive birth cohorts of older cancer survivors: A longitudinal modeling analysis of the U.S. Health and Retirement Study. *American Journal of Epidemiology, 191,* 104–114.

Puente, A. N., Terry, D. P., Faraco, C. C., Brown, C. L., & Miller, L. S. (2014). Functional impairment in mild cognitive impairment evidenced using performance-based measurement. *Journal of Geriatric Psychiatry and Neurology, 27*(4), 253–258.

Rajan, K. B., Hebert, L. E., Scherr, P. A., Mendes de Leon, C. F., & Evans, D. A. (2013). Disability in basic and instrumental activities of daily living is associated with faster rate of decline in cognitive function of older adults. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences, 68,* 624–630.

Rajan, K. B., Weuve, J., Barnes, L. L., McAninch, E. A., Wilson, R. S., & Evans, D. A. (2021). Population estimate of people with clinical Alzheimer's disease and mild cognitive impairment in the United States (2020–2060). *Alzheimer's & Dementia, 17,* 1966–1975.

Raymo, J. M., & Wang, J. (2022). Loneliness at older ages in the United States: Lonely life expectancy and the role of loneliness in health disparities. *Demography, 59,* 921–947.

Reuser, M., Willekens, F. J., & Bonneux, L. (2011). Higher education delays and shortens cognitive impairment: A multistate life table analysis of the U.S. Health and Retirement Study. *European Journal of Epidemiology, 26,* 395–403.

Riffin, C., Van Ness, P. H., Wolff, J. L., & Fried, T. (2017). Family and other unpaid caregivers and older adults with and without dementia and disability. *Journal of the American Geriatrics Society, 65,* 1821–1828.

Robitaille, A., van den Hout, A., Machado, R., Bennett, D. A., Čukić, I., Deary, I. J., . . . Muniz Terrera, G. (2018). Transitions across cognitive states and death among older adults in relation to education: A multistate survival model using data from six longitudinal studies. *Alzheimer's & Dementia, 14,* 462–472.

Rote, S. M., & Moon, H. (2018). Racial and ethnic differences in caregiving frequency: Does immigrant status matter? *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 73,* 1088–1098.

Sauerberg, M., & Canudas-Romo, V. (2022). Comparing cohort survival in good health: A research note on decomposing sex differentials in the United States. *Demography, 59,* 2013–2024.

Sauvaget, C., Yamada, M., Fujiwara, S., Sasaki, H., & Mimori, Y. (2002). Dementia as a predictor of functional disability: A four-year follow-up study. *Gerontology, 48,* 226–233.

Schwartz, B. S., Glass, T. A., Bolla, K. I., Stewart, W. F., Glass, G., Rasmussen, M., . . . Bandeen-Roche, K. (2004). Disparities in cognitive functioning by race and ethnicity in the Baltimore Memory Study. *Environmental Health Perspectives, 112,* 314–320.

Sisco, S., Gross, A. L., Shih, R. A., Sachs, B. C., Glymour, M. M., Bangen, K. J., . . . Manly, J. J. (2015). The role of early-life educational quality and literacy in explaining racial disparities in cognition in late life. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 70,* 557–567.

Skoog, I., & Gustafson, D. (2006). Update on hypertension and Alzheimer's disease. *Neurological Research, 28,* 605–611.

Smith, D. B., Feng, Z., Fennell, M. L., Zinn, J. S., & Mor, V. (2007). Separate and unequal: Racial segregation and disparities in quality across U.S. nursing homes. *Health Affairs, 26,* 1448–1458.

Solé-Auró, A., Beltrán-Sánchez, H., & Crimmins, E. M. (2014). Are differences in disability-free life expectancy by gender, race, and education widening at older ages? *Population Research and Policy Review, 34,* 1–18.

Sonnega, A., Faul, J. D., Ofstedal, M. B., Langa, K. M., Phillips, J. W. R., & Weir, D. R. (2014). Cohort profile: The Health and Retirement Study (HRS). *International Journal of Epidemiology, 43,* 576–585.

Steensma, C., Loukine, L., & Choi, B. C. K. (2017). Evaluating compression or expansion of morbidity in Canada: Trends in life expectancy and health-adjusted life expectancy from 1994 to 2010. *Health Promotion and Chronic Disease Prevention in Canada: Research, Policy and Practice, 37*(3), 68–76.

Stewart, K. A., Grabowski, D. C., & Lakdawalla, D. N. (2009). Annual expenditures for nursing home care: Private and public payer price growth, 1977 to 2004. *Medical Care, 47,* 295–301.

Suthers, K., Kim, J. K., & Crimmins, E. (2003). Life expectancy with cognitive impairment in the older population of the United States. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 58,* S179–S186.

Thomas, V. S. (2001). Excess functional disability among demented subjects? Findings from the Canadian Study of Health and Aging. *Dementia and Geriatric Cognitive Disorders, 12,* 206–210.

Tienda, M., & Mitchell, F. (Eds.). (2006). *Multiple origins, uncertain destinies: Hispanics and the American future*. Washington, DC: National Academies Press.

Todorov, A., & Kirchner, C. (2000). Bias in proxies' reports of disability: Data from the National Health Interview Survey on disability. *American Journal of Public Health, 90,* 1248–1253.

Tom, S. E., Hubbard, R. A., Crane, P. K., Haneuse, S. J., Bowen, J., McCormick, W. C., . . . Larson, E. B. (2015). Characterization of dementia and Alzheimer's disease in an older population: Updated incidence and life expectancy with and without dementia. *American Journal of Public Health, 105,* 408–413.

Tsai, Y. (2017). Education and disability trends of older Americans, 2000-2014. *Journal of Public Health, 39,* 447–454.

U.S. Census Bureau. (2020, September 15). *Inequalities persist despite decline in poverty for all major race and Hispanic origin groups*. Retrieved from: https://www.census.gov/library/stories/2020/09/poverty-rates-for-blacks-and-hispanics-reached-historic-lows-in-2019.html

U.S. Census Bureau. (2022). *Educational attainment of the population 18 years and over, by age, sex, race, and Hispanic origin: 2021* (Table 1) (Educational Attainment in the United States: 2021 Report). Retrieved from https://www.census.gov/data/tables/2021/demo/educational-attainment/cps-detailed-tables.html

Verruca, L., Guralnik, J. M., Salive, M. E., Pahor, M., Corti, M. C., Baroni, A., & Havlik, R. J. (1996). Cognitive impairment and risk of stroke in the older population. *Journal of the American Geriatrics Society, 44,* 237–241.

Vespa, J., Medina, L., & Armstrong, D. M. (2018). *Demographic turning points for the United States: Population projections for 2020 to 2060* (Current Population Reports, No. PS25-1144). Washington, DC: U.S. Census Bureau. Retrieved from https://www.census.gov/content/dam/Census/library/publications/2020/demo/p25-1144.pdf

Wang, S., Phillips, D., & Lee, J. (2021). Disability prevalence in midlife (aged 55–65 years): Cross-country comparisons of gender differences and time trends. *Women's Midlife Health, 7,* 1. https://doi.org/10.1186/s40695-020-00061-0

Whitson, H. E., Hastings, S. N., Landerman, L. R., Fillenbaum, G. G., Cohen, H. J., & Johnson, K. S. (2011). Black–White disparity in disability: The role of medical conditions. *Journal of the American Geriatrics Society, 59,* 844–850.

Williams, D. R., Neighbors, H. W., & Jackson, J. S. (2008). Racial and ethnic discrimination and health: Findings from community studies. *American Journal of Public Health, 98*(Suppl. 9), S29–S37.

Wong, E., Backholer, K., Gearon, E., Harding, J., Freak-Poli, R., Stevenson, C., & Peeters, A. (2013). Diabetes and risk of physical disability in adults: A systematic review and meta-analysis. *Lancet: Diabetes & Endocrinology, 1,* 106–114.

World Health Organization. (2017). *Life expectancy and healthy life expectancy: Data by county* [Data set]. Global Health Observatory data repository. Retrieved from https://apps.who.int/gho/data/node.main.688

Wu, L.-W., Chen, W.-L., Peng, T.-C., Chiang, S.-T., Yang, H.-F., Sun, Y.-S., . . . Kao, T.-W. (2016). All-cause mortality risk in elderly individuals with disabilities: A retrospective observational study. *BMJ Open, 6,* e011164. https://doi.org/10.1136/bmjopen-2016-011164

Yaffe, K., Falvey, C., Harris, T. B., Newman, A., Satterfield, S., Koster, A., . . . Simonsick, E. (2013). Effect of socioeconomic disparities on incidence of dementia among biracial older adults: Prospective study. *BMJ, 347,* f7051. https://doi.org/10.1136/bmj.f7051

Yu, W.-C., Chou, M.-Y., Peng, L.-N., Lin, Y.-T., Liang, C.-K., & Chen, L.-K. (2017). Synergistic effects of cognitive impairment on ADL disability in all-cause mortality among men aged 80 years and over: Results from longitudinal older veterans study. *PloS One, 12,* e0181741. https://doi.org/10.1371/journal.pone.0181741

Zaninotto, P., Batty, G. D., Stenholm, S., Kawachi, I., Hyde, M., Goldberg, M., . . . Head, J. (2020). Socioeconomic inequalities in disability-free life expectancy in older people from England and the United States: A cross-national population-based study. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences, 75,* 906–913.

Zsembik, B. A., Peek, M. K., & Peek, C. W. (2000). Race and ethnic variation in the disablement process. *Journal of Aging and Health, 12,* 229–249.

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