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Explaining the Increasing Disability Prevalence among Mid-Life US Adults, 2002 to 2016

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Abstract

Several recent studies have documented an alarming upward trend in disability and functional limitations among US adults. In this study, we draw on the sociomedical Disablement Process framework to produce up-to-date estimates of the trends and identify key social and medical precursors of the trends.

Using data on US adults aged 45–64 in the 2002–2016 National Health Interview Surveys, we estimate parametric and semiparametric models of disability and functional limitations as a function of interview time. We also determine the impact of socioeconomic resources, health behaviors, and health conditions on the trends.

Our results show increasing prevalence in disability and functional limitations. These trends reflect the net result of complex countervailing forces, some associated with increases in functioning problems (unfavorable trends in economic well-being, especially income, and psychological distress) while other factors have suppressed the growth of functioning problems (favorable trends in educational attainment and some health behaviors, such as smoking and alcohol use).

The results underscore that disability prevention must expand beyond medical interventions to include fundamental social factors and be focused on preventing or delaying the onset of chronic health problems and functional limitations.

Keywords

Disability; US adults; trend; functioning; social determinants; income

Disability is costly in many ways. At the national level, health care expenditures related to disability are estimated around $400 billion annually (Anderson et al. 2010). Additional economic losses due to lower productivity and caregiving are large and projected to grow further as the US population ages (Freedman and Spillman 2014). Disability is also a strong predictor of lower quality of life, hospitalization, institutionalization, and mortality (Cutler 2001, Freedman and Spillman 2014). The exorbitant costs of disability to individuals, families, and communities (Freedman, Martin and Schoeni 2002, Fried et al. 2001) make it imperative that we carefully track its levels and trends, and understand the causes of any changes in prevalence.

Our analysis has two aims. The first aim is to provide up-to-date estimates of trends in disability and functional limitations for mid-life US adults. Focusing on mid-life adults is critical because trends found in this age group are a harbinger of future disability levels as the cohorts enter older adulthood in the coming decades. The second aim is to investigate how changes in socioeconomic resources, health behaviors, and health conditions predict the functioning trends. Identifying the key precursors is imperative for effective targeting of prevention and intervention efforts.

Extensive literature has documented US trends in disability in the past century (Verbrugge and Liu 2014). Disability rates increased in the 1960s and 70s (Crimmins, Saito and Ingegneri 1997, Verbrugge 1989) but then declined steadily through the 1980s and 1990s (Crimmins and Saito 2001, Crimmins 2004, Manton, Gu and Lamb 2006). The declines in the late 20th century were pronounced and systemic across all major population groups. In contrast, much less is known about early 21st century trends. Continued declines in disability were observed among older adults (Freedman et al. 2013, Martin et al. 2007, Martin, Schoeni and Andreski 2010, Seeman et al. 2010, Tsai 2015) but studies of the non-elderly have suggested stagnating or even increasing functional limitations and disability (Crimmins and Beltrán-Sánchez 2011, Freedman et al. 2013, Martin et al. 2010, Martin, Schoeni and Andreski 2010), especially among less-educated men and women (Zajacova and Montez 2017).

Based on patterns from prior decades, as well as recent trends among older adults, we could expect continued declines in functioning problems. On the other hand, based on the emerging findings among non-elderly respondents, we could expect stable or increasing levels of functioning problems. Further refinement of our working hypothesis derives from the Disablement Process framework, in which our work is conceptually grounded (Verbrugge and Jette 1994). This widely-used sociomedical model describes how health conditions lead to functioning problems and focuses especially on predisposing socioeconomic resources, health behaviors, and demographic factors that speed up (exacerbate) or slow down the process of disablement. The present analysis examines population-level trends over time rather than the gradual disablement process at the individual level. Thus we expect that changing distribution of key risk factors in the population may have affected the prevalence of functioning problems.

However, different risks and resources may have countervailing effects on functioning trends, depending jointly on the direction of their effect on the disablement process (speeding it up or slowing it down) and how their distribution in the population changed over time. One set of factors comprises socioeconomic resources, such as educational attainment, economic wellbeing, and certain types of social ties. The gradual increase in educational attainment in the population, coupled with education's importance to health, made schooling an important driver of functioning improvements in the late 20th century (Freedman and Martin 1999, Schoeni, Freedman and Martin 2008). We expect that further increase in the average educational attainment in the mid-life population between 2002 and 2016 slows down increases in functioning problems.

On the other hand, the observation period spans the Great Recession of 2007–2009. This period was characterized by severe economic shocks followed by little economic recovery for many American families. It also launched a decade-long decline in homeownership rates (Goodman and Mayer 2018), which may have had consequences for disability in particular, given the importance of home ownership for modifying the environment to accommodate health problems and functional limitations. We therefore expect that declines in economic wellbeing may have exacerbated the growth of functioning problems. In addition, changes in certain types of social ties and living arrangements may have adversely affected trends in functioning as well, given their importance for emotional and instrumental support. For instance, between 1990 and 2015, the rise in the proportion of adults living alone rose the most for middle-aged adults (Wu 2017).

Health behaviors are also an important determinant of functioning (Cutler 2001). The increases in obesity in the population and concomitant metabolic and musculoskeletal problems are likely to worsen functioning (Martin and Schoeni 2014); in contrast, the declining prevalence of smoking may have the opposite effect and suppress the growth of functioning problems (Martin, Schoeni and Andreski 2010). Among health conditions, the declining prevalence of severe cardiovascular problems, thanks to better prevention and management of clinical symptoms, may slow down increases in functioning problems (Tsai 2016, Yokota et al. 2016). In contrast, pain and depression or distress have both become more prevalent among American adults and could be a precursor to the growth of functioning problems (Grol-Prokopczyk 2017, Weinberger et al. 2017, Zimmer and Zajacova 2018). We therefore expect a complex set of influences on the functioning trends, with some predisposing factors exerting positive effects on the trends while other factors exerting negative effects.

Answers to the two aims will contribute to the body of knowledge about contemporary trends in functioning in mid-life US adults. Moreover, our results will show how fundamental predisposing factors such as educational attainment and economic wellbeing, intervening factors like health behaviors, and proximate factors like health conditions affect aggregate trends in disability and functional limitations. We analyze functional limitations in addition to disability because in the mid-life sample, physical limitations such as difficulty walking or climbing stairs are a salient problem and a potential precursor of disability as posited by the Disablement Process. The term “functioning” refers to both outcomes collectively.

DATA AND METHODS

Data

We use the National Health Interview Surveys (NHIS) 2002–2016 (Blewett et al. 2016). The NHIS is an annual cross-sectional, nationally-representative survey of the non-institutionalized US population. It is the best available source of data for this study because it includes a long series of questions on functional limitations and disability, important covariates, and a large sample size of non-elderly respondents. We start with the year 2002 because it is the first year for which information about arthritis, an important covariate of physical functioning, is collected systematically; 2016 is the most recent available wave of data.

Sample is defined as "sample adult" women and men age 45 to 64 who were interviewed between January 2002 and December 2016 and provided valid information about functioning. The "sample adult" group is a random subsample of 43% of all adult NHIS respondents; this group was administered all of the health, functional limitations, and disability measures used here. Of the 150,552 "sample adults" age 45–64, 150,515 (99.9%) answered all disability questions and 149,761 (99.5%) answered all functional limitation questions; our analyses include these adults. See section below about our approach for handling missing data on predictors.

Variables

The key predictor is the time of interview, constructed from interview month and year as $yearmonth = year + (month - 0.5)/12$. Thus, the earliest interviews conducted in January 2002 are assigned a value of 2002.042 and last interviews conducted in December 2016 have a value of 2016.958. This continuous time variable is then recoded to range from −0.5 to 0.5 using the formula $time = (yearmonth - 2009.5)/15$, so that the coefficient associated with a one unit change in time is the change in the dependent variable from the start to the end of the observation period. In other words, the coefficient for time is interpretable as the change in outcome across the 15-year time period.

Outcomes are disability and functional limitations. Disability is operationalized as needing help with activities of daily living (ADLs) or instrumental activities of daily living (IADLs). ADLs are assessed using the prompt, "Because of a physical, mental, or emotional problem, does [the respondent] need the help of other persons with personal care needs," including bathing or showering, dressing, eating, using the toilet, getting around inside the home, and getting in or out of bed or chairs. Needing help with any of these six personal care needs is defined as having an ADL disability. IADLs are assessed with a single question that asks whether the respondent, "because of a physical, mental, or emotional problem, needs the help of other persons in handling routine needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes." Following Spector and Fleishman (1998), we combine the ADL and IADL measures and define individuals as experiencing disability if they responded that they needed help in at least one of these domains. Among adults with disability in our analytic sample, 58% had only an IADL limitation, 8% had only an ADL limitation, and 34% had both.

Functional limitations assessed the level of difficulty with physical tasks. The respondents were asked: "By yourself, and without any special equipment, how difficult is it for you to:" walk up 10 steps, carry 10 pounds, grasp objects, reach over your head, sit two hours, stand two hours, stoop or bend or kneel, and walk a quarter mile. We aggregated the responses, and dichotomized the resulting variable, so that "any difficulty in at least one domain" is coded as 1 and "no limitation in any domain" is coded as 0.

Basic covariates included in all models comprise demographic and interview-related information. Age, ranging from 45–64 years, is a continuous variable measured in single years and centered on 55. Gender is coded with male as reference. Race/ethnic categories are non-Hispanic white (reference), non-Hispanic black, Hispanic, and other. Place of birth is dichotomized (US-born is reference) and region of residence categories are Northeast (reference), Midwest, South, and West. We also control for interviews conducted using a proxy respondent and interviews in a language other than English.

Hypothesized precursors include socioeconomic resources, health behaviors, and health conditions.

Educational attainment is categorized as less than high school or a GED, high school diploma, some college or associate degree, and bachelor's degree or more (reference). Social ties are measured with two household-composition variables available in NHIS. Marital status is categorized as married or cohabiting (reference), divorced or separated, widowed, or never married. The number of children currently residing in the household, including own, step, or adopted children, is categorized as no children (reference), one child, and two or more. Economic well-being is captured with several indicators. As a short-term indicator of material well-being, household income is measured using the ratio of total household income to the household composition, expressed as a percentage of a year-specific federal poverty line. It is categorized as below poverty line, 100–199% of poverty line, 200–399%, and 400% or more (reference). As a long-term measure of material well-being, home ownership is categorized as owning a home (reference), renting, or 'other' situation. Respondents also reported whether their residence is a house or apartment (reference) versus a trailer or mobile home. With respect to employment, we used information from the year preceding the interview to slightly reduce the risk of endogeneity. We categorized respondents as having worked all year (reference), part of the year (1–11 months), or none of the year. We also controlled for current employment status, coded as employed (reference), unemployed, or not in the labor force.

Health behaviors include smoking, alcohol use, and body mass index (BMI). Smoking was categorized as never (reference), former, and current. Alcohol use was categorized as never, former, current moderate drinking, and current binge drinking. Binge drinking was assessed in NHIS as "In the past year, on how many days did you have 5 or more drinks of any alcoholic beverage?" Following precedent (Schoenborn, Stommel and Ward 2014), we use a cutoff of 3 or more days. This cutoff also yields a proportion of binge drinkers in our sample compatible with CDC's estimates of US adults age 45–64 who binge-drink. BMI was calculated by the NHIS using self-reported weight and height using the standard formula. We included it in models as a 5-level categorical variable because of its nonlinear (J-shaped) relationship with functioning.

Health conditions were assessed using the prompt: "Have you ever been told by a doctor or other health professional that you had …" The 13 conditions include angina pectoris, arthritis, cancer, coronary heart disease (CHD), chronic bronchitis, emphysema, diabetes, heart attack, other heart condition, hypertension, kidney disease, liver condition, and stroke. Two additional health variables include psychological distress and pain. Psychological distress was measured using the Kessler Scale (K6), which asks respondents to self-report the frequency the following six symptoms during the month before the interview: felt nervous, hopeless, restless or fidgety, worthless, depressed, and that everything was an effort. The K6 is widely used to measure psychological distress in the general population (Kessler et al. 2002). Finally, respondents reported whether they experienced pain during the past three months in one of the following four sites: lower back, neck, face/jaw, or severe headaches/migraines. We constructed a summary pain index that ranges from 0 to 4.

Missing data—The proportion of missing data across all variables is low. Missing values range from 0% to 0.8% for all but five covariates: proxy interview (1.5% missing), the K6 index (1.9%), alcohol use (2.1%), BMI (4.4%), and family income (14.1%).

Approach

We estimated a series of logistic models of the form $Logit(F_i) = \alpha + \beta t_i + \sum_{j=1}^{k} \gamma_j x_{ij}$, where F_i is the presence of a physical functioning problem (disability or functional limitation=1) reported by individual *i*; t_i captures the time of interview; $x_{i1}, \ldots x_{ik}$ are the values for individual *i* for each of *k* control variables. For our analyses, the most important coefficient is β because it shows the change in the outcome over the observation period as explained above. For results in Table 3, we estimated a set of linear probability models for each control variable x_i included separately: $F_i = \alpha + \beta t_i + \gamma x_i$ to observe the effect of each hypothesized precursor on the estimated time trend β. We also estimated a series of semiparametric partial-linear models of F_i using the *plreg* command (Lokshin 2006), where the βt_i term is replaced by a smooth function of time $f(t_i)$ and estimated by lowess procedure in Stata (Cleveland 1979). This model allows capturing the time trend nonparametrically while additively including any control variables; we display the estimated basic- and fully-adjusted trends of disability and functional limitations in Figures 1 and 2, respectively.

All analyses were conducted on pooled 2002–2016 data. The logistic and linear probability models take into account the sampling weights, clustering, and stratification of the complex sampling design of NHIS using the *svy* suite of commands in Stata.

Analytic choices—Two important choices needed to be made with respect to the estimated models: how to model the discrete outcomes and how to deal with missingness. The outcomes could be modeled using logistic or linear probability models (LPM). Logistic models make examining changes in the trend coefficient across nested or non-nested models more complex (Breen, Karlson and Holm 2013) compared to LPM; moreover, the widely-adopted KHB method for comparing changes in odds ratios across nested nonlinear models is not available in MI estimation (Kohler, Karlson and Holm 2011). We therefore chose logistic models in some analyzes because of the ease of interpretation in the form of odds ratios and their established usage in social science research for dichotomous outcomes. We used LPM in Table 3 where we focused on the comparison of estimates across different models.

The three options for dealing with missingness included complete-case, missing-indicator, and multiple imputation (MI, Rubin 1987) approaches. The optimal choice in observational studies is somewhat debatable (Knol et al. 2010, White and Carlin 2010), however, MI is more likely than other approaches to yield unbiased estimates under various missingness mechanisms (Sterne et al. 2009). We therefore show findings from multiply-imputed logistic models using chained equations (Royston and White 2011).

Sensitivity analyses—We conducted extensive additional analyses to verify the robustness of our findings to alternative model specifications. 1) We re-estimated the models without adjusting for the complex sampling design of NHIS (National Center for Health Statistics 2017). The results were the same as those shown below. 2) We re-estimated the models using complete-case and missing-indicator approaches. The results using these alternative approaches were fully comparable to the results shown here for disability; for functional limitations, the fully-adjusted complete-case and missing-indicator models showed that the trend was completely explained by the covariates; therefore, our findings using MI can be viewed as a conservative estimate of the effects of the covariates on the trends. 3) We compared findings from logistic models to linear probability models (LPM). The two sets of findings were comparable or nearly identical, indicating that our results are robust.

We also conducted checks of complex temporal trends. 4) We relaxed the assumption that the effect of the controls and covariates on functioning were constant over time. We estimated models where each control variable and covariate was interacted with a linear time trend. We found that only the effect of education on functioning became stronger over time. However, taking this interaction into account in the models did not materially alter the results. 5) We tested for nonlinear time trends by estimating models that included higher-order quadratic and cubic terms for interview time. We found no departures from linearity for disability. For functional limitations, some models showed a slight deceleration of the increases over time; however the linear term remained the predominate force. 6) Finally, we tested whether reporting of functional problems changed over time. We estimated logistic models of disability and functional limitations, respectively, as a function of all health conditions, allowing these effects to vary across time. If reporting of functioning problems changed over time, it would potentially be evident in significant interaction terms indicating a changing relationship between underlying conditions and functioning problems. However, the analyses did not support this hypothesis. Only 3 of 15 health conditions changed significantly over time in their effect on disability reporting; moreover, the direction of the interaction term was not consistent. For functional limitations, no interaction term was significant, providing indirect support for consistent reporting of functioning over time. All results from the sensitivity analyses are available from the authors.

RESULTS

Table 1 shows characteristics of the target population and changes in the characteristics over time. Among community-residing Americans aged 45–64, 4.4% had a disability and 40.8% had a functional limitation. Both measures of functional problems increased significantly from 2002 to 2016. This trend could be related to the changing characteristics of the population: the distribution of most covariates also changed over time. Educational attainment increased significantly while economic indicators worsened: over time, the proportion of low-income families, renters, and adults who did not work increased significantly. Among health behaviors, smoking rates decreased but BMI and binge-drinking increased. For most health conditions, the prevalence increased or remained unchanged.

Table 2 shows the estimated change over time (trend) of disability and functional limitations, net of seven different covariate sets. Only the trend coefficient is shown for parsimony; full tables are available on request. Net of demographics in Model 1, the prevalence of disability is 21% higher in 2016 compared to 2002 (OR=1.21, p<.001). Also controlling for education in Model 2, disability prevalence increased by 33% (OR=1.33, p<.001). That is, if the average educational attainment in the population had not increased over time, the disability growth would have been even steeper. Social ties (Model 3) play a relatively modest role in trends. Economic circumstances have a sizeable impact: net of this set of correlates in Model 4, the disability trend attenuates to a 14% increase (OR=1.14, p<.05). Health behaviors, included jointly in Model 5, act as suppressors of the trend: net of these covariates, the disability growth becomes steeper (OR=1.35, p<.001). Model 6 controls for health conditions. Perhaps not surprising given that health conditions are the proximate precursors of disability, taking into account their changing distribution yields a flat disability trend (OR=1.05, p>.05). Finally, the joint effect of all covariates in Model 7 also fully explains the increase in disability over time (OR=1.01, p>.05).

Functional limitations increased by 26% from 2002 to 2016, net of demographic covariates in Model 1 (OR=1.26, p<.001). As for disability, education is a strong suppressor of the increase (Model 2, OR=1.35, p<.001). Social ties (Model 3) exert only minimal influence on the trend. Economic circumstances, which played a critical role in the disability trend, have little impact on the functional limitations trend (Model 4, OR=1.27, p<.001). Similarly, health behaviors don’t have an effect on the functional limitations trend (Model 5, OR=1.25, p<.001). Chronic health conditions (Model 6) exert a strong effect, although the growth of functional limitations remains significant (OR=1.15, p<.001) after adjusting for health conditions. Finally, the joint influence of all correlates in Model 7 explains about one-half of the growth of functional limitations (OR=1.13, p<.001).

Table 3 shows how each predictor individually influences the observed functioning trends. The role of each predictor is often similar for the two outcomes but there are important differences. Family income and psychological distress are the strongest predictors of growth of both disability and functional limitations. Other factors that explain the increase include diabetes, pain, and hypertension. Changes in the rates of home ownership and employment are important correlates of disability trends but less so of functional limitation trends. Other covariates exert the opposite, suppressor, effect: lower rates of smoking and changing patterns of alcohol use, greater educational attainment, a greater proportion of foreign-born adults, as well as some conditions (angina), suppress the growth of functioning problems in the population.

Figures 1 and 2 illustrate the unadjusted and adjusted trends in both outcomes. Net of only basic demographics, both disability and functional limitations clearly increase over time. Taking into account the socioeconomic resources, health behaviors, and health conditions, both trends become much flatter with little or no systematic growth from 2002 to 2016.

DISCUSSION

The two aims of this study were to document up-to-date trends in disability and functional limitations among US adults age 45–64 and to identify key socioeconomic resources, health behaviors, and health conditions that influence the trends. This issue is important and urgent. It is important because of the prohibitive costs of disability to individuals, families, and communities. In 2000, there were 62 million Americans age 45–64; by 2020, that age group is projected to grow to 84 million adults, a 35% increase. Even if disability rates remained unchanged, there would be 35% more persons needing assistance – especially problematic given that the number of younger adults and potential caregivers is diminishing relative to the older population.

This issue is also urgent because of reported declines in health and longevity among American adults in the early 21st century (Chen and Sloan 2015, Montez and Zajacova 2013, Sasson 2016, Zajacova and Montez 2017), a startling reversal of long-term trends toward better health and longer lives (Crimmins 2004). It will be critical to develop a comprehensive interdisciplinary approach to combat the problems and reverse the observed declines in population health and longevity.

Unfortunately, our results corroborate the disturbing trends in other health dimensions. We find a substantial increase of functioning problems among mid-life Americans. In aggregate, 4.4% of adults age 45–64 reported a disability but the percentage grew from 3.9% in 2002 to 4.9% in 2016, a 25% increase. Functional limitations, with a 40.8% prevalence in the pooled sample, were reported by 37% in 2002 and over 45% in 2016, a 23% increase in relative terms.

The growth of functioning problems is driven by a complex interplay of socioeconomic resources, health behaviors, and health conditions. These broad factors, as well as individual measures within each factor, act as countervailing forces on the functioning trends, some speeding up and others slowing down the increases, as posited by the Disablement Process framework (Verbrugge and Jette 1994). For instance, educational attainment increased over the observation period. This increase significantly slowed the growth of functioning problems. If it weren't for the higher average attainment in 2016 compared to 2002, the growth of functioning problems would be even steeper: 33% for disability and 35% for functional limitations.

In contrast, the deteriorating economic conditions contributed powerfully to the growth of functioning problems. All economic indicators –family income, home ownership, and employment status-- had the same direction of effects: they were significant predictors of the increases. However, family income was uniquely important: it was the most powerful predictor of the growth of disability and functional limitations. This likely reflects the drastic reduction in income that the average family experienced during the Great Recession and from which they did not recover economically, as well as the central importance of income for health. However, there were also important differences in the effect of economic precursors on disability versus functional limitations.

The two outcomes can be viewed as a high-threshold (disability) and low-threshold (limitations) measure of functioning problems. Jointly, they provide an inclusive picture of functioning at different points of the disablement process. Since the two outcomes are linked in a logical progression through the disablement process, some similarities in findings should be expected. An important distinction, however, is that limitations are largely physiological in nature, arising from impairments and chronic conditions. Disability, in contrast, is defined as "a gap between personal capability and environmental demand" (Verbrugge and Jette 1994) and thus is an inherently social characteristic. As such, fundamental factors like economic well-being may be expected to have a particularly strong effect because income and other resources may be used to alter the "environmental demands" and conditions to bridge the gap created by impairments and limitations, such as making necessary home alterations.

Indeed, home ownership and past employment, in addition to income, were among the four most powerful precursors of disability growth, surpassing all physical health problems. Income allows people to buy medications, eye glasses, comfortable beds that don't aggravate stiff joints; home ownership allows people to modify their physical space in critical ways that can accommodate limitations -- access to these kinds of resources can prevent existing limitations from becoming disabilities. We could even posit that for disability, economic well-being is a proximate determinant. Home ownership and prior employment were less prominent in determining functional limitations, for which pain, hypertension, diabetes, or BMI were more salient correlates. Nonetheless, the fact that the relative crudely measured economic inputs had a more prominent role in disability trend than did the specific health conditions highlights the pervasive effects of the chronic and acute financial strains that many Americans increasingly encounter, especially since the Great Recession.

Health conditions, as the most proximal precursors to functioning problems, jointly explained all of the increase in disability and a major part of the increase in functional limitations. It is important to keep in mind that this does not mean that the more distal factors are less important but instead that they may operate via chronic conditions to influence functioning. It is also important to note that most critical indicator was psychological distress rather than physical conditions such as arthritis, potentially highlighting the increasing 'despair' among a large subset of US adults which has been implicated in mortality increases (Monnat and Brown 2017), and which likely play a role in the growth of functioning problems as well.

Disentangling the countervailing influences of individual characteristics was also important for health behaviors. Lower rates of smoking were a powerful suppressor of increases in functioning problems. In contrast, BMI, despite being a noisy measure of behavioral choices, was fairly prominent in driving the increases. Somewhat surprising was the role of alcohol use, which was the strongest suppressor of disability growth. We found fewer non-drinkers over time, but also more binge drinkers. It is not clear why these changing patterns, combined with their specific effects on each outcome, makes alcohol use such a powerful suppressor of the trends, a puzzle that should be addressed in future work.

We note several limitations of the analysis. The NHIS samples only community-dwelling respondents, which excludes adults in nursing homes and other long-term care facilities who have much higher rates of disability. If the rate of institutionalization changed substantially over the study period, it could bias our estimation of changes over time. Fortunately this does not appear to be the case because the changes in institutionalization due to disability have been modest and the proportion of the target population at ages 45–64 in institutions is low (She and Stapleton 2006, Stapleton, Honeycutt and Schechter 2012). An additional limitation pertains to the cross-sectional nature of the data, which precludes examining causal effects of the hypothesized precursors. Our cross-sectional measures reveal a static burden at each time point rather than the dynamics of the disablement process at the individual level, and show that the social and medical factors influence the aggregate patterns in a way consistent with the original dynamic conceptualization of disability (Jette 2007, Verbrugge and Jette 1994). All findings must be therefore interpreted as the result of changes in the distribution of predictors in the population over time on the changes in functioning trends. Thus while the relationship between any predictor and level of functioning problems could be biased by endogeneity, as long as the causal process (endogeneity included) does not change over time, our results provide an unbiased relationship between changing conditions and functioning. We also note that the persistent increases over time in both functioning measures are not necessarily linear: we observed a deceleration of the increases in functional limitations in our sensitivity analyses, while the nonparametric visualization suggested the opposite, accelerating pattern in the most recent years. We will have to wait for future data to determine whether functioning problems will level off or further continue their increase. A final note of caution is that disability and functional limitations are self-reported in the NHIS data. If US adults changed systematically how they understand and report functioning problems over time, the observed trends could be biased. We addressed this possibility by testing whether the association of health conditions with functioning problems changed over time. There was no indication of any systematic changes, offering indirect evidence against differential reporting over time. Nonetheless, future studies should use alternative data sources with objective measures of functional problems to address this issue.

Our findings contribute to the emerging body of evidence that the worsening socioeconomic conditions for many Americans are brining negative health returns. The fact that income was the strongest determinant of the increasing trends, despite its relative remove from the physiological process of disablement, highlights the importance of upstream focus for improving the health of American adults and families. To lower disability levels in the older population, efforts must be focused earlier in the life course on preventing or delaying onset of major chronic health problems. The efforts, furthermore, need to reach beyond individual-level interventions to improve health behaviors or prevent the onset of chronic illness; they must be aimed at decreasing economic inequalities and at improving economic circumstances in which American adults and their families work and live.

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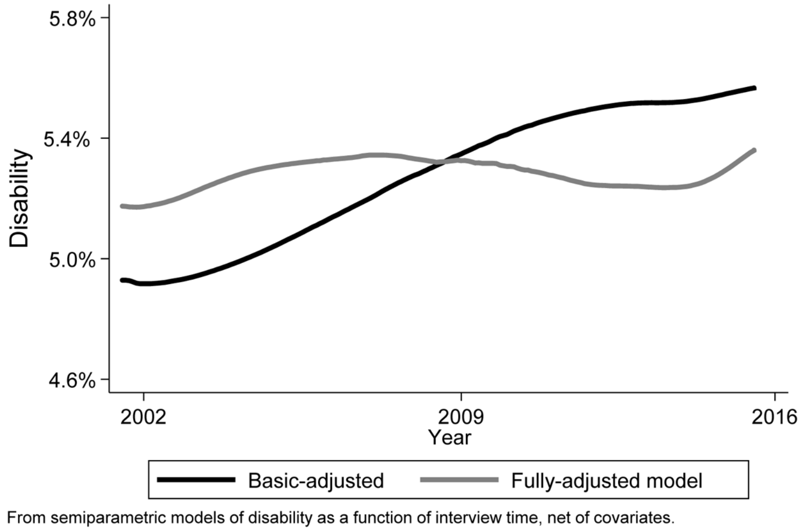

Fig 1.
Disability Trend 2002–2016, US Adults Age 45–64

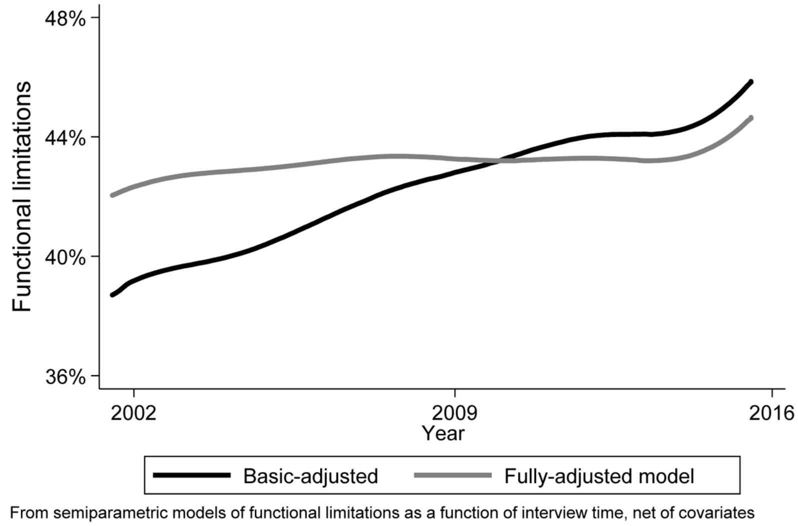

Fig 2.
Functional Limitations 2002–2016, US Adults Age 45–64

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Table 1

Select characteristics of the analytic sample and changes in the characteristics from over the observation period

	Percent[1]	Change 2002–2016[2]
Disability	4.4	.268***
Functional limitations	40.8	.260***
Female	51.5	n.s.
Age, mean (s.e.)	53.8 (3.6)	.004***
Foreign-born	14.7	.577***
Proxy respondent	1.1	.524***
Foreign language used	4.9	.472***
Race		
Non-Hispanic white	72.9	Ref.
Non-Hispanic black	11.2	.275***
Hispanic	10.7	.623***
Other	5.2	.653***
Marital status		
Married/cohabiting	71.0	Ref.
Divorced/separated	17.1	.195***
Widowed	3.4	−.127*
Never married	8.4	.441***
Children at home		
None	60.2	Ref.
One	21.0	.091**
Two or more	18.8	.138***
Educational attainment		
Less than HS or GED	15.4	−.348***
High school diploma	25.2	−.472***
Some college or AA degree	29.0	−.104**
College degree or more	30.4	Ref.
Family income		
>4 times poverty line	50.0	Ref.
2–3.99 times	26.8	n.s.
1–1.99 times	13.5	.382***
Below poverty line	9.7	.498***
Home ownership		
Owns	78.1	Ref.
Rents	20.1	.521***

	Percent[1]	Change 2002–2016[2]
Other	1.8	.252**
Trailer/mobile/other home	5.2	−.187*
Months worked last year		
12 months	63.0	Ref.
1–11 months	11.5	n.s.
Did not work	25.5	.168***
Employment status		
Employed	69.6	Ref.
Unemployed	3.7	.586***
Not in labor force	26.7	.091**
Health measures		
Arthritis	29.7	.057*
Angina	2.5	−.551***
Cancer	8.9	.249***
CHD	4.6	n.s.
Chronic bronchitis	5.0	n.s.
Diabetes	13.0	.434***
Emphysema	2.2	n.s.
Heart attack	3.6	n.s.
Other heart condition	8.1	n.s.
Hypertension	37.1	.274***
Kidney disease	1.8	.205***
Liver condition	2.2	.192*
Stroke	2.7	.290***
CES-D score (0–24 range)	2.6 (2.6)	.002***
Pain (0–4 range)	0.7 (0.6)	.007***
Smoking		
Never	53.3	Ref.
Former	26.0	−.376***
Current	20.7	−.449***
Alcohol use		
Never	17.6	−.388***
Former	17.3	−.152***
Current	52.2	Ref.
Current binge	12.9	.420***
BMI	28.4 (3.9)	.002***

* p<.05

** p<.01

*** p<.001

Adjusted for complex sampling design of the NHIS 2002–2016.

Ref. = reference category; n.s. = not significant (p≥0.5)

[1] Age, K6, pain, and BMI are continuous variables and summarized with a mean (s.d.)

[2] Change over time column shows whether a variable changed significantly between 2002 and 2016. We estimated appropriate regression model (linear, logistic, multinomial logistic) of each variable as a function of linear time trend. We show the time trend for each variable and its significance level. For ease of interpretation, positive (upward) trends are on the left of the "Change" column, non-significant (flat) trends in the middle, and negative (downward) trends on the right.

Table 2

Disability and functional limitation changes over time, net of different covariate sets.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Disability	1.21***	1.33***	1.18**	1.14*	1.35***	1.05	1.01
Functional limitations	1.26***	1.35***	1.25***	1.27***	1.25***	1.15***	1.13***
Covariate sets							
Key demographics	✓	✓	✓	✓	✓	✓	✓
Education		✓					✓
Social ties			✓				✓
Economic wellbeing				✓			✓
Health behaviors					✓		✓
Health conditions						✓	✓

* p<.05

** p<.01

*** p<.001

Table shows odds ratios (ORs) for a linearly-specified time trend from logistic models of each outcome. The models for disability and functional limitations are estimated separately; thus each of the 14 ORs comes from a separate regression model.

Table 3

Trend estimates for disability and functional limitations, net of each correlate

Included covariate	Trend in disability	Included covariate	Trend in limitations
Income	0.003 (n.s)	Income	0.037***
Psychological distress	0.004*	Psychological distress	0.041***
Home ownership	0.006**	BMI	0.046***
Worked last year	0.007**	Age	0.046***
Diabetes	0.007**	Pain	0.048***
Pain	0.008***	Hypertension	0.050***
Hypertension	0.008***	Diabetes	0.051***
BMI	0.008***	Worked last year	0.054***
Age	0.009***	Home ownership	0.055***
Marital status	0.009***	Employment status	0.057***
Proxy resp.	0.009***	Arthritis	0.060***
Employment status	0.009***	Stroke	0.061***
Stroke	0.009***	Cancer	0.061***
Kidney disease	0.010***	Marital status	0.061***
Cancer	0.010***	Kidney disease	0.063***
Arthritis	0.010***	Proxy resp.	0.063***
Liver disease	0.011***	Liver disease	0.063***
CHD	0.011***	CHD	0.064***
Female	0.011***	Female	0.065***
BIVARIATE TREND	0.011***	**BIVARIATE TREND**	0.065***
Race/ethnicity	0.011***	Emphysema	0.065***
Region	0.011***	Other heart condition	0.065***
Non-English interview	0.011***	Heart attack	0.066***
Emphysema	0.011***	Chronic bronchitis	0.066***
Heart attack	0.011***	Region	0.066***
Trailer/mobile home	0.011***	Trailer/mobile home	0.066***
Chronic bronchitis	0.012***	Non-English interview	0.067***
Other heart condition	0.012***	Children at home	0.067***
Children at home	0.012***	Alcohol use	0.068***
Angina pectoris	0.013***	Angina pectoris	0.069***
Foreign-born	0.013***	Race/ethnicity	0.070***
Education	0.014***	Education	0.074***
Smoking	0.014***	Foreign-born	0.075***

Included covariate	Trend in disability	Included covariate	Trend in limitations
Alcohol use	0.015***	Smoking	0.076***

*p<.05

**p<.01

***p<.001

The table shows coefficients for the time trend from linear probability models of disability (left column) and physical limitations (right), respectively. Each model only controls for the time of interview plus one covariate; the label identifies the covariate. The rows are ordered from the largest to smallest point estimate of the interview time, which allows us to compare the effect of each individual covariate on the changes in disability and functional limitations.