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Race Differences in ADL Disability Decline 1984-2004: Evidence From the National Long-Term Care Survey

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Abstract

Objective—Disability declined in lower levels of impairment during the late 20th century. However, it is unclear whether ADL disability also declined, or whether it did so across race. In this study, we examine cohorts entering later life between 1984 and 1999, by race, to understand changing ADL disability.

Method—We used latent class methods to model trajectories of ADL disability and subsequent mortality in the National Long-Term Care Survey among cohorts entering older adulthood (ages 65-69) between 1984 and 1999. We examined patterns by race, focusing on chronic condition profiles.

Results—White cohorts experienced consistent declines in ADL disability but Blacks saw little improvement with some evidence for increased disability. Stroke, diabetes, and heart attack were predominant in predicting disability among Blacks.

Discussion—Declining disability trends were only observed consistently among Whites, suggesting previous and future disability trends and their underlying causes should be examined by race.

Keywords

disability; trajectories; race; chronic conditions; cohort

The latter half of the 20th century boasted consistent decreasing disability trends among older adults (Freedman et al., 2004), while the early 21st century presented stabilizing or even increasing disability (Martin, Freedman, Schoeni, & Andreski, 2010; Seeman, Merkin, Crimmins, & Karlamangla, 2010). Observed trends are primarily concentrated at lower levels of impairment, while findings are inconsistent for more severe disability measures such as activities of daily living (ADLs). Furthermore, it is not clear how minority groups, and particularly Black individuals, experienced these population trends. Studies suggest that

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examining chronic conditions is important in changing disability rates in the population, and that changing disease incidence and mortality may substantially account for race differences in ADL trends (Freedman, Schoeni, Martin, & Cornman, 2007; Seeman et al., 2010; Yang, 2008). In this article, we address three questions.

Research Question 1: Are reductions in ADL-level disability visible longitudinally in younger cohorts between 1984 and 2004?

Research Question 2: Are cohort patterns in disability similar for Whites and Blacks?

Research Question 3: How do chronic conditions predict disability trajectories, and do they do so differentially across race?

Background

Trends in Disability 1980-2010

The last two decades of the 20th century showed clear declines in disability prevalence among older adults, considered “one of the most significant advances in the health and well-being of Americans” during this period (Freedman et al., 2013; see also Schoeni, Freedman, & Martin, 2008). Declines in less severe functional limitations and instrumental activities of daily living (IADLs; Lawton & Brody, 1969) measures were documented by many studies across numerous data sources (Freedman, Martin, & Schoeni, 2002). However, there was less consensus regarding measures of more severe disabilities, such as ADLs (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963).

Understanding patterns in ADLs is particularly important, because they are considered more direct measures of older adult well-being, and they more closely reflect the economic burden of disability, relative to measures of less severe impairments (IADLs, etc.). For example, 40% of those reporting difficulty with one ADL and 90% of those with three or more ADLs require paid or unpaid caregiving assistance (Johnson & Wiener, 2006). This is likely because ADLs tap into basic daily personal care needs of individuals, such as bathing and dressing, that are especially salient for long-term care, whereas IADLs tap into more instrumental or household tasks, such as shopping and cleaning (Freedman et al., 2004).

Inconsistency in ADL trends included observed decreases (Manton & Gu, 2001), increases (Crimmins & Saito, 2000), and general stability (Lin et al., 2012) during these decades. In a systematic analysis of individuals aged 70 years and older from five nationally representative data sources, Freedman and colleagues (2004) found limited evidence of increasing ADL impairment in the 1980s, followed by a decline in the mid to late 1990s. Together, these findings suggest that over the 20-year period, ADL trends may have remained relatively stable (Lin et al., 2012). The beginning of the 21st century is now revealing evidence of increasing disability, driven disproportionately by racial minorities (Martin et al., 2010; Seeman et al., 2010). Freedman and colleagues (2013) reexamined the population aged 65 years and older during the years 2000-2008, and found a generally stable pattern in ADL-level disability across multiple surveys. Only one data source, the National Long Term Care Survey (NLTCS), showed evidence of ADL *increases* during this period. In

sum, although the literature found consensus on declines in less severe markers of disablement during the 1980s and 1990s, evidence of changing ADL impairment is still mixed between the 1980s and early 2000s. Furthermore, little is known on how racial and ethnic minorities experienced these trends, although research suggests they are at particular risk of disability increases (Seeman et al., 2010).

Racial Variation in Disability

Any functional gains observed in the late 20th century were almost certainly not equitably distributed across the population. Older minorities, especially Blacks, may not have experienced disability declines similar to the overall population. Blacks consistently have the worst health, disability rates, and mortality levels of any racial group compared with Whites (Hayward & Heron, 1999; Liang, Xu, Bennett, Ye, & Quiñones, 2010). However, evidence for disability trends among minorities is especially inconsistent. Some studies found no significant differences in disability trends (Schoeni, Freedman, & Wallace, 2001). Others suggest that Blacks in particular experienced increases in disability (Clark, 1997). Using the NLTCs, Manton and Gu (2001) found that ADL impairment remained relatively stable for Whites between the early 1980s and 90s. However, Blacks showed increases in mild (one to two ADLs) disability in the 1980s followed by declines in the mid to late 1990s. More moderate (three to four ADLs) and severe (five to six ADLs) levels of impairment showed stability, similar to Whites. The more recent documented increases in disablement among older adults since 2000 occurred disproportionately among Blacks (Seeman et al., 2010). Together, these findings suggest that, relative to Whites, a better understanding of disability trends among Blacks in the late 20th century may be especially important in explaining current and future observed trends.

Importance of Chronic Disease and Mortality

Key to understanding changing disability trends and race differences are the chronic conditions associated with impairment. The literature suggests that changes in chronic condition prevalence and severity underlie disability trends of the past few decades (Freedman et al., 2007). Scholars linked declining disability of the late 20th century to decreasing disablement in vision impairments and cardiovascular conditions including heart disease, hypertension, and stroke (Freedman et al., 2007; Taylor & Lynch, 2011). Increases in disability in the early 2000s are associated with arthritis, diabetes, and obesity, conditions disproportionately experienced by racial minorities (Martin et al., 2010; Seeman et al., 2010).

Also of significant importance in understanding race and cohort differences in disability is the role of mortality. Studies of disability trends alone often do not accommodate or highlight mortality shifts in younger cohorts or that mortality risk associated with disease or disability differs by race (Geronimus, Bound, Waidmann, Colen, & Steffick, 2001; Hayward & Heron, 1999). Furthermore, reductions in overall mortality during the late 20th century were driven substantially by cohort change, and varied across disease-specific mortality (Yang, 2008). These findings suggest that including chronic diseases as key predictors of disability, and mortality as an additional outcome, is important for understanding any race differences.

Cohort Variation in Disability

Although repeated cross-sectional trend studies are powerful in providing estimates of disability prevalence in the population over historical periods, examining cohort trends can reveal important diverging processes, especially when longitudinal patterns are considered (Lynch, 2003). Lin and others (2012) examined age, period, and cohort disability patterns for older adults in the National Health Interview Survey (NHIS) between 1982 and 2002. Although *period* trends replicate the generally stable ADL disability trends previously observed (Freedman et al., 2004; Manton & Gu, 2001), *cohort* trends suggest disability declines (lower disability levels) from cohorts born in the early to mid-1900s. Other research presents similar cohort effects longitudinally (Taylor & Lynch, 2011; Yang & Lee, 2009) along with significant race disparities. Together, these studies suggest that a reexamination of ADL disability patterns among cohorts entering older adulthood between 1980 and 2000 may shed additional light on whether disability declines were experienced for both Black and White older adults and what role chronic diseases played in these patterns.

For the present study, we examined long-term disability experiences among four 5-year birth cohorts, ages 65 to 69, entering the NLTCS in 1984, 1989, 1994, and 1999 to determine whether ADL declines were visible from 1984 to 2004. We estimated these effects separately for Whites and Blacks to determine whether ADL declines occurred across race. We modeled mortality as an outcome of both the predictors and disablement, as cohort change in mortality has also been observed during this historical period. Finally, we examined chronic disease profiles corresponding to different disability experiences as factors that may partially explain race differences in disability and mortality change among younger cohorts.

Method

Data

We used publicly available data from the 1984-2004 NLTCS, along with linked Medicare and Vital Statistics records. For these analyses, we kept only those reporting White or Black on the race measure, dropping other races and ethnicities. The NLTCS is a panel study with replenishment developed to examine health, disability, and health care utilization among older adults. The study is nationally representative of community and institutional-dwelling Medicare beneficiaries in 1982, 1984, 1989, 1994, 1999, and 2004. Although the NLTCS ended in 2004 (such that more recent data are available), we chose to reexamine this data source because (a) it was among the most cited for disability trends in the 1980s and 1990s, (b) it includes data after 2000 during a period of observed disability trend reversal, (c) it provides ADL measures for both community and institutional-dwelling older adults, and (d) the panel design allows for the longitudinal examination of disablement.

Cohort replenishment (ages 65-69) at each wave allowed the NLTCS to maintain representativeness but also allowed us to examine multiple cohorts at the same ages. For our analysis, we examined four 5-year birth cohorts entering later life between the mid 80s and late 90s, each measured for up to three waves (a 10-year span). The cohorts represented are those born in 1915-1919, 1920-1924, 1925-1929, and 1930-1934. The first three cohorts

were observed for three waves, and the 1930-1934 cohort was observed for two (they aged into the survey in 1999 and the NLTCs ended in 2004). Although this cohort was not followed for the same amount of time, we chose to include it because the late 1990s was a period especially associated with ADL declines (Freedman et al., 2004). Although our analysis is focused on a relatively narrow range of birth cohorts, previous research found significant changes in disability and mortality among these cohorts specifically (Lin et al., 2012; Taylor & Lynch, 2011; Yang, 2008).

Appendix A presents the sample size for each time point by cohort and by race. Of the 22,718 Whites and Blacks originally sampled (aged 65-69) in each of these four cohorts, 21,466 cases comprised the analytic sample; 5.5% were missing. Most of the missingness (~4%) was due to individuals missing on the disability measure over the observation window. A small number of cases ($n = 325$; 1.4%) were missing on the chronic condition measures because the linkage with Medicare files was incomplete. These cases were dropped. The final sample sizes were 19,991 White and 1,555 Black older adults.

Measures

Disability—The most widely used measures of disability include ADLs and IADLs (Katz et al., 1963; Lawton & Brody, 1969). We chose to focus on ADLs, because previous findings were considerably more inconsistent for ADLs during this time period (Freedman et al., 2004), and ADLs represent more severe and, therefore, more burdensome levels of disability (Johnson & Wiener, 2006). The NLTCs ADL measures asked whether the respondent required help (from a person or special equipment) for six activities: eating, getting in and out of bed, walking around inside, dressing, bathing, and getting to the bathroom or using the toilet without help. Each item was coded 0 if the respondent did not need help and 1 if he or she did. The six items were then summed to create an index (ranging from 0 to 6). Increases and decreases (i.e., recovery) in ADL-level disability were captured longitudinally as increases or decreases in the index values over time.

Chronic conditions and mortality—Although the NLTCs included measures of chronic disease, they were only asked of the disabled in most waves. However, the NLTCs boasts 100% linkage to Medicare files (1982-2004). Medicare records were drawn from inpatient and outpatient procedures, hospice, home health agencies, skilled nursing facilities, and physicians for each year the respondent contributed to these analyses. Diagnosis codes from Medicare records capture diseases diagnosed in a given year, along with previous diagnoses justifying treatment or procedures undertaken in that year (diseases could have existed previously). We used diagnosis codes (ICD-9; World Health Organization, 1977) in the Medicare files to create annual measures (by calendar year from 1982 to 2004) of nine chronic conditions: arthritis/rheumatism, diabetes, hearing conditions, heart attack, hip fracture, hypertension, respiratory conditions, stroke, and vision conditions. The International Classification of Diseases (ICD-9) code brackets are included in Appendix B. If individuals had diagnosis codes falling within these brackets in a given calendar year, we coded the presence of the condition with 1 (0 otherwise). Because our interest is in condition profiles corresponding to disability experiences over the observation window rather than predicting disability in any given year, and because we cannot know exactly when diseases

were first diagnosed, we use the time-varying measures of each disease in each year to create nine time-invariant measures for each respondent. This approach is consistent with other research using the NLTCs Medicare linked files (e.g., Taylor & Lynch, 2011). If the respondent had any report of each disease during their individual observation window (the 10 years observed for the three older cohorts and 5 years for the 1930-34 cohort), we coded them with 1 (0 otherwise). Although including a time-varying measure of disease would be preferable in predicting disability trajectories, we were not able to include large numbers of covariates in these models because they would not converge to a unique solution. Furthermore, we would argue that previous research suggests morbidity is a process occurring over time that culminates in disease diagnosis, disability, and ultimately death (Crimmins, Kim, & Vasunilashorn, 2010). Therefore, capturing diagnosis in any given year is a proxy for the underlying disease processes occurring within individuals over time.

Mortality was taken from the Vital Statistics files linked to the NLTCs and was coded as a binary variable indicating whether the individual died (starting at ages 65-69) during the observation window. Notably, the 1930-1934 cohort was observed for only two waves (rather than three for other cohorts); therefore, mortality results for this group should be interpreted with caution. Although this binary indicator is a crude measure of mortality and does not capture individuals after the observation window, our modeling strategy did not allow a time-varying distal outcome. Previous studies incorporating mortality into health trajectory analysis often use a similar, time-invariant measure capturing mortality over the observation window (Taylor & Lynch, 2011; Warner & Brown, 2011; Yang & Lee, 2009).

Race and demographic covariates—To establish patterns of disability and cohort variation, along with chronic disease associations among Black and White older adults, all models were estimated separately by race. We use this approach, consistent with other literature on racial differences in trends (Clark, 1997; Manton & Gu, 2001), as the dynamics of disability trends over time are shown to vary by race (which may not be well captured in a pooled model with race as a covariate). Furthermore, the literature suggests that chronic conditions and mortality differentials across race may play important roles in disability trends, providing additional support for separate analyses. We establish the significance of differential covariate effects *across* race using coefficient difference tests (Clogg, Petkova, & Haritou, 1995), which we discuss in the text. Dichotomous cohort indicators (1920-1924, 1925-1929, 1930-1934; 1915-1919 = reference) were used to examine cohort differences. Age (continuous 65-69) and sex (female = 1) were included in all analyses.

Analytic Strategy

We modeled disability trajectories for each individual for up to three waves (10 years). Although this approach means a relatively narrow range of cohorts can be examined compared with other longitudinal age-period-cohort techniques (Lynch, 2003), it allows cohorts to be examined at similar ages rather than extrapolating cohort effects to ages outside the observation window.

Most demographic research on disability treats it as binary (i.e., presence vs. absence). Although this strategy can be useful for understanding changing disability prevalence, it

does not allow us to understand change in the severity of disability. Furthermore, examining cohorts longitudinally can be especially powerful in understanding observed trends (Lynch, 2003). Along with individual trajectory methods such as growth curves or random effects models, recent research increasingly utilizes group trajectory approaches as a way to identify multiple common longitudinal patterns of disablement severity (Gill, Gahbauer, Lin, Han, & Allore, 2013; Liang et al., 2010; Taylor & Lynch, 2011; Zimmer, Martin, Nagin, & Jones, 2012).

In this study, we used nonparametric latent class analysis (LCA; Lazarsfeld & Henry, 1968). Nonparametric LCA assumes that time-specific measures follow a particular distribution (i.e., normal), that the parameters of the distribution (i.e., μ and variance) vary by latent class, and that, conditional on membership in a class, individuals' measures are independent across time (Lynch & Taylor, 2016). Thus, the likelihood function can be written as follows:

$$\prod_{i=1}^n \prod_{t=1}^{T_i} \sum_{k=1}^K f(y_{it}|c_k, \theta_k) f(c_k),$$

Where $f(y_{it}|c_k, \theta_k)$ is the probability density function for the i^{th} individual's value of y at time t , conditional on membership in class c_k (with its associated parameter vector θ_k); T_i are the number of occasions individual i is observed; and $f(c_k)$ is the discrete probability a member of the population belongs to class k (of the K total classes). Given the independence of observed data across time, the θ_k do not imply a parametric pattern in y over time, only that members of different classes have different patterns (for example, see Collins & Lanza, 2010).

The best model (the number and shape of trajectories) is chosen through an examination of overall and component fit statistics (including Bayesian information criterion [BIC] and Akaike information criterion [AIC]), amount of classification error (e.g., entropy), and residuals, along with consistency with existing theory. Generally, models with lower BIC and AIC values provide a better fit to the data, allowing model parsimony to be rewarded. Entropy statistics closer to one convey models with well-separated classes. The percentages of individuals in each latent class, etc. are also evaluated for substantive uniqueness, given that classes may be sensitive to non-normally distributed outcomes.

The specification of the model with unique T_i indicates individuals may not be observed on all occasions, including those who die or drop out. Missingness on outcome variables was handled in the analyses using a full information maximum likelihood (FIML) estimator, which computes the likelihood function using all available information for each individual. We also incorporated mortality into our analysis by treating it as a distal outcome both of the disability trajectories and covariates. The inclusion of mortality as a distal outcome allowed us to examine whether younger cohorts of Whites and Blacks were significantly less likely to die over time. All LCA analyses were performed using Mplus 4 software (Muthén & Muthén, 2004).

Our modeling steps proceeded as follows. First, five models, with one to five latent classes, were estimated for each racial group without covariates to determine the best fitting models (and thus, the number and shape of the trajectories) for Black and White older adults. Second, cohort was introduced as a predictor variable in each racial group (controlling for age and gender) in the best fitting latent class model to replicate the finding from previous studies that show decreases in disability across cohorts. Finally, we included chronic condition predictors in the LCA models to establish disease profiles for long-term disability trajectory experiences. A graphic representation (path diagram) of the final models can be found in Appendix C to show the estimated relationships between variables.

One noted problem of studying racial differences among older adults is small relative sample sizes for racial/ethnic minority groups, where significance tests may be underpowered. In addition, in our analyses, which are conducted separately by race, a sample of size of roughly 1,555 (Blacks) is relatively small for the complexity of the LCA models we are estimating. We address differences in statistical power by race through sensitivity analyses in which we simulated a larger Black subsample (a “bootstrapped” sample) to obtain a sample size equal to that of the Whites. We used this simulated sample to evaluate whether significant differences would exist between Blacks and Whites (and for cohort and condition effects within race) if our Black subsample was comparable in size with the White subsample. All tables and figures presented reflect only the original NLTCs sample, but we discuss the additional findings in the text when they vary from the presented models (which may be underpowered).

Results

Table 1 presents descriptive statistics for Whites, Blacks, and the total sample, including statistical tests evaluating racial differences in covariates and outcomes. Clear racial differences exist in chronic disease levels, disability levels, and mortality. Whites had significantly higher diagnosis rates of arthritis, sensory (hearing and vision) and respiratory problems, and hip fracture than Blacks. Blacks had higher rates of diabetes and hypertension. There were no significant racial differences in heart attacks, respiratory diseases, or stroke. At each time point, mean ADL levels were significantly higher for Blacks, and there was a substantial difference in mortality with 24% of Whites and 34% of Blacks dying during the observation window.

The mean ADL levels across time for the best fitting observed classes of disability trajectories and simultaneously estimated mortality probabilities for each trajectory are presented separately for Whites (Figure 1) and Blacks (Figure 2). In latent class analysis, the numbers of latent classes are generally determined by selecting the model with the lowest BIC value, but it is often reasonable to err on the side of parsimony and unique class experiences/profiles (Collins & Lanza, 2010; Nagin & Tremblay, 2005). Examination of BIC and other statistics suggested a five-class model revealed the best fit for both races, but we selected the three-class model for both Whites and Blacks because models with more than three classes produced classes that were extremely small (less than 1% of the sample) and had trajectories that were approximately identical, substantively, to those found in the three-class model. Overall model fit statistics can be found in Appendix D.

Based on the three-class model, Blacks and Whites had generally similar trajectories of low (with a slight increase over age), moderate, and high (with decrease at the older ages) ADL disability trajectories. Although the mean level of ADLs within each class was roughly similar across races, the percentage experiencing trajectories with moderate or high ADL disability was more than doubled (10%) among Blacks compared with Whites (4%). For both groups, mortality was highest for those with high and moderate trajectories. Blacks and Whites had similar levels of mortality for members of the high-disability class, but Blacks had substantially higher probabilities of death among the low disability class (36% vs. 23%).

Because there was a notable amount of functional improvement visible in the high-ADL trajectories in Figures 1a and 2a, we further examined individual experiences in each class to determine how much decrease in ADLs occurred. Although findings revealed that reductions in ADL impairment over time among those with high-impairment trajectories were common (35% of White and 29% of Black individuals experienced declines in disability), they were also common among persons with moderate-impairment trajectories (34% White, 39% Black). ADL declines were rare among persons with low-impairment trajectories (1% White, 2% Black).

Table 2 presents results evaluating cohort differences in disability. For Whites, persons in the younger cohorts were substantially less likely than those in the oldest cohort to be in both the high-impairment and moderate-impairment classes versus the low-impairment class (odds ratios [ORs] range from .61 to .75). The one exception is that the 1925-1929 cohort did not differ in the odds of being moderately impaired. Overall, findings suggest that ADL declines among older Whites late in the 20th century were generally consistent across severity of disability (both high and moderate) and across the cohorts we observe (such that 1920-1924, 1925-1929, and 1930-1934 cohort were all less likely to experience high and moderate trajectories than their counterparts in the 1915-1919 cohort). The risk of mortality was also significantly smaller for younger cohorts, suggesting that younger cohorts of Whites experienced gains in both quality and quantity of life.

In contrast to the results for Whites, the results for Blacks showed no statistically significant cohort changes in the proportion of the subpopulation assigned to each disability class, and some ORs were substantially greater than 1. In sensitivity analyses using the simulated sample, we found that increased likelihood of high and moderate impairment classes among the 1925-1929 cohort became significant or marginally significant (ORs = 1.10 and 1.33), and lower likelihood of moderate disability trajectories became significant for the 1930-1934 cohort (OR = 0.64). Cohort differences in mortality were also nonsignificant in the regular sample, with the exception of the 1930-1934 cohort (where the observation window was only 5 years). Some reductions in mortality became significant in the simulated sample. Coefficient difference tests (Clogg et al., 1995) reveal significant differences in cohort effects for Whites and Blacks for both high and moderate impairment classes, but not in mortality.

Table 3 presents results of associations between chronic conditions and both disability class membership and mortality. Among Whites, experiencing sensory conditions (hearing and vision) and hypertension was associated with decreased likelihood of high and moderate

disability and mortality throughout the decade net of other conditions. Having had a heart attack was not associated with disability but increased mortality odds by 29%. Hip fracture and stroke were associated with both moderate- and high-impairment classes but were not associated with mortality. Diabetes was associated with high and moderate disability and increased mortality odds (21%). Respiratory disorders were associated with moderate disability trajectories and increased risk of mortality (OR = 1.44). Arthritis was not associated with disability classes once other conditions were included. Once chronic conditions were included, cohort effects for disability classes (ORs) were reduced by 9% to 33% and became nonsignificant. Furthermore, the reduced risk of mortality among younger cohorts (Table 2) reversed direction except for the 1930-1934 cohort, suggesting chronic diseases are associated with much of the improvement in disability and 10-year mortality among younger cohorts of Whites.

Among Blacks, vision problems were associated with lower likelihood of the high disability class and mortality. Similar to Whites, hypertension and arthritis were generally associated with lower likelihood of high and moderate disability and mortality. Having a heart attack was associated with high and moderate disability and increased mortality risk in the simulated sample. These findings suggest that heart attacks were more severe for Blacks compared with Whites, net of other conditions. Stroke was especially associated with disability among Blacks, multiplying the odds of being in the high-disability class by more than 4 times and being in the moderate class by more than 2 times. Consistent with Whites, stroke was not significantly associated with mortality. Diabetes was associated with high and moderate disability, becoming significant in the simulated sample, but it was not associated with mortality. Respiratory disease was not significant for Blacks for disability or mortality net of other diseases. Once chronic conditions were included in the models, the magnitudes of the ORs for cohort effects increased and remained significant in the simulated sample, suggesting younger cohorts of Blacks (with the exception of the 1930-1932 cohort) experienced greater long-term disablement at the same level of chronic disease compared with older cohorts.

Results of coefficient difference tests for the final model revealed significant differences in chronic disease effects across race. Sensory conditions (vision and hearing problems) were more strongly associated with disability and mortality among Whites. Heart attack and stroke were more strongly associated with high disability trajectories for Blacks. Hip fracture was significantly associated with greater mortality for Blacks, although this effect was not significant in Table 3. Diabetes predicted moderate disability trajectories more among Blacks but mortality more among Whites. Respiratory diseases showed increased risk among Whites, associated with both moderate disability trajectories and mortality.

Discussion and Conclusion

Our first two research questions addressed whether declines in ADL-level disability were visible longitudinally in different cohorts between 1984 and 2004 for White and Black older adults. Although previous findings of period trends in ADLs between 1980 and 2000 are mixed, with a roughly stable pattern emerging collectively over the two decades (Freedman et al., 2004; Manton & Gu, 2001), our findings for White older adults are consistent with Lin

and colleagues (2012) in showing declining disability among younger cohorts over this time period. Specifically, younger cohorts of White older adults saw consistently lower ADL impairment, in both high- and moderate-disability classes, along with corresponding decreases in mortality. We also examined these patterns among Black older adults. In contrast to Whites, younger cohorts of Blacks saw no consistent declines, with limited evidence for increased disability in some cohorts. Only the 1930-1934 birth cohort (ages 65-69 in 1999) showed limited evidence of decline in moderate disability. These findings are generally consistent with the diverging period trends reported by Manton and Gu (2001) among Blacks in the NLTCs during the 1980s and 1990s.

Our third research question addressed how chronic conditions predict disability trajectories, and how they do so differentially across race. We replicated previous findings on sensory impairments (hearing and vision) and hypertension, which are implicated in downward disability trends (Freedman et al., 2007). These conditions were associated with membership in low-impairment classes, and more so for Whites than Blacks. In examining race differences in disease effects, we find that heart attack, stroke, and diabetes were more strongly associated with higher disability among Blacks, while respiratory disease was more strongly associated for Whites. These findings suggest that among Black older adults, prevalent chronic diseases are generally associated with greater ADL-level impairment longitudinally compared with Whites. Furthermore, these findings, taken with the disparities in cohort effects, suggest that the magnitude of racial disparities in disease also did not consistently decrease among younger cohorts. It is worth noting that these diseases (heart attack, stroke, and diabetes) are also those closely linked with obesity, a factor implicated in findings showing recent upward trends in disability (Seeman et al., 2010). Therefore, it is possible that racial disparities in the impact of these diseases may have increased among cohorts entering older adulthood in the mid to late 2000s.

These findings further understanding of previous inconsistencies, but also raise questions about why diverging ADL cohort trends occurred across races. As noted, ADLs are a measure of more severe impairment, but disability is a social construct and personal care needs are influenced by personal and environmental resources. As Freedman and others (2004) noted, decreases in difficulty with bathing could reflect younger cohorts that are more physically able or simply an increase in walk-in showers enabling them to bathe independently. Therefore, although we find no consistent improvements among Black older adults, and link these to particularly disabling conditions, it is possible that White older adults were simply more advantaged in terms of resources needed to carry out these tasks independently.

Although we believe these findings contribute to a long, debated, and evolving literature on disability trends, race disparities, and chronic disease, our study has several limitations worth noting here. First, the NLTCs is appropriate for our study, but the long time period between follow-ups (5 years) does not make it useful for studying short-term disability dynamics, including recovery. Data sources using monthly measures (see Gill et al., 2013, for example) are better suited to capturing these effects. Our disability measure included only ADL-level disability, and although our findings replicate previous research showing three classes of ADL disability (Zimmer et al., 2012), it is likely that a measure capturing

lower levels of impairment would yield differences in the number of trajectories/classes and thus be more discriminating in capturing the breadth of disparities (e.g., Liang et al., 2010; Taylor & Lynch, 2011). Although we believe the inclusion of mortality in our models is a notable strength of the analysis, we were only able to include it as a time-invariant variable. We also were not able to estimate time-varying measures of disease and suggest this as a direction for future research. Finally, all of our analyses were unweighted because the sample weights and strata differ by survey year, and because we combined cohorts from multiple years in our analysis. Although cohorts were similar on demographic characteristics, it is impossible to derive nationally representative trends from these analyses.

Despite these limitations, we believe these findings have important implications for understanding previous estimates and future projections of disability trends. First, they suggest that stalling or reversing period trends in disability among young-old cohorts of Whites may not reflect changing disability in younger cohorts, suggesting functional gains may continue longitudinally in this racial group across a spectrum of ADL disability. The lack of consistent ADL declines in younger cohorts of Black older adults may also help to explain the observed disability increases since 2000 disproportionately experienced by race/ethnic minorities (Seeman et al., 2010). Furthermore, our limited support for the finding that increases in long-term disablement in younger cohorts of Black older adults occurred suggests observed increases in Black ADL-level disability occurred earlier than the 2000s (specifically the 1980s). Together, findings suggest that policies and interventions aimed at minority older adults will be increasingly important in the decades to come.

Specifically, findings suggest that increased accessibility to medications and treatments for heart attack, stroke, and diabetes among older African Americans may reduce the severity of disablement associated with these conditions. Furthermore, and noted above, access to assistive devices and changes to living environments may substantially influence ADL-level disablement, such that increased access or interventions aimed at revising living situations for older minorities may be especially salient. Future research should further examine which ADL items drive race differences in cohort and disease effects (Freedman et al., 2004) to target interventions and treatments toward specific personal care needs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix A

Sample Sizes for 1915-1934 Cohorts Over Time in the Analytic Sample.

	1915-1919 cohort	1920-1924 cohort	1925-1929 cohort	1930-1934 cohort
White, $n = 19,991$				
Age 65-69 in	1984	1989	1994	1999
Time 1	7,018	4,250	3,364	4,201
Time 2	2,855	1,864	1,635	1,996
Time 3	2,098	1,414	1,163	N/A
Black, $n = 1,555$				
Age 65-69 in	1984	1989	1994	1999
Time 1	500	312	275	370
Time 2	210	139	121	171
Time 3	152	93	74	N/A

Appendix B

Chronic Condition Codes.

Condition/event	International Classification of Diseases (ICD) Codes
Arthritis (general, based on National Arthritis Data Workgroup [NADW])	95.6, 95.7, 98.5, 99.3, 136.1, 274.xx, 277.2, 287.0, 334.6, 353.0, 354.0, 355.5, 357.1, 390, 391, 437.4, 443.0, 446.xx, 447.6, 696.0, 710.xx, 716.xx, 719.0, 719.2-719.9, 720.xx, 721.xx, 725.xx-727.xx, 728.0-728.3, 728.6 728.9, 729.0-729.1, and 729.4728.9, 729.0-729.1, and 729.4
Diabetes	250.0-250.9
Hearing problems	389.xx
Heart attack	410.xx
Hip fracture	820.xx
Hypertension	401.xx-403.xx
Chronic respiratory diseases	490.xx-496.xx
Stroke	433.xx, 434.xx, 436.xx
Vision problems	365.xx, 366.xx, 369.9

Appendix C

Path Diagram of Estimated Latent Class Models With Mortality Outcome.

Note. ADL = activities of daily living.

Appendix D

Overall Fit Statistics for LCA Model Choice.

Model	Log likelihood	Number of parameters	BIC	AIC	Entropy
White, <i>n</i> = 19,911					
1-Cluster	-53,389.506	7	10,6848.306	10,6793.01	—
2-Cluster	-37,817.91	12	75,754.609	75,659.821	0.987
3-Cluster	-29,045.629	17	58,259.541	58,125.258	0.988
4-Cluster	-21,441.035	22	43,099.849	42,926.071	0.986
5-Cluster	-14,819.807	27	29,906.887	29,693.613	0.987
Black, <i>n</i> = 1,555					
1-Cluster	-5,018.515	7	10,088.475	10,051.03	—
2-Cluster	-3,938.692	12	7,965.575	7901.384	0.972
3-Cluster	-3,240.31	17	6,605.557	6514.62	0.974
4-Cluster	-2,818.475	22	5,798.633	5,680.95	0.973
5-Cluster	-2,430.88	27	5,060.189	4,915.76	0.975

Note. LCA = latent class analysis; BIC = Bayesian information criterion; AIC = Akaike information criterion.

References

- Clark DO. US trends in disability and institutionalization among older blacks and whites. *American Journal of Public Health*. 1997; 87:438–440. DOI: 10.2105/AJPH.87.3.438 [PubMed: 9096549]
- Clogg CC, Petkova E, Haritou A. Statistical methods for comparing regression coefficients between models. *American Journal of Sociology*. 1995; 100:1261–1293. DOI: 10.1086/230638
- Collins, LM., Lanza, ST. Latent class and latent transition analysis: With applications in the social, behavioral, and health sciences. Hoboken, NJ: John Wiley; 2010.
- Crimmins E, Kim JK, Vasunilashorn S. Biodemography: New approaches to understanding trends and differences in population health and mortality. *Demography*. 2010; 47:S41–S64. DOI: 10.1353/dem.2010.0005 [PubMed: 21302421]
- Crimmins EM, Saito Y. Change in the Prevalence of diseases among older Americans: 1984–1994. *Demographic Research*. 2000; 3(9)doi: 10.4054/DemRes.2000.3.9
- Freedman VA, Martin LG, Schoeni RF. Recent trends in disability and functioning among older adults in the United States: A systematic review. *The Journal of the American Medical Association*. 2002; 288:3137–3146. DOI: 10.1001/jama.288.24.3137 [PubMed: 12495394]
- Freedman VA, Martin LG, Shinberg D, Waidmann T, Crimmins E, Schoeni RF, et al. Manton K. Resolving inconsistencies in trends in old-age disability: Report from a technical working group. *Demography*. 2004; 41:417–441. DOI: 10.1353/dem.2004.0022 [PubMed: 15461008]
- Freedman VA, Schoeni RF, Martin LG, Cornman JC. Chronic conditions and the decline in late-life disability. *Demography*. 2007; 44:459–477. DOI: 10.1353/dem.2007.0026 [PubMed: 17913006]
- Freedman VA, Schoeni RF, Seeman TE, Waidmann TA, Spillman BC, Andreski PM, et al. Merkin SS. Trends in late-life activity limitations in the United States: An update from five national surveys. *Demography*. 2013; 50:661–671. DOI: 10.1007/s13524-012-0167-z [PubMed: 23104207]
- Geronimus AT, Bound J, Waidmann TA, Colen CG, Steffick D. Inequality in life expectancy, functional status, and active life expectancy across selected black and white populations in the united states. *Demography*. 2001; 38:227–251. DOI: 10.1353/dem.2001.0015 [PubMed: 11392910]
- Gill TM, Gahbauer EA, Lin H, Han L, Allore HG. Comparisons between older men and women in the trajectory and burden of disability over the course of nearly 14 years. *Journal of the American Medical Directors Association*. 2013; 14:280–286. DOI: 10.1016/j.jamda.2012.11.011 [PubMed: 23294968]
- Hayward MD, Heron M. Racial inequality in active life among adult Americans. *Demography*. 1999; 36:77–91. DOI: 10.2307/2648135 [PubMed: 10036594]
- Johnson, R., Wiener, J. Profile of frail older Americans and their caregivers. Washington, DC: The Urban Institute; 2006. The Retirement Project, Occasional Paper Number 8 Retrieved from http://www.urban.org/UploadedPDF/311284_older_americans.pdf
- Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged: The index of ADL: A standardized measure of biological and psychosocial function. *The Journal of the American Medical Association*. 1963; 185:914–919. DOI: 10.1001/jama.1963.03060120024016 [PubMed: 14044222]
- Lawton MP, Brody EM. Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*. 1969; 9:179–186. doi:org/10.1093/geront/9.3_Part_1.179. [PubMed: 5349366]
- Lazarsfeld, PF., Henry, NW. Latent structure analysis. New York, NY: Houghton Mifflin; 1968.
- Liang J, Xu X, Bennett JM, Ye W, Quiñones AR. Ethnicity and changing functional health in middle and late life: A person-centered approach. *The Journals of Gerontology, Series B: Psychological Sciences & Social Sciences*. 2010; 65:470–481. DOI: 10.1093/geronb/gbp114
- Lin SF, Beck AN, Finch BK, Hummer RA, Master RK. Trends in US older adult disability: Exploring age, period, and cohort effects. *American Journal of Public Health*. 2012; 102:2157–2163. DOI: 10.2105/ajph.2011.300602 [PubMed: 22994192]
- Lynch SM. Cohort and life-course patterns in the relationship between education and health: A hierarchical approach. *Demography*. 2003; 40:309–331. DOI: 10.1353/dem.2003.0016 [PubMed: 12846134]

- Lynch, SM., Taylor, MG. Trajectory models for aging research. In: George, Linda K., Ferraro, Kenneth F., editors. Handbook of aging and the social sciences. San Diego, CA: Academic Press; 2016. p. 23-51.
- Manton KG, Gu X. Changes in the prevalence of chronic disability in the United States black and nonblack population above age 65 from 1982 to 1999. Proceedings of the National Academy of Sciences of the United States of America. 2001; 98:6354–6359. DOI: 10.1073/pnas.111152298 [PubMed: 11344275]
- Martin LG, Freedman VA, Schoeni RF, Andreski PM. Trends in disability and related chronic conditions among people ages fifty to sixty-four. Health Affairs. 2010; 29:725–731. DOI: 10.1377/hlthaff.2008.0746 [PubMed: 20368601]
- Muthén, L., Muthén, B. Mplus user's guide. 3rd. Los Angeles, CA: Author; 2004.
- Nagin DS, Tremblay R. Developmental trajectory groups: Fact or a useful statistical fiction? Criminology. 2005; 43:873–904. DOI: 10.1111/j.1745-9125.2005.00026.x
- Schoeni RF, Freedman VA, Martin LG. Why is late-life disability declining? Milbank Quarterly. 2008; 86:47–89. DOI: 10.1111/j.1468-0009.2007.00513.x [PubMed: 18307477]
- Schoeni RF, Freedman VA, Wallace RB. Persistent, consistent, widespread, and robust? another look at recent trends in old-age disability. The Journals of Gerontology, Series B: Psychological Sciences & Social Sciences. 2001; 56:S206–S218. DOI: 10.1093/geronb/56.4.S206
- Seeman TE, Merkin SS, Crimmins EM, Karlamangla AS. Disability trends among older Americans: National health and nutrition examination surveys, 1988-1994 and 1999-2004. American Journal of Public Health. 2010; 100:100–107. DOI: 10.2105/AJPH.2008.157388 [PubMed: 19910350]
- Taylor MG, Lynch SM. Cohort differences and chronic disease profiles of differential disability trajectories. The Journals of Gerontology, Series B, Psychological Sciences & Social Sciences. 2011; 66:729–738. DOI: 10.1093/geronb/gbr104
- Warner DF, Brown TH. Understanding how race/ethnicity and gender define age-trajectories of disability: An intersectionality approach. Social Science & Medicine. 2011; 72:1236–1248. DOI: 10.1016/j.socscimed.2011.02.034 [PubMed: 21470737]
- World Health Organization. Manual of the 34 international classification of diseases, injuries, and causes of death, based on the recommendations of the ninth revision conference, 1975, and adopted by the twenty-ninth world health assembly. Geneva, Switzerland: Author; 1977.
- Yang Y. Trends in U.S. adult chronic disease mortality, 1960-1999: Age, period, and cohort variations. Demography. 2008; 45:387–416. DOI: 10.1353/dem.0.0000 [PubMed: 18613487]
- Yang Y, Lee LC. Sex and race disparities in health: Cohort variations in life course patterns. Social Forces. 2009; 87:2093–2124. DOI: 10.1353/sof.0.0183
- Zimmer Z, Martin LG, Nagin DS, Jones BL. Modeling disability trajectories and mortality of the oldest-old in china. Demography. 2012; 49:291–314. DOI: 10.1007/s13524-011-0075-7 [PubMed: 22246796]

Figure 1.
Three classes of estimated ADL-level disability trajectories and 10-year mortality probabilities for corresponding disability trajectories, White.
Note. ADL = activities of daily living.

Figure 2.
Three classes of estimated ADL-level disability trajectories and 10-year mortality probabilities for corresponding disability trajectories, Black.
Note. ADL = activities of daily living.

Table 1

Descriptive Statistics for White and Black Older Adults Aged 65 to 69 in 1984, 1989, 1994, and 1999 (1915-1919, 1920-1924, 1925-1929, and 1930-1934 Birth Cohorts).

Covariates	White	Black	Total	Diff. test ^{a,b,c}
<i>N</i>	19,911	1,555	21,466	
Age	66.95 (1.34)	67.01 (1.35)	66.96 (1.34)	NS ^a
Female (%)	55.22	55.69	55.25	NS ^b
1915-1919 Cohort (%)	36.98	34.92	36.83	NS ^b
1920-1924 Cohort (%)	22.12	20.58	22.01	NS ^b
1925-1929 Cohort (%)	18.17	19.68	18.28	NS ^b
1930-1934 Cohort (%)	22.73	24.82	22.88	NS ^b
Arthritis (%)	72.32	66.05	71.87	*** ^b
Diabetes (%)	37.41	54.47	38.64	*** ^b
Hearing problems (%)	18.38	10.29	17.80	*** ^b
Heart attack (%)	29.23	29.58	29.26	NS
Hip fracture (%)	8.86	4.57	8.55	*** ^b
Hypertension (%)	76.64	83.67	77.15	*** ^b
Respiratory (%)	53.12	50.29	52.92	* ^b
Stroke (%)	35.16	35.82	35.21	NS ^b
Vision problems (%)	66.04	56.85	65.37	*** ^b
ADLs Wave 1	0.17 (0.79)	0.38 (1.17)	0.18 (0.82)	*** ^{a,c}
ADLs Wave 2	0.33 (1.07)	0.62 (1.43)	.36(1.10)	*** ^{a,c}
ADLs Wave 3	0.47 (1.25)	0.77 (1.51)	0.49 (1.27)	*** ^{a,c}
Mortality (%)	24.45	33.89	25.14	*** ^b

Note. ADL = activities of daily living; MANOVA = multivariate analysis of variance.

^a Difference tests are *t* tests.

^b Difference tests are chi-square tests.

^c Difference tests are MANOVAs.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

Table 2

Cohort Differences in Classes of Disability Trajectories and Mortality (Odds Ratios): White and Black.

Classes	High ^a	Moderate ^a	Mortality ^b
White <i>N</i> = 19,991			
Sample %	1.99	2.09	—
Covariates			
Age	1.12 **	1.21 ***	1.16 ***
Female	1.19	1.44 ***	0.53 ***
1920-24 cohort	0.72 *	0.71 *	0.86 ***
1925-29 cohort	0.61 **	0.79	0.86 ***
1930-34 cohort	0.75 *	0.66 **	0.27 ***
Log likelihood (number of parameters)	-28460.56 (32)		
BIC	57,237.88		
Entropy	0.99		
Black <i>n</i> = 1,555			
Sample %	4.75	5.23	—
Covariates			
Age	1.02	1.05	1.12 **
Female	1.35	1.01	0.64 ***
1920-24 cohort	0.93	1.02	0.85
1925-29 cohort	1.10	1.33	0.88
1930-34 cohort	0.93	0.64	0.25 ***
Log likelihood (number of parameters)	-3182.064 (32)		
BIC	6,599.30		
Entropy	0.97		

Note. BIC = Bayesian information criterion.

^aReferent group is low disablement.

^bReferent group is those surviving the observation window.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Chronic Disease Effects in Classes of Disability Trajectories and Mortality (Odds Ratios): White and Black.

Classes	High ^a	Moderate ^a	Mortality ^b
White <i>n</i> = 19,991			
Sample %	1.99%	2.09%	—
Covariates			
Age	1.11 **	1.20 ***	1.21 ***
Female	1.34 **	1.60 ***	0.71 ***
1920-1924 cohort	0.85	0.78	1.14 **
1925-1929 cohort	0.82	0.97	1.34 ***
1930-1934 cohort	0.95	0.88	0.28 ***
Arthritis	0.79	0.84	0.35 ***
Diabetes	1.91 ***	1.70 ***	1.20 ***
Hearing problems	0.27 ***	0.66 **	0.37 ***
Heart disease	0.81	1.10	1.29 ***
Hip fracture	1.98 ***	1.67 ***	0.96
Hypertension	0.69 **	0.69 **	0.51 ***
Respiratory	1.03	1.72 ***	1.44 ***
Stroke	1.90 ***	1.66 ***	1.00
Eye problems	0.35 ***	0.51 ***	0.25 ***
Log likelihood (number of parameters)	-26,297.01 (59)		
BIC	53,178.05		
Entropy	0.99		
Black <i>n</i> = 1,555			
Sample %	4.69	5.19	—
Covariates			
Age	1.00	1.04	1.12 *
Female	1.64	1.05	0.89
1920-1924 cohort	1.00	1.04	1.11
1925-1929 cohort	1.54	1.53	1.47 *
1930-1934 cohort	1.32	0.76	0.27 ***
Arthritis	0.47 *	1.16	0.38 ***
Diabetes	2.23 **	1.59	1.09
Hearing problems	0.61	1.13	0.82
Heart disease	1.50	1.27	1.52 **
Hip fracture	0.90	1.14	1.32
Hypertension	0.50	0.37 *	0.50 ***
Respiratory	1.47	0.81	1.01

Classes	High ^a	Moderate ^a	Mortality ^b
Stroke	4.25 ***	2.42 ***	0.91
Eye problems	0.49 ***	0.85	0.33 ***
Log likelihood (number of parameters)		-3,022.010 (59)	
BIC	6,477.63		
Entropy	0.98		

Note. BIC = Bayesian information criterion.

^aReferent group is low disablement.

^bReferent group is those surviving the observation window.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.