Black–White Disparity in Disability Among U.S. Older Adults: Age, Period, and Cohort Trends

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Objectives. This study delineates activities of daily living (ADL) and instrumental activities of daily living (IADL) black–white disparity trends by age, period, and cohort (APC) and explores sociodemographic contributors of cohort-based disparity trends.

Method. We utilized multiple cross-sectional waves of National Health Interview Survey data (1982–2009) to describe APC trends of ADL and IADL disparities using a cross-classified random effect model. Further, we decomposed the cohort-based disparity trends using Fairlie's decomposition method for nonlinear outcomes.

Results. The crossover ADL and IADL disparities (whites > blacks) occurring at age 75 increased with age and reached a plateau at age of 80, whereas period-based ADL and IADL disparities remained constant for the past 3 decades. The cohort disparity trends for both disabilities showed a decline with each successive cohort except for ADL disparity among women.

Discussion. We examined the role of aging on racial disparity in disability and found support for the racial crossover effect. Further, the racial disparity in disability will disappear should the observed pattern of declining cohort-based ADL and IADL disparities persist. Although education, income, and marital status are important sociodemographic contributors to cohort disparity trends, future studies should investigate individual behavioral health determinants and cohort-specific characteristics that explain the cohort-based racial difference in ADL and IADL disabilities.

Key Words: Age-period-cohort model—Black–white disparity—Disability—Older adults.

SUBSTANTIAL epidemiological and sociological studies have consistently shown that U.S. non-Hispanic black (black, hereafter) older adults experienced a greater prevalence of disability compared with their non-Hispanic white (white, hereafter) counterparts (Fuller-Thomson, Nuru-Jeter, Minkler, & Guralnik, 2009; Kelley-Moore & Ferraro, 2004; Mendes de Leon, Barnes, Bienias, Skarupski, & Evans, 2005). Late-life disability trend studies generally center around two types of activity limitations: (a) activities of daily living (ADL) such as showering, toileting, and dressing and (b) instrumental activities of daily living (IADL) such as handling everyday finances, household chores, and grocery shopping. Despite evidence showing decline in older age disability over the last three decades (Cutler, 2001; Institutes of Medicine, 2007; Manton, Corder, & Stallard, 1993; Schoeni, Martin, Andreski, & Freedman, 2005), studies on trends of black–white disparity in disability are sparse and results are equivocal.

Freedman and Martin (1998) examined period (survey year-based) trends of three functional limitations: difficulty lifting, climbing, and walking by analyzing data from the Survey of Income and Program Participation between 1984 and 1993. The results showed larger declines of functional limitations for blacks than for whites or other races. Using the National Long Term Care Survey (NLTCS), Manton and Gu (2001) showed that black–white differences (black minus white) in the percentage of older adults who had 1–2 (from 2.4% to 3.1%), 3–4 (from 1.7% to 2.3%), or 5–6 ADL disabilities (from 2.9% to 3.5%) increased between 1982 and 1989; however, such differences narrowed between 1994 and 1999 (1 or 2 ADLs from 1.9% to 0.6%; 3 or 4 ADLs from 3.0% to 0.7%; and 5 or 6 ADLs from 2.3% to 2%). For IADL only disability, the percentage difference decreased in both periods: 1982–1989 (from 3.5% to 3.0%) and 1994–1999 (from 2.5% to 1.4%). Using the National Health Interview Survey (NHIS), Schoeni, Freedman, and Wallace (2001) found that the rate of any disability (ADL or IADL disability) declined for both blacks and whites between 1982 and 1996, but there was not a significant difference in the decline. In comparison to the paucity of period-based trends discussed above, many studies (Clark, 1997; Ferraro & Farmer, 1996b; Johnson, 2000; Kelley-Moore & Ferraro, 2004; Kim & Miech, 2009; Liao, McGee, Cao, & Cooper, 1999; Mendes de Leon et al., 1997, 2005) describe the life-course (age-based) pattern of late-life disabilities. These findings will be discussed below.

Several hypotheses exist to elucidate the role of aging and racial health disparities. First, the double jeopardy

hypothesis assumes that both aging and minority status contribute to "double disadvantages" of the health of a subpopulation (Ferraro & Farmer, 1996a; Jackson, 1971). Thus, increasing black–white disparity in disability with aging process would be observed according to this hypothesis. Although the widening of disparity in disability with increasing age was evident in some studies (Clark, 1997; Liao, et al., 1999), other studies (Johnson, 2000; Kim & Miech, 2009; Mendes de Leon et al., 1997) found support for the second hypothesis, age-as-leveler hypothesis. This hypothesis is contrary to the double jeopardy hypothesis and suggests that while inequality of health remains in old age, it is attenuated (House et al., 1994). Some researchers (Clark, 1996; Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993; Johnson, 2000) even suggest a crossover of disability (blacks have lower level of disability than whites) that occurs around the age of 80. Finally, a few studies (Clark & Maddox, 1992; Ferraro, 1987; Ferraro & Farmer, 1996a) that tested the double jeopardy hypothesis came to another conclusion, namely that older age neither attenuates nor exacerbates black–white differences in health. Results of some disability trend studies (Ferraro & Farmer, 1996b; Kelley-Moore & Ferraro, 2004; Mendes de Leon et al., 2005) confirmed this persistent inequality of disability status among blacks and whites across the life course.

Aside from the period-based and age-based disparity trend studies, there were very few studies that examined the disability prevalence on another critical temporal dimension—birth cohort. A recent study (Seeman, Merkin, Crimmins, & Karlamangla, 2010) has shown that U.S. older adults aged 60–69 years in the recent National Health and Nutrition Examination Survey (1999–2004) had significantly higher ADL limitation, IADL limitation, and impaired mobility than those aged 60–69 interviewed in the 1988–1994 survey. To our knowledge, to date, there is no study that focuses on the cohort-based trend of black–white disparity in disability; therefore, it is necessary to explicate these cohort trends as they have been shown in other health studies to be nontrivial contributors to temporal health trends (Reither, Hauser, & Yang, 2009; Yang, 2008). In addition, most of the period-based studies discussed earlier are outdated and concentrated only on a relatively short time span (10–15 years). Thus, we intend to explore how black–white disparity in disability changes across a larger time span between 1982 and 2009 using representatives of birth cohorts born between 1895 and 1940. To achieve this, we will use the age-period-cohort (APC) model to delineate black–white disparity trends of disability among adults aged 70 and older.

Age, Period, and Cohort

In the realm of demography, time can be captured by three unique temporal dimensions: APC. Age (A) is an indicator of the biological aging process which brings about internal physiological change due to an accumulation of exposure,

genetic manifestation of disease, and/or the natural breakdown of the human body (Yang, 2007). Given that aging is a proxy for accumulated exposure, stress, and disadvantaged social roles that stem from external sources shaped by the social–political and technological environments, it seems obvious that individual aging processes can have differential impacts on racial groups over time.

Moreover, the persistence of health disparities over time suggests that social forces are operating that replicate themselves as individuals die and others are born into a social system. Therefore, period effects (a temporal phenomenon that is associated with all age groups simultaneously) and cohort effects (shared societal experiences attributed to individuals within defined birth year groupings), that are external to an individual may also play vital roles in determining the dynamic health pattern over time. Period effects (P) reflect technological, environmental, economic, and sociocultural changes over time that affect the entire population simultaneously, but perhaps not equally. For example, a period characteristic such as a flooding that leads to an increase in food prices may impose greater impacts on those with lower incomes than the more well-off. Birth cohort (C), on the other hand, is defined as a set of individuals who were born in similar years and experience similar formative social experiences over their life course (Yang & Land, 2008). Although birth cohorts progress through life together and experience similar historical and social events, successive cohorts that experience different historical and social conditions differ in their exposure to socioeconomic, behavioral, and environmental risk factors.

As each temporal dimension (A-P-C) distinctively contributes to the study of population health—including disability, focusing only on one or two of the three dimensions would produce biased estimations of the racial health disparity trend (Mason, Mason, Winsborough, & Poole, 1973; Ryder, 1985; Yang & Land, 2008). As discussed earlier, the majority of racial disparity studies on disability revealed only changes in disparity based on age or a narrow range of survey years (period); therefore, the main focus of our study is to estimate the independent effect of age, a broader range of period, and birth cohort, while simultaneously controlling for each A-P-C dimension to delineate and partial out the ADL and IADL disparity trends along each temporal dimension.

Method

Study Population

Our study used data from the NHIS. We included adults aged 70 and older (71 for year 1982), who responded to the survey between 1982 and 2009. The age of 70/71 was chosen because this is the youngest common denominator for age for which the disability items were inquired between the 1982–2009 survey periods. The NHIS is a repeated

cross-sectional survey of the civilian, noninstitutionalized population in the United States that is administered annually by the National Center for Health Statistics (NCHS). Each NHIS survey allows for representative sampling of U.S. households by utilizing a multistage area probability design. The Minnesota Population Center (2012) created the Integrated Health Interview Series (IHIS), which harmonizes NHIS variables to allow consistent coding across each survey to facilitate temporal analysis. Thus, we retrieved all data from the IHIS website except for disability variables (ADL and IADL disabilities) that were unavailable between the 1982 and 1996 survey years. These data were directly retrieved from the NHIS website (National Center for Health Statistics [NCHS], 2012) and merged with our master IHIS data set. We excluded a small portion of respondents that belong to the 1885 (0.05%), 1890 (0.34%), and 1895 (1.4%) cohorts due to small sample sizes which may distort the estimates for these cohorts. The final sample consists of 187,599 respondents, of which 36.1% (*n* = 67,757) are white men, 4.3% (*n* = 8,012) are black men, 52.4% (*n* = 98,305) are white women, and 7.2% (*n* = 13,525) are black women. In addition, because proxy reporting by family members was allowed between 1982 and 1996 NHIS, we also performed sensitivity analyses that dropped respondents who self-responded partly, whose proxy responded, and whose responding status is unknown. Such disparity trends were then compared with our results (Figures 2 and 3) using all respondents. The trends between these two groups were very similar, thus, only the "all respondents" results were presented in this article. Results for the sensitivity analysis are available upon request.

Study Variables

Dependent variables.—We used two self-reported disability outcomes in this study: ADL and IADL disabilities. These variables were collected consistently from 1982 to 2009. Prior to 1997, respondents aged 70 and older (71 and older for 1982 survey year) were asked two questions related to their disability status: (a) Because of any impairment or health problem, do you/does _____ need the help of other persons with personal care (ADL) needs, such as eating, bathing, dressing, or getting around this home? and (b) Because of any impairment or health problem, do you/does _____ need the help of other persons in handling routine (IADL) needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes? In NHIS 1982–1996, respondents who answered "yes" to question (a) skipped question (b) and those who answered "no" to question (a) were subsequently asked about question (b). The personnel from the NCHS provided a reason for such skip pattern (Division of Health Interview Statistics, personal communication, December 30, 2010). They indicated that NHIS (1982–1996) was initially interested in the most severe form of disability (i.e., limitation of personal care needs); thus, they assumed that if an individual cannot engage in personal care activities by themselves, they will not be able to accomplish routine tasks without assistance from others. Thus, when estimating the disparity of IADL disability between 1982 and 1996, we assumed that those who indicated having ADL disability also had limitations in IADL activities and included them along with those who indicated only had IADL disability in question (b) of the survey administered prior to 1997. This coding procedure is consistent with our previous study (reference blinded) that used multiple years of the NHIS. In addition, we also conducted a chi-square test between respondents who had either ADL or IADL disability after 1997 and we found that 85% of respondents who had ADL limitations also had IADL limitation (*p* < .001, Cramer's *V* = 0.56). Thus, this evidence shows the adequacy of our assumption.

The same set of disability questions were used for 1997 onward; however, the leading sentence of both questions was changed as follows, "Because of a physical, mental, or emotional problem, do/does (you/anyone in the family)…." Respondents answered both ADL and IADL questions regardless of their responses to the ADL question. Again, we included those who had both ADL and IADL disabilities and those who only had IADL disability to estimate the disparity of IADL disability between 1997 and 2009. To determine the ADL disability status between 1982 and 2009, we include those with ADL limitation(s) only and those with limitations to both ADL and IADL activities. In our data set, about 0.02% (*n* = 39) and 0.03% (*n* = 67) of respondents are missing information on ADL and IADL disability, respectively. Respondents who were missing either ADL or IADL information were dropped from the respective ADL and IADL analyses.

Independent variables.—The main independent variables for our analyses were the three distinct temporal dimensions: APC. Although the period and cohort variables were not modeled directly, their estimates were obtained via a postestimation strategy discussed in the analysis section. The age variable, which was modeled directly, was centered around the median age of the cohort band to which the individual belonged. This helps preserve the estimates from the bias associated with systematic variation in mean age across cohorts (Miyazaki & Raudenbush, 2000). Also, centering eases the interpretation of the model intercept. The cohort-median-centered age variable was treated as a curvilinear function of disability and both a linear and squared age term were modeled simultaneously. Although we chose age of 70 and older as our inclusion criteria, the top-coded ages for 1982–1995, 1996, and 1997–2009 were 99, 90, and 85, respectively. We allowed the top-coded age to vary by survey year; however, we restricted our age-based disparity trend to age 84 as we do not feel confident in estimating the disparity for ages beyond the top-coded categories.

Period is defined as the year that the respondent was interviewed. Period ranges from 1982 to 2009. Birth cohort was estimated by subtracting age from period and we subsequently group these cohorts into 5-year cohort bands to break the linear dependence between each A-P-C dimension which is known as the identification problem in demographic research. The midpoint of the 5-year band was used to indicate all respondents who were born within that 5-year range. For example, individuals who were born between 1893 and 1897 were grouped into the 1895 cohort. Following the logic described above, our cohorts range from 1895 to 1940 with a 5-year gap between each category.

We also adjusted for respondents' sociodemographic characteristics in our A-P-C models by adding control variables. Categorical control variables include region of residence (northeast—reference, north central/mid-west, south, and west) and marital status (married—reference, never married, and other category which combines widowed, divorced, and separated). We decided to eliminate employment status in our models for two reasons. First, there is very small amount of variation in this variable as 91% of respondents in our data set were retired. Second, the inclusion of the employment variable prevented model convergence. The race variable was dichotomized as white or black. Those who are missing race information (9%) were dropped from our data set. The amount of missing for region of residence (0%) and marital status (0.2%) was minimal. We imputed all missing values with the modal category for categorical control variables.

The body mass index (BMI; defined as weight in kilograms divided by the square of height in meters) was calculated by the IHIS using self-reported weight and height. Approximately 20.1% of respondents did not have BMI information in the data set, thus, BMI values for these individuals were imputed with the grand mean. After the imputation, we then categorized BMI into four categories using the Centers for Disease Control and Prevention's (2011) BMI classification system: normal weight—reference, underweight, overweight, and obese. We also did another sensitivity test to see if the disparity trends of all respondents with imputed BMI differ from trends without individuals who missed BMI information. The results look very similar; thus, only all-respondents trends were shown in this paper. Two continuous control variables were added in our models as well. The combined family income was adjusted for both household size and the Consumer Price Index (CPI) retrieved from the Bureau of Labor Statistics (2010). We first adjusted the combined household income for household size by taking the household income divided by the square root of total number of person in the household. Subsequently, the household size-adjusted income was divided by the CPI of each particular survey year (1982–2009) over 100 ($CPI_{survey\ year}/100$), where 100 is the CPI for the reference period (1982–1984). For example, if the respondent was interviewed in 2007, the household

size-adjusted income was further adjusted for the CPI in 2007. Approximately 19% of the respondents are missing the income information, thus, we replaced missing with the grand mean of household size- and CPI-adjusted income. For the education variable, we recoded the original categorical variable from the IHIS so that respondents' education attainment was measured as years (0–18) of formal education completed. There are about 3% of respondents in our data set missing the education information. We replaced missing with the grand mean years of education for these individuals. The years of education completed were cohort-median-centered before being added to the models and the household income was centered around the grand mean. Missing indicators were entered in the model for all independent variables that had missing values. Although missing indicators were included in the model, we do not anticipate that the missing information will affect our results as the predicted probabilities were calculated assuming individuals who do not have any missing information (missing indicator = 0). Table 1 summarizes the respondent characteristics by race and gender.

Analysis

Tackling the identification problem.—As mentioned earlier, we grouped individuals born in a specific 5-year range (e.g., 1898–1902) into a single cohort (e.g., 1900) to break the perfect linear dependence with age and period. Extant A-P-C literature has suggested several methods (Fienberg & Mason, 1978; Heckman & Robb, 1985; Mason et al., 1973; O'Brien, 2000) including the most recently developed cross-classified random effect model (Yang & Land, 2008) to break the exact linear dependence between APC (period = age + cohort). In this paper, we utilized the cross-classified random effect model to estimate the black–white disparity in disability (Yang & Land, 2008).

APC disparity trends in ADL and IADL disabilities.— To examine the disparity trend by APC, we fit a logistic cross-classified random effect regression model for each disability outcome (ADL and IADL disabilities) that was stratified by four gender–racial groups (white men, black men, white women, and black women). Thus, four sets of logistic regressions were performed for each disability outcome. In each regression, the ADL or IADL disability (yes/no) was regressed on age (cohort-median centered) in linear and squared terms, and sociodemographic control variables in the fixed effect portion of the model. We also specified the random intercept for each period (single interview year) and cohort (5-year band). The random intercept for a period is shared across all cohorts for a given year and vice versa.

In addition, the predicted probabilities of ADL/IADL disabilities for our models were calculated separately for each A-P-C dimension and for each of the four racial and gender

Table 1. Respondents' Characteristics by Gender and Race[a]

	Men			Women			All		
	White (N = 67,757)	Black (N = 8,012)	p value	White (N = 98,305)	Black (N = 13,525)	p value	White (N = 166,062)	Black (N = 21,537)	p value
Region (%)[b]			p < .001			p < .001			p < .001
Northeast	22.3	15.7		23.3	17.2		22.9	16.6	
North Central/Midwest	26.6	18.8		27.1	17.6		26.9	18.0	
South	31.9	56.7		31.6	56.6		31.7	56.7	
West	19.2	8.8		18.0	8.6		18.5	8.6	
Marital status (%)[b]			p < .001			p < .001			p < .001
Married	76.9	59.3		38.8	22.9		54.3	36.4	
Never married	3.4	4.3		4.1	4.7		3.9	4.6	
Others (widowed, divorced, and separated)	19.7	36.4		57.1	72.4		41.8	59.0	
Employment status (%)[b]			p < .001			p < .001			p < .001
Working	12.9	10.7		6.4	7.1		9.0	8.4	
Unemployed	0.4	0.6		0.2	0.3		0.3	0.4	
Retired	86.7	88.7		93.5	92.6		90.7	91.2	
Age (mean)[c,d]	76.2	75.9	p < .001	76.9	76.6	p < .001	76.6	76.3	p < 0.001
Years of formal education completed (mean)[c,d]	11.8	9.0	p < 0.001	11.5	9.7	p < 0.001	11.6	9.4	p < 0.001
CPI-adjusted annual family income (mean)[c]	12,324.2	8,904.7	p < 0.001	11,330.2	8,264.9	p < 0.001	11,735.8	8,502.9	p < 0.001

Notes. ADL = activities of daily living; CPI = Consumer Price Index; IADL = instrumental activities of daily living.
[a]Although two different outcomes (ADL and IADL) were examined in this study, the total number of respondents available for each outcome-specific analysis was different; however, the difference was very small. The total number of respondents for each specific group presented in this table was based on individuals who did not miss ADL information. In addition, figures presented in this table do not account for survey weights.
[b]Chi-square tests were used to determine the statistical significance.
[c]Independent sample *t* tests were used to determine statistical significance.
[d]Overall means were reported here; however, cohort-median-centered variables (age and education) were used in the model.

subgroups while holding the rest of the model variables at the intercept which yielded an accurate interpretation given the level of measurement for many of our variables and the centering approaches we utilized. For example, the predicted probability of ADL disability for each cohort for the black men model was calculated while specifying sociodemographic dummy variables at the reference category (married, retired, residence at the northeast region, and normal BMI) and holding years of education and age at the median value of each cohort and income at the grand mean value. The racial difference (black minus white) in predicted probabilities for each period and cohort and for men and women were plotted for both ADL and IADL disabilities, which visually demonstrates the extent of disparity for each period and cohort. Although there is still not a consensus on whether relative disparity (black–white ratio) or absolute disparity (black–white difference) is a better approach to accurately depict health disparity (Houweling, Kunst, Huisman, & Mackenbach, 2007; King, Harper, & Young, 2012; Scanlan, 2006), we will show the black–white difference as our main results and briefly discuss any discrepancy between the absolute and relative (results not shown) approaches. As our age variable was cohort-median-centered, the predicted probability of ADL and IADL disabilities for each possible age within each cohort was calculated for all racial–gender groups. Subsequently, we averaged the predicted probability for each age across cohorts for each of the four racial–gender groups. Finally, we calculated the difference of average predicted probability between blacks and whites for men and women separately and these differences were plotted for both genders and both disability outcomes.

The survey weights were not accounted for in our analyses due to the limitation of applying weights to the data that are not cross-classified by the levels of the weights (strata/ primary sampling units [PSU]). However, the variables (i.e., income and race) that were used in the complex survey design for NHIS are included in our models, a strategy which eliminates biasing the intercept in models based on data sets that are collected using complex sampling designs that may not represent the population without weighting (Kalton, 1983).

Further, we decomposed the adjusted-cohort-based disparity trend for ADL and IADL disabilities to assess the relative contribution of each sociodemographic control variable using Fairlie's (2005) decomposition method. Fairlie's method is an expansion of the Blinder–Oaxaca decomposition technique (Blinder, 1973; Oaxaca, 1973), which has been widely applied in social science to quantify the contribution of measurable characteristics of group differences. The advantages of Fairlie's decomposition are its applicability to the binary outcomes and the coefficients from the logit model, which are not feasible in Blinder–Oaxaca's method. This approach allows us to determine the extent to which each measured covariate is contributing to the overall racial disparity, regardless of the size of the disparity

for any given cohort. In both linear and nonlinear decomposition methods, the racial gap can be explained by two components. The first component represents the racial gap explained by group differences (i.e., black–white differences) in the distribution of the compositional factors (i.e., distribution of sociodemographic factors in our model). The second component represents the racial gap due to differential risks (e.g., lower education attainment) experienced by disadvantaged group (i.e., blacks) relative to advantageous group (i.e., whites). In addition, the second component of the racial gap also includes the influence due to group differences in unmeasurable or unobserved covariates. Given the difficulty in interpreting the results for unexplained portion of the gap, studies, including our current study, do not focus on the second component of the racial gap (Fairlie, 2005). Thus, the percent contributions of sociodemographic factors presented in our decomposition figure (Figure 5) only consider the explained portion of racial gap. Finally, all of the statistical analyses in this study were performed in Stata 12.1.

RESULTS

The temporal trends derived from our cross-classified random effect logistic regression models are difficult to envision from the long tables of regression output; thus, we favor predicted probability figures to represent our results. The regression results are available by request from the corresponding author. Figure 1A displays the general age trends (including blacks and whites) of ADL and IADL disabilities. The predicted probability of both ADL and IADL disabilities increases continually with age.

Figure 2 shows the racial differences (black–white) in predicted probability for ADL and IADL disabilities by age and gender. We observed almost no ADL disparity among men across the entire age range (70–84) that we examined; however, women initially showed a decline of disparity then a crossover effect was observed at age 75. Around the same age, women began to show greater ADL disparity compared with men. The crossover effect suggests that white women have higher predicted probability of having ADL disability than black women after the age of 75; however, the reversed disparity (whites > blacks) started to decline at age 80. Similarly, the crossover age effects were evident for IADL disability among both men and women around the age of 75. After the age of 75, white men and women seem to experience higher IADL disability than black men and women, respectively. Although the IADL disparity reached a plateau at the age of 80 for women, men showed a continuous increase of IADL disparity. In contrast to greater ADL disparity observed among women, men had higher IADL disparity than women. In another covariate unadjusted model (results not shown), we found similar age-based ADL and IADL disparity patterns; however, the crossover occurred
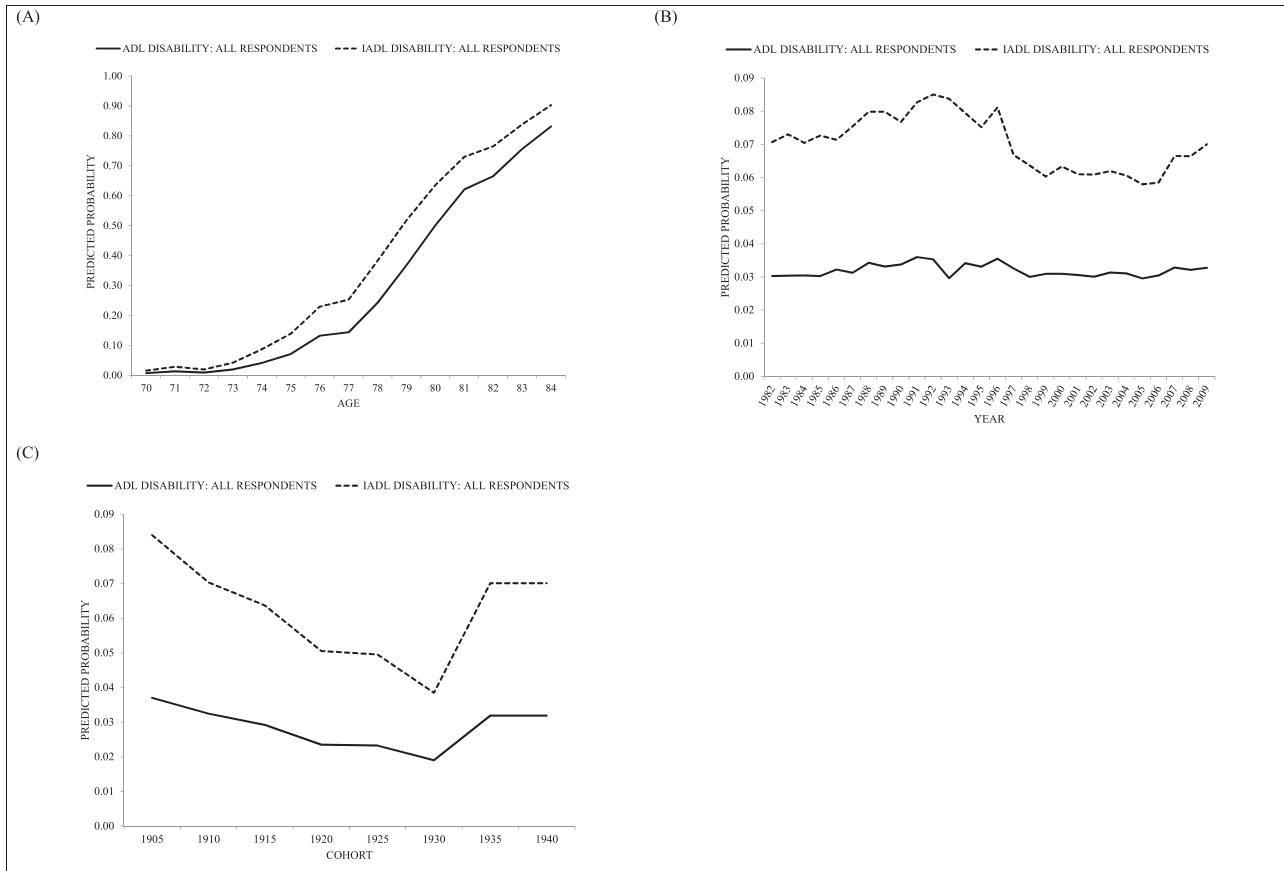
Figure 1. Sociodemographic- and APC-adjusted age, period, and cohort trends of ADL and IADL disabilities: (A) general age trends of ADL and IADL disabilities: ages 70–84, (B) general period trends of ADL and IADL disabilities: years 1982–2009, and (C) general cohort trends of ADL and IADL disabilities: cohorts 1905–1940. ADL = activities of daily living; APC = age, period, and cohort; IADL = instrumental activities of daily living.

slightly later compared with the covariate adjusted model. This means that the disadvantages among blacks would disappear at earlier age if blacks had the same socioeconomic profile as whites. In the covariate unadjusted model, the racial crossover effects occurred at ages 75, 76, and 78 for IADL disparity for men, IADL disparity for women and ADL disparity for women, respectively, whereas the crossover effects mainly occurred at age 75 in the covariate adjusted model (Figure 2). Finally, the relative disparities (results not shown) we plotted indicated similar patterns to absolute disparities shown in this article except the IADL disparity for men reached a plateau around the age of 79—this is in contrast to the continuously increasing IADL disparity among men shown in Figure 2.

The period-based general trend of ADL disability (Figure 1B) was essentially flat, whereas the period-based IADL trend showed minor fluctuations with the greatest drop of IADL disability occurring between 1996 and 1999. The period-based racial disparity trends shown in Figure 3 were also flat for ADL disability and this was similar for both men and women. The IADL disparities for both genders, however, showed greater fluctuations throughout the past three decades. In terms of gender difference, women

consistently experience a greater disparity than men across survey years and this is obvious for both disability outcomes. Finally, both men and women tend to experience greater IADL disparity than ADL disparity. Comparing these results to the relative disparity results, the patterns for ADL and IADL disparity for both men and women were very similar between two approaches; however, women's ADL disparity tend to be higher than the IADL disparity in the relative disparity approach.

The cohort-based general trend in Figure 1C demonstrated a general decline of ADL and IADL disability, which was followed by an uptick between 1930 and 1935 and it remained at the same level for the 1940 cohort. Figure 4 illustrates the cohort-based disparity trends for both types of disability. Unlike the crossover effects that we observed in age-based disparity trends, blacks generally had higher predicted probability of ADL and IADL disabilities regardless of gender and type of disability in the cohort-based disparity trends. For both ADL and IADL disparities, the disparities declined continually across each successive cohort for men. The IADL disparity also declined for women; however, the ADL disparity trend remained quite constant for women. The observed declining disparity trends, however, are much more
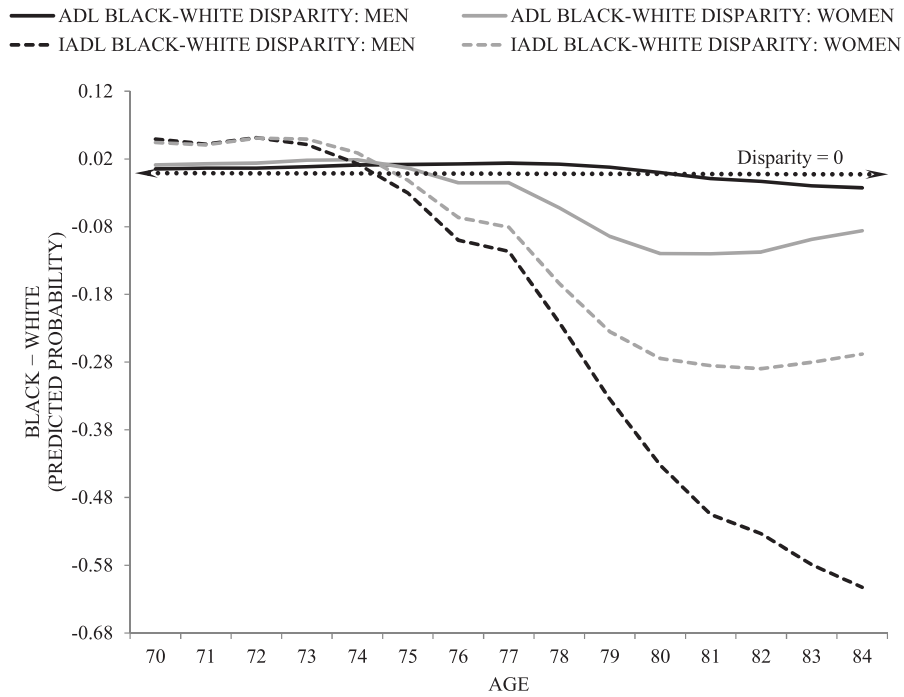
Figure 2. Period-, cohort-, and sociodemographic-adjusted age trends of black–white disparity in ADL and IADL disabilities among men and women: for U.S. adults aged 70–84, 1982–2009. ADL = activities of daily living; IADL = instrumental activities of daily living.
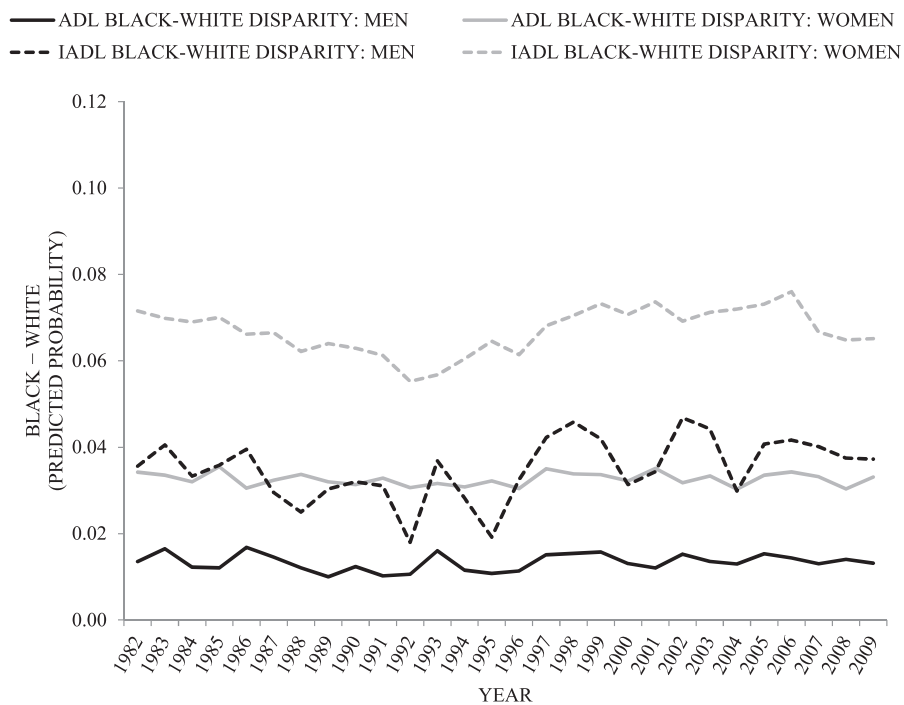

Figure 3. Age-, cohort-, and sociodemographic-adjusted period trends of black–white disparity in ADL and IADL disabilities among men and women: for U.S. adults aged 70 and older, 1982–2009. ADL = activities of daily living; IADL = instrumental activities of daily living.

pronounced among men than women. Among both men and women, IADL disparities appear to decline more rapidly than ADL disparities. In addition, women experienced greater disparities than men with regard to each cohort (except 1905 cohort) and both types of disability. Finally, the persistent black–white disparities for both types of disability among men seem to almost disappear in the 1935 cohort; however, the predicted probability rebounded for IADL disability and
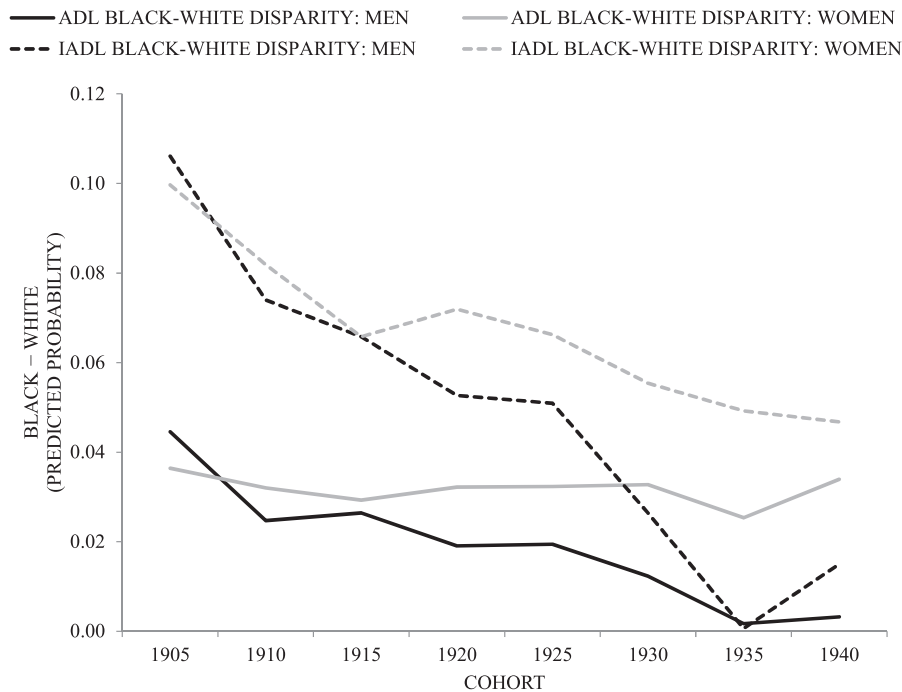
Figure 4. Age-, period-, and sociodemographic-adjusted cohort trends of black–white disparity in ADL and IADL disabilities among men and women: for U.S. adults aged 70 and older, 1982–2009. ADL = activities of daily living; IADL = instrumental activities of daily living.

it remained at the same level for ADL disability for the most recent cohort (1940). These results should be taken with a grain of salt, however, as they represent sociodemographic-adjusted disparity trends. That is, unless progress can be made to reduce differences in income and education disparities, disability disparities will remain large and persistent, although evidence of their decline is supported across the birth cohorts measured here. Comparing our cohort results to the relative disparity approach, two discrepancies were observed. First, both ADL and IADL disparities among women tend to increase across cohorts in the relative measure approach; however, ADL disparity among women remained flat and IADL disparity for women decreased across cohorts in the absolute measure approach (see explanations in discussion). Second, for women, the ADL disparity was larger than IADL disparity for each of the successive cohort in the relative disparity approach, whereas the reverse is true in the absolute disparity approach (Figure 4).

To further explicate the unique cohort effect on ADL and IADL disabilities, we decomposed both cohort-based ADL and IADL disparity trends to determine the relative contribution of sociodemographic control factors included in our model. Figure 5 shows the compositional shifts of the cohort-based ADL and IADL disparity trends by gender. The percent contribution of these sociodemographic factors represents how much each factor contributes to the explained black–white difference in ADL/IADL disability for each individual cohort band. Further, we include the cohort disparity trend so that readers can compare the relative contribution of each covariate to the disparity, while

simultaneously considering the amount of disparity in each successive cohort.

Racial differences in education and income persistently contributed to the ADL disparities among men (Figure 5A) and women (Figure 5B). Education, however, exerted greater contributions than income in most cohorts. For example, in the 1905 cohort, the ADL racial disparity would have been 72% smaller if black men were to have the same education profile as white men, whereas, the reduction of the disparity would have only been 32% if black men's income profiles were similar to white men's. The same education and income patterns were also observed for both genders for the IADL disparity (Figure 5C and D). For ADL disparity, the racial difference in marital status was not important in explaining the black–white gap for the earliest cohorts; however, it became more important starting from the 1915 cohort for men and the 1920 cohort for women. The increase in importance of marital status is more salient for IADL disparity: there was a continuous increase in the percent contribution of marital status among men (except 1940 cohort) and women across cohorts. In contrast, there was a remarkable decline in the importance of region of residence across the cohorts for IADL disparity among men (except 1915, 1930, and 1940 cohorts) and women (except 1930 and 1940 cohorts). For ADL disparity among men, there seems to be an initial decline of importance of the region of residence from the 1905 cohort to the 1910 cohort; however, the trend reversed after the 1910 cohort. A pattern similar to men's was observed among women with the exception that the rebound began a little later in the 1925 cohort.
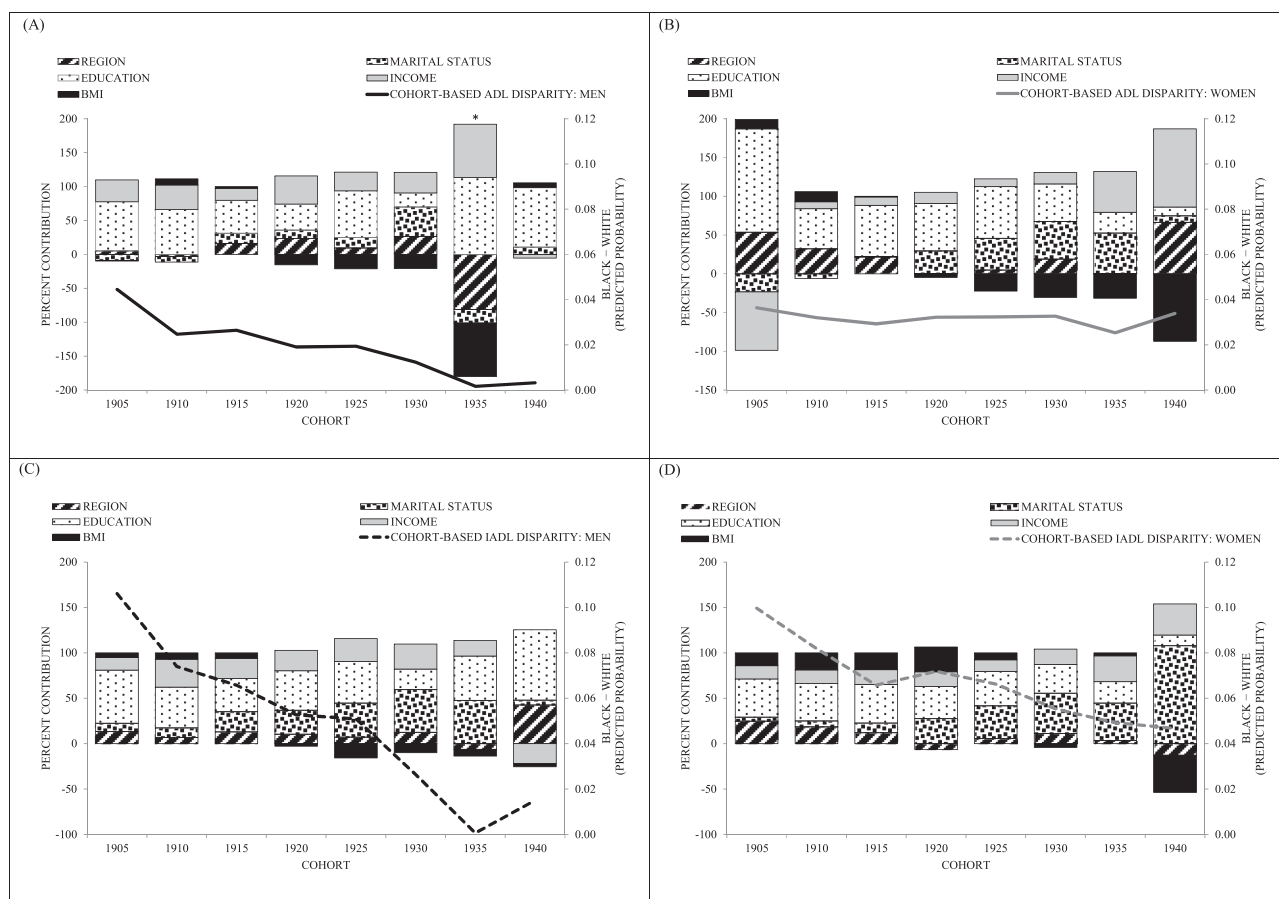
Figure 5. Sociodemographic contributions to the cohort-based ADL and IADL disparity trends among men and women: (A) contributions to black–white disparity in ADL disability: men, (B) contributions to black–white disparity in ADL disability: women, (C) contributions to black–white disparity in IADL disability: men, and (D) contributions to black–white disparity in IADL disability: women. ADL = activities of daily living; IADL = instrumental activities of daily living. *The actual percent contributions of education and region for ADL disparity among men in 1935 cohort do not match with what were shown in the figure. The percent contribution for education (283.6%) and region (−163.1%) for cohort 1935 among men were very large, thus, the contributions for these two covariates were re-scaled in cohort 1935 to improve the readability of Figure 5A.

BMI does not play an important role for men regardless of the type of disability gap. Among women, BMI became an increasingly important contributor to ADL disparity between the 1920–1940 cohorts. However, for these cohorts, the difference in BMI distribution favors black women. This suggests that the ADL disparity between black and white women would have been larger if black women were to have the same BMI distribution as white women. Finally, the relative contribution of BMI for IADL disparity among women remained quite constant across all cohorts except for 1930 and 1935 cohorts.

Discussion

Generally, blacks have a higher predicted probability of having ADL/IADL disability compared with whites and these racial gaps tend to be larger among women than men for both types of disability. These patterns were observed in two temporal dimensions: period and cohort. Although a very small amount of ADL disparity was observed for men, a crossover effect (whites had higher predicted probability

of ADL disability than blacks) was found for women at age 75—the reversed ADL disparity reached a plateau at the age of 80. A similar crossover in IADL disparity was observed for both men and women at age 75 although men showed a continuous increase of IADL disparity thereafter while women showed a plateau of disparity at the age of 80. It should be noted that these crossover effects would have occurred later if we had not adjusted the sociodemographic measures. The observed racial crossover effects were consistent with a previous study (Johnson, 2000) that also reported a black–white racial crossover for advanced ADL (i.e., IADLs) at age 86. In addition, a racial crossover was found at age 76 for the cumulative average number of six chronic diseases: chronic lung disease, cancer, heart disease, hypertension, diabetes, and stroke. Finally, the greater ADL disparity observed among women in the age trend is consistent with a previous study's finding that the black–white disparity in disability was significantly higher among women than men across the life span, although this result tends to change slightly over time (Mendes de Leon et al., 2005).

Unlike the age-based disparity trends, for both genders, the period-based disparity trends for ADL disparity were flat and the IADL disparity trends show greater variation. In comparison to the study by Manton and Gu (2001), we did not find an increase in ADL disparity between 1982 and 1989 and a decrease in ADL disparity between 1994 and 1999 as the ADL disparity trends that we observed have remained unchanged for the past three decades (1982–2009). Similarly, for IADL disparity, we did not observe an increase in IADL disparity between 1982 and 1989 for men and women nor did we find a decrease of IADL disparity between 1994 and 1999 among men and women.

Several reasons might contribute to the discrepancies in ADL and IADL disparities between our study and Manton and Gu's (2001). First, the samples that were used for statistical analyses were substantially different. We used the data from NHIS, whereas Manton and Gu (2001) used the data from the NLTCS which includes the sample from institutionalized persons who were not drawn in the NHIS survey. The age cut points for which the disability questions were asked were also different—65 and older for NLTCS; and 70 and older for NHIS. Second, the survey design was different—NHIS utilized the repeated cross-sectional design, whereas NLTCS utilized the longitudinal approach. Third, the period-based black–white differences observed in our study were adjusted for sociodemographic factors and the effects of age and cohort; whereas, the disparity estimated in the study by Manton and Gu (2001) were only age standardized. In the end, our study uses a much wider time trend and appropriately adjusts these period trends for both age and cohort. Although virtually all temporal studies—which rely almost exclusively on period—adjust for age, our study additionally adjusts for cohort. Given the strong cohort trends observed in this study and our previous study (reference blinded), it is likely the other studies that present period trends may be confounding both period and cohort in their results. For these reasons, we show relatively flat period trends in disparity, net of the strong and declining cohort disparity trends.

For the cohort-based disparity trends, although the continual decline of ADL and IADL disparities was evident for men and women (except for the flat ADL disparity for women), such declines are more salient for men. Because of the lack of studies focusing on the cohort-based disparity trends in disability, we were not able to compare our study results to previous investigations. Further, although increasing ADL and IADL disparities were observed among women in the relative disparity approach, the ADL disparity among women remained flat and IADL disparity decreased across successive cohorts in the absolute disparity approach. We argue that the larger IADL black–white ratio seen in the more recent female cohorts might be inflated as there were smaller IADL black–white differences in the more recent cohorts. Previous studies have reported that the smaller the difference between two groups, the larger the ratio will become (Houweling et al., 2007; Scanlan, 2006).

The results of the decompositions showed that education and income persistently contribute to the cohort-based ADL and IADL disparity trends. It is important to note that we have only modeled the direct influence of education in the decomposition models; this direct influence is certainly an underestimate of the total influence of education as education may operate indirectly through income, marital status, region of residence, and household composition. A previous study (Fuller-Thomson et al., 2009) similarly found that 90% of black–white differences in ADL and functional limitation among men and 75% of such differences among women were explained by education and poverty level. In addition, for men, BMI was not an important contributor of the cohort-based ADL and IADL disparity trends although the negative contribution became larger between 1920 and 1935 cohorts and turned to a very small positive contribution in 1940 cohort for ADL disparity. Although it is plausible that the BMI contribution in 1940 cohort may continue to grow, we do not expect this to be the case. Many previous studies have found that BMI (or obesity) does not associate with ADL or IADL disability (Alley & Chang, 2007; Freedman, Schoeni, Martin, & Cornman, 2007; Martin, Schoeni, & Andreski, 2010). For ADL disparity among women, BMI gradually gained relevance after the 1920 cohort; however, among these cohorts, we identified an unusual pattern that the ADL disparity would have been larger if black women were to have the same pattern of BMI as white women (i.e., more favorable BMI's). This unusual pattern may partly be explained by the fact that a moderate amount of respondents (20.1%) who had no BMI information were imputed with the grand mean BMI value which may have biased our estimates toward the null. On the other hand, for IADL disparity among women, the contribution of BMI seems quite consistent in the expected direction across the cohorts (except 1930 and 1940 cohorts).

The black–white differences in marital status became an increasingly important contributor to the ADL/IADL disparity among recent cohorts. This is consistent with earlier evidence which suggests a significant relationship between marital status and disability among older adults (Goldman, Korenman, & Weinstein, 1995). Researchers indicated that widowed men are more likely to need help with ADL than married men. Single women and divorced men are less likely to need assistance with ADL compared with married women and married men, respectively. Further, the increasing contribution of marital status to disability is consistent with the increasing black–white gap of proportions of currently unmarried and never married individuals in the past decades (1953–1994) (Waite, 1995). The remarriage rate was also found to be higher for whites than blacks (Bennett, Bloom, & Craig, 1989). Finally, black women have higher probability of engaging in relatively short-lived "cohabitation" relationships than whites and they are less likely to

move from cohabitation to marriage (Bumpass, Cherlin, & Sweet, 1991).

Contrary to marital status, the black–white difference in region of residence is becoming a less relevant contributor to the IADL disparity. This is true as most blacks started migrating from the South (historically lagging in industrialization and income) around the time of War World I (1914) until about 1970s when blacks returned to the South due to southern economic growth and the decline of overt discrimination (Fuguitt, Fulton, & Beale, 2001). Thus, the spreading of blacks' migration to other regions of the United States may provide an explanation of the diminishing contribution of regional differences on IADL disparity. For ADL disparity, however, the contribution of region dropped gradually and reverted back to a mildly increasing contribution to the disparity trend.

There are several limitations of our study. The following selection biases could potentially affect disparity estimates: (a) selective mortality prevented us from estimating the disability rate for the least healthy individuals who died prior to the survey, (b) blacks have higher mortality than whites and this is nonrandom, and (c) NHIS does not draw samples from the institutionalized population; thus, selective rate of admission to nursing homes or assisted living facilities may affect our disparity estimates. Further, as discussed earlier, prior to 1997, NHIS allowed proxy reports by family members when self-report of the disability status was not available. Approximately 12% of our data on disability were reported by proxies. Although previous research has suggested that self-report and proxy report may differ from each other (Magaziner, Zimmerman, Gruber-Baldini, Hebel, & Fox, 1997), a more recent study (Chen, Hsieh, Mao, & Huang, 2007) reported that it is appropriate to use proxy report to measure disability level for research purposes. Our sensitivity tests also found that "self-reporters only" disparity trends resemble the disparity trends using "all respondents." Finally, our testing of the age crossover effect was limited by the fact that while age is adjusted for cohort trends through our cohort-centering approach, it is not fully adjusted for period given that period is entered as a random effect in the model. However, given the relatively flat period effects, the amount of bias in the age effects can be expected to be trivial.

Despite these limitations, our study represents a substantial improvement over prior studies of temporal disparity trends in disability. Although many previous studies focused on black–white disparity in disability using period trends (i.e., survey year), our study is the first to examine the ADL/IADL disparity trends by APC and also simultaneously control for each temporal factor. We were also able to examine the period disparity trend for a much larger time spectrum that spans almost three decades (1982–2009). As the majority of the disparity in disability literature focuses on the effect of age and race on disability status, we revisited this issue and found support for the crossover effect—blacks begin to earn advantages in ADL and IADL disabilities over whites around the age of 75. We also explicate the cohort-based disparity trend for ADL and IADL disabilities. Our results suggest declining ADL and IADL disparity across successive birth cohorts; if these patterns hold, this is great news for disparity researchers assuming that progress can be made for reducing sociodemographic disparities (e.g., education and income) in the coming decades.

Although we have identified that income, education, and marital status are important sociodemographic contributors to the cohort-based racial disparity in ADL and IADL disabilities, future studies should investigate individual level behavioral health determinants and cohort-specific characteristics that might explain the cohort-based black–white difference in ADL and IADL disabilities. Finally, although the general cohort prevalence of ADL and IADL disabilities were decreasing across the cohorts, there was an uptick between 1935 and 1940 cohort. This information would be beneficial for hospital or nursing care facility administrators as this is indicative of an upcoming influx of older and disabled individuals whom could be potentially enrolled in their facilities. In addition, our study found a crossover aging effect on ADL and IADL disabilities around the age of 75. One possible mechanism is the selective mortality effect—black men and women who survived to the age of 75 may be relatively more healthy and frail black men and women may have died earlier than frail white men and women. If this holds true, policy makers as well as health professionals should invest in reducing excess mortality among blacks earlier in life. Further, efforts in reducing excess mortality should target blacks with low socioeconomic status as our study results also found that advantages in disability among blacks would occur earlier if sociodemographics were adjusted.

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