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Modifiable factors for disability: Is there potential for reducing racial disparities in disability in older age?

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Modifiable Factors for Disability: Is There Potential for Reducing Racial Disparities in Disability in Older Age?

by

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DEDICATION

This dissertation is dedicated to my parents who have taught me that education is the bread and butter in life. Because of the historic and politic context my parents grew up in, they achieved very little formal education. This is why they wanted me to soar above them and they invested everything they had for this purpose.

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ABSTRACT

White-Black disparities in disability in the older population are consistently reported in the literature, and are usually ascribed to differences in socio-economic, health, and cognitive status. However, the role of modifiable influences on disability, such as health and lifestyle behaviors or health care utilization on these differences is less clear. This dissertation examines: (1) longitudinal White-Black differences in disability and the potential contributions of distinct health behaviors to these differences; (2) White-Black differences in the effects of health care utilization on trajectories of disability; and (3) whether cognition mediates the effects of health behaviors on disability in Whites and in Blacks, independent of established confounders for these relationships.

This dissertation uses longitudinal data from the Asset and Health Dynamics among the Oldest Old study (AHEAD). Trajectories of disability in basic (ADL) and instrumental (IADL) activities of daily living are fit using mixed effects models with time-varying predictors. The mediation effect is tested using a multilevel mediation model.

Results indicate that health behaviors close the residual White-Black gap in IADL trajectories but not the residual gap in ADL trajectories. Physical activity participation and maintenance of a normal weight or overweight status resulted in lower ADL and IADL disability levels over time among Whites. None of the health behaviors influenced longitudinal trajectories of disability in Blacks. Short-stay nursing home and home health care utilization was associated with lower ADL and IADL disability levels over time among Blacks. Cognition mediated the effect of physical activity participation on ADL and cognitive IADL in Whites but not in Blacks. That is, physical activity participation had positive effects on ADL and IADL disability both directly, and indirectly through beneficial effects on cognition.

Modifiable influences on disability, such as health and lifestyle behaviors and health care utilization should be targeted by intervention programs and regulatory policies in order to narrow or eliminate the White-Black disability disparities. Such interventions may represent effective avenues for achieving the goals of *Healthy People 2010*.

INTRODUCTION

Healthy People 2010, the 10-year health objectives agenda developed by the U.S. Department of Health and Human Services, has as a major goal eliminating health disparities in the U.S. population (USDHHS, 2000). This goal is embedded in the premise that the health of the individual and the health of the community are intimately intertwined (USDHHS, 2000). Hence, community health improvement can be achieved by addressing the determinants of health at the individual level (e.g., biological, behavioral), environmental level (e.g., social and physical environment), and policy level (e.g., policies and interventions, access to and quality of health care). In line with the goal of *Healthy People 2010* to eliminate health disparities, this dissertation examines a series of modifiable determinants of health that may influence the White-Black disparities in disability in older age.

The theoretical framework guiding this research project is the disablement model developed by Verbrugge and Jette (1994). This model proposes a socio-medical explanatory framework for the changes in physical functioning resulting from chronic conditions, and shaped by individual, environmental, and societal factors. Among the factors hypothesized to determine the development and progression of disability, this research project focuses on health and lifestyle behaviors (i.e., physical activity participation, alcohol consumption, smoking, and body weight status) as individual level determinants of health, and on health care utilization (i.e., doctor visits, hospitalizations, nursing home stays, and home health care) as policy level determinants of health.

The data for this project come from the Asset and Health Dynamics Among the Oldest Old (AHEAD), which was compiled and made publicly available by the RAND Center for the Study of Aging (2006). The AHEAD cohort is a nationally representative sample of 8,222 community-dwelling elders aged 70 years and older at baseline in 1993, including their spouses/ partners regardless of age. Participants were re-interviewed in 1995, 1998, 2000, and 2002. A detailed description of the study design and sampling methods is presented elsewhere (Soldo, Hurd, Rodgers, & Wallace, 1997). Because data on physical activity participation is available from 1995 on, the first and third studies, which include this variable among the predictor variables, use the 1995 wave of data collection as baseline.

Disability, the outcome examined in this study, is measured by difficulty with basic (ADL) and instrumental (IADL) activities of daily living. Details on the construction and measurement of each variable included in the analyses are presented in each respective study.

All three studies have a longitudinal design including time varying predictors, where longitudinal changes in the outcome variables are examined relative to longitudinal changes in predictor variables. The first two studies use mixed effects models to fit trajectories of disability; the third study uses a multilevel mediation model.

The first study examines whether there are residual White-Black differences in trajectories of disability after controlling for socio-economic and health status; whether these residual disparities are attributable to differences in health and lifestyle behaviors; and whether health and lifestyle behaviors affect the disability trajectories differently in White and in Black older adults. The second study investigates whether the utilization of specific health care services is associated with different disability outcomes in White and in Black older adults, independent of established determinants of health care utilization. The third study tests whether cognition mediates the effects of health and lifestyle behaviors on disability and whether this mediation effect holds in White and in Black older adults after adjusting for correlates of cognitive function and disability.

The identification of modifiable factors associated with White-Black disparities in disability contributes to the policy agenda of *Healthy People 2010*. The incorporation of evidence-based modifiable factors for disability in interventions programs and regulatory policies has the potential to reduce White-Black disparities in disability.

STUDY 1

THE ROLE OF HEALTH AND LIFESTYLE BEHAVIORS ON WHITE-BLACK DISPARITIES IN DISABILITY

Abstract

White-Black disparities in disability in the older population are consistently reported in the literature, but the role of underlying health behaviors, such as physical activity, smoking, alcohol consumption, and weight status on these differences is less clear.

Longitudinal changes in White-Black differences in disability and the potential contributions of distinct health behaviors to these differences independent of socio-economic and health status were examined. All White and Black participants from the Asset and Health Dynamics among the Oldest Old study (AHEAD) (N=4,472) who were non-demented at baseline were followed up biannually from 1995 to 2002. Trajectories of disability in basic (ADL) and instrumental (IADL) activities of daily living were fit using mixed models with time-varying predictors.

When the effects of health behaviors were taken into account, adjusting for socio-economic and health status, there were still residual White-Black differences in longitudinal changes in ADL but not in IADL disability. Analyses stratified by race indicated that in Whites physical activity participation was related to lower rates of

change over time in ADL and IADL disability. Also, Whites who were underweight or obese had the highest rates of increase over time in ADL disability. None of the health behaviors influenced longitudinal trajectories of disability in Blacks.

Modifiable risk factors such as physical activity or weight status should lay the foundation for individualized interventions aimed at minimizing or eliminating White-Black disability disparities. Such programs may represent effective avenues for achieving the goals of *Healthy People 2010*.

Introduction

White-Black disparities in functional limitations and disability in the older population have been extensively documented (Berkman, Singer, & Manton, 1989; Kelley-Moore & Ferraro, 2004; Li, 2005; Mendes de Leon et al., 1997), although the etiology of these disparities has not been fully deciphered. Commonly reported correlates of White-Black disparities in disability include socio-economic status (SES: Clark & Maddox, 1992; Kelley-Moore & Ferraro, 2004; Mendes de Leon et al., 1997; Mendes de Leon, Barnes, Bienias, et al., 2005), cognitive performance (Zsembik, Peek, & Peek, 2000), and multiple chronic conditions (Kelley-Moore & Ferraro, 2004; Zsembik et al., 2000). Although some studies on White-Black disability disparities found no residual differences after adjusting for socio-economic and health characteristics (Mendes de Leon et al., 1997; Wray & Blaum, 2001), others reported persistent differences even after controlling for such factors (Kelley-Moore & Ferraro, 2004; Mendes de Leon et al., 2005; Moody-Ayers, Mehta, Lindquist, Sands, & Covinsky, 2005; Zsembik et al., 2000). These inconsistencies suggest that other determinants of functional status and disability may contribute to these disparities.

The beneficial effects of healthy lifestyle behaviors, such as regular participation in physical activity, not smoking, drinking within the recommended limits, and maintaining a normal weight status on health and functional status are substantiated in the epidemiological, medical, sociological, and gerontological literature. Moreover, these lifestyle behaviors are likely to coexist (Ewing, Schmid, Killinsworth, Zlot, & Raudenbush, 2003; Wannamethee, Shaper, Whincup, & Walker, 2004), and their effects on disability tend to be interactive and additive (Hubert, Bloch, Oehlert, & Fries, 2002; Wei et al., 1999). Nevertheless, few studies examined the effects of such modifiable health and lifestyle behaviors on White-Black disparities in disability.

Health and Lifestyle Behaviors and Disability in Older Adults

Observational studies suggest that self-reported physical activity participation is associated with delayed onset of disability and slower progress of disability over time independent of additional risk factors (Berk, Hubert, & Fries, 2006; He & Baker, 2004; Reynolds & Silverstein, 2003; Seeman et al., 1995). Although inconsistent, intervention studies find that participants in the intervention groups have better physical functioning, higher odds of recovering from disability, and lower odds of worsening compared to control groups (Binder et al., 2002; Capodaglio, Ferri, & Scaglioni, 2005; Julie & Jette, 2001; Nelson et al., 2004; Penninx et al., 2002; Phelan, Penninx, LoGerfo, & Leveille, 2004). Additionally, other studies indicate that physical activity can buffer the negative effects of obesity on disability (Di Francesco et al., 2004; Ferraro & Kelley-Moore, 2003; He & Baker, 2004) or of aging-related weight loss (Dziura, Mendes de Leon, Kasl, & Di Pietro, 2004).

The relationship between smoking and health has been demonstrated by epidemiological and medical studies. In the gerontological literature this relationship is also found, with some research finding evidence that smoking predicts onset of disability (Branch, 1985; Reynolds & Silverstein, 2003), and higher odds of having any physical functioning limitations (Landerman et al., 1998; Ostermann & Sloan, 2001). However, Kelley-Moore and Ferraro (2004) found that current smoking was associated with lower levels of disability in both Whites and Blacks.

Although moderate alcohol consumption has some protective effects on physical functioning (LaCroix, Guralnik, Berkman, et al., 1993), excessive consumption is associated with higher disability (Ensrud et al., 1994; Seeman et al., 1995) and higher odds of having any kind of physical functioning limitation and of developing incident disability (Ostermann & Sloan, 2001). In addition, Landerman and colleagues (1998) found a U-shaped effect of alcohol consumption, where both abstainers and heavy drinkers were at high risk of developing mobility limitations compared to those who consumed the recommended amount.

Obesity is associated with earlier onset and higher levels of disability (Di Francesco et al., 2004; Ferraro & Kelley-Moore, 2003; He & Baker, 2004; Inelmen, Sergi, Miotto, Peruzza, & Enzi, 2003; Reynolds & Silverstein, 2003; Sturm, Ringel, & Andreyeva, 2004; Wannamethee et al., 2004), and with fewer years free of disability and longer years with disability (Peeters, Bonneux, Nusselder, et al., 2003; Reynolds, Saito, & Crimmins, 2005). Moreover, the risk of earlier onset and increased severity in physical functioning limitations increases gradually with the increase in body mass index above the normal values (He & Baker, 2004; Sturm et al., 2004; Zoico et al., 2004).

Similar detrimental effects on disability have been reported for being underweight (Ferraro & Kelley-Moore, 2003). Two studies in particular found a U-shaped relationship between body mass index (BMI) and functional status, where both extremely low and high BMI values were associated with high risk of functional impairment (Ferraro & Booth, 1999; Galanos, Pieper, Cornoni-Huntley, Bales, & Fillenbaum, 1994).

Despite the beneficial effects of healthy lifestyle behaviors described previously, older Blacks are less likely to practice them. Older Blacks are less likely to participate regularly in physical activity and more likely to be inactive (Center for Disease Control [CDC], 2006a), are more likely to be current smokers (CDC, 2006b; Sudano & Baker, 2006; Winkleby, Cubbin, Ahn, & Kraemer, 1999; Wray, Alwin, & McCammon, 2005), and overweight or obese (Roberts & Reither, 2004). Considering the empirical evidence on the effects of health behaviors on disability, as well as White-Black differences in the prevalence of health behaviors, it is likely that a segment of White-Black disparities in disability unexplained by SES and health characteristics may be the result of differences in underlying health and lifestyle behaviors.

The disablement model developed by Verbrugge and Jette (1994) describes the main pathway to disablement as triggered by the pathological processes specific to a disease, which result in functional impairments, functional limitations, and disability (Verbrugge & Jette, 1994). Risk factors, such as health and lifestyle behaviors, are hypothesized to have predisposing and enduring effects and extensive locus of action on the disablement pathway (Verbrugge & Jette, 1994). Due to their predisposing nature, risk factors may explain differential patterns of disability across various population groups.

In light of the current knowledge on the effects of health behaviors on physical functioning and disability, this study examines the longitudinal effects of modifiable risk factors (i.e.., physical activity participation, smoking, alcohol consumption, and weight status) on White-Black disparities in trajectories of disability. The research questions of this study are:

(1) Are there persistent differences in longitudinal trajectories of disability between White and Black older adults independent of SES and health status?

(2) If so, are these residual differences attributable to disparities in health behaviors?

(3) What are the specific contributions of modifiable health behaviors on trajectories of disability in White and in Black older adults after adjusting for SES and health status?

The underlying hypothesis of this study is that a White-Black gap in disability exists independent of SES and health status, and that these residual differences are attributable to disparities in health behaviors.

Methods

Data and Study Population

The data for this study come from Asset and Health Dynamics among the Oldest Old (AHEAD) study, which was compiled and made publicly available by RAND Center for the Study of Aging (2006). The AHEAD cohort is a nationally representative sample of 8,222 community-dwelling elders aged 70 years and older at baseline in 1993, including spouses/ partners regardless of age. Participants were re-interviewed in 1995, 1998, 2000, and 2002. A detailed description of the study design and sampling methods is presented elsewhere (Soldo, Hurd, Rodgers, & Wallace, 1997).

The inclusion criteria for selecting this study sample from the baseline AHEAD cohort include age 70 and older, White and Black race/ethnicity, and non-demented cognitive status as defined by Herzog and Wallace (1997). Additionally, during the follow-up participants who had a proxy reporting on their behalf were excluded from that respective wave. Becoming institutionalized during the follow-up was not an exclusion criterion, so participants who were interviewed in nursing homes were included in the analyses while controlling for their institutionalized status.

Because physical activity was not assessed at the baseline interview in 1993, this study uses the 1995 interview as its baseline. Therefore, in the rest of this paper the term "baseline" refers to the 1995 interview. After applying these inclusion criteria, the sample size was 4,472, representing 4054 (90.65%) Whites and 418 (9.34%) Blacks. The overall attrition rates for the whole period of follow-up were 45.99% in Whites (e.g., 41.25% due to death, 2.70% due to institutionalization and not being interviewed, and 3.41% due to proxy responses) and 47.06% in Blacks (e.g., 47.53% due to death, 1.65% due to institutionalization and not being interviewed, and 1.88% due to proxy responses).

Measures

Outcome variables

The outcome variables for this study are self-reported difficulties with basic (ADL) and instrumental (IADL) activities of daily living. Difficulties with ADLs are measured by a summary index including six tasks (i.e., bathing, eating, dressing, walking across a room, using the toilet, and getting in and out of bed) (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963). The range of scores for this index varies from 0 to 6, where 0 represents no difficulty and 6 represents difficulty with all six ADLs. Difficulty with IADLs is measured by a summary index including five tasks (e.g., using a phone, taking medications, handling money, shopping, and preparing meals). The scores for this index range from 0 to 5, where 0 represents no difficulty and 5 represents difficulty with all five IADLs.

Predictor variables

The predictors used in this study reflect health and lifestyle behaviors at each wave, and include participation in vigorous physical activities, smoking, alcohol consumption, and weight status. Participants reported on whether or not they participated in vigorous physical activities (i.e., sports, heavy housework, or a physically demanding job) for at least three times a week during the last 12 months.

Smoking was originally measured in AHEAD using two dummy variables indicating current smoking and having ever smoked. In order to differentiate distinct levels of risk on disability, a new ordinal variable was created to indicate never smoking=0, former smoking=1, and current smoking=2.

To reconcile inconsistent measures of alcohol consumption across waves and the National Institute on Alcohol Abuse and Alcoholism (2006) recommendation of no more than a drink a day or seven drinks a week, a new variable was created with three response options: 0= does not drink/abstainer, 1=1 to 2 drinks/day, 2= 3 drinks or more/day. To test previous findings reported in the literature of higher detrimental effects on physical functioning of being an abstainer or heavy drinker compared to drinking the recommended alcohol amount (Landerman et al., 1998), a squared effect of the drinking variable was tested in addition to the linear effect, and the values of the drinking variable were centered at the mean.

BMI represents the ratio between weight converted into kilograms and squared height converted into meters. Outlier values for the BMI variable were replaced with the corresponding value of $^{+}/-3.29$ of their standardized z score (Tabachnick & Fidell, 2001). The continuous BMI variable was recoded into an ordinal variable according to the World Health Organization (2007) definition indicating being underweight (BMI$<$ 18.5 kg/m^2 =0), normal weight (BMI=18.5-24.9 kg/m^2 =1), overweight (BMI= 25-29.9 kg/m^2 =2), and obese (BMI$>$ 30kg/m^2 =3). The values of the BMI group variable were centered at the mean, and both the linear and the squared BMI values were included in the analyses to test the previously reported U-shaped relationship between weight status and functional status (Ferraro & Booth, 1999; Galanos et al., 1994).

Control variables

Demographics include age, gender (0=male; 1= female), race (0= Whites, 1= Black), and marital status (0= married/ partnered, 1= not married/ partnered). SES was measured by educational attainment (range= 0-17 years of formal education; centered at 12 years) and net household wealth. The net wealth variable represents the sum of all self-reported wealth (i.e., housing, real estate, checking, savings) minus all debt (i.e., mortgage, debt). Outlier values for the wealth variable were replaced with the corresponding value of +/-3.29 of their standardized z score (Tabachnick & Fidell, 2001). Because the wealth variable has a very wide range of values and a skewed distribution, the original continuous variable was recoded into an ordinal variable based on the quartile distribution of the baseline values.

Health status was measured by two variables: (1) self report of health (i.e., 5= excellent, 4= very good, 3= good, 2= fair, and 1= poor) and (2) a multiple morbidity index. The multiple morbidity index sums eight diagnosed conditions reported by the participants: high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis.

Cognitive status measures self-reported performance in memory (e.g., self-rated memory, immediate word recall), mental status (e.g., backwards count, date naming), abstract reasoning (e.g., similarities), and vocabulary. The range of possible scores is 0 to 35, but at baseline all participants had scores above the cutoff score of 8 indicative of severe cognitive impairment (Herzog & Wallace, 1997).

All analyses were also adjusted for institutionalization and non-random attrition. Because differences in survival associated with age, gender, race/ethnicity, and health status (Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993) may result in non-random attrition over time and bias the results, all models control for non-random attrition as well. A non-random attrition indicator was calculated using a binary probit method (Berk, 1983) based on predictors identified previously in the literature to be associated with drop-out (e.g., age, gender, race, and health status: Guralnik et al., 1993). This probit method estimated a hazard rate (called inverse Mills ratio or attrition lambda) reflecting the likelihood of dropping out of the study. A higher value of attrition lambda indicates a higher likelihood of not completing the study.

Statistical Analysis

Conditional hierarchical mixed models were used to examine White-Black differences in disability trajectories and the effects of time-varying health behaviors on these trajectories. This statistical method allows the examination of changes in the outcome over time associated with changes in predictors over time (Littell et al., 2005; Raudenbush & Chan, 1993). This method represents an improvement in the data analysis of disability trajectories, because the majority of previous studies used either only baseline values or change scores as predictors.

Time was centered at the mean, and modeled both as a linear and as a quadratic predictor in order to distinguish potential patterns of accelerated change. The random effects specified in all models are intercept and slope which vary among subjects, while all other predictors, covariates, and interaction terms defined above were defined as fixed effects. To reduce multicollinearity between linear and quadratic regression coefficients, age was centered at the mean (Johnson, 2006). Separate models were run for ADL and IADL disability.

In the first step, a model testing the existence of the White-Black gap in disability independent of SES and health status included main (e.g., Race, Time, $Time^2$) and interaction effects of time and race (e.g., Time-by-Race, $Time^2$-by- Race) while controlling for SES and health status (Model I). In the second analytic step, a model testing whether potential residual White-Black differences after adjusting for SES and health status were attributable to health behaviors included additionally the main and time effects of health behaviors (Model II). The effects of each of the health behaviors at univariate level were tested in fully adjusted models, and only the main and time effects that were significant at univariate level were included in the final full model. Therefore, the final model for the whole sample (Model II) included only the significant effects at univariate level for each of the four health behaviors. In the third analytic step, Models III and IV estimated the distinctive effects of health behaviors on trajectories of ALD and IADL disability in fully adjusted models, separately for White and Black older adults.

Results

At baseline, Whites and Blacks were comparable in terms of age and gender composition. Blacks were significantly less likely to be married or partnered and more likely to have fewer years of education, less household wealth, more multiple morbidities, lower cognitive performance score, and to report poorer health compared to Whites. With regard to health behaviors, Blacks were significantly less likely to participate in physical activities, and more likely to be abstainers and to have higher BMI compared to Whites. There were no White-Black differences in smoking. The mean scores of ADL and IADL were higher in Blacks than in Whites (Table 1).

Table 1

Baseline sample description

	Whites (N=4054)	Blacks (N=418)	*p*
Age (*M, SD*)	78.94 (5.44)	78.48 (5.08)	0.131
Gender (% women)	61.14	64.90	0.099
Marital status (% married/ partnered)	52.68	33.76	<0.001
Education (*M, SD*)	11.77 (3.12)	9.90 (3.66)	<0.001
Household wealth *(* M, SD*)*	286,191 (500,857)	76, 507 (206,285)	<0.001
Morbidity (*M, SD*)	1.85 (1.31)	1.99 (1.32)	0.028
Cognition (*M, SD*)	21.58 (4.56)	18.18 (4.75)	<0.001
Self reported health (%)			<0.001
excellent	11.42	4.69	
very good	26.24	21.43	
good	31.67	28.79	
fair	20.93	31.70	
poor	9.74	13.39	
Physical activity (% yes)	34.46	22.82	<0.001
Smoking (%)			0.613
never	46.83	50.89	
former	45.85	39.29	
current	7.33	9.82	
Drinking (%)			<0.001
abstainer	70.22	81.49	
recommended	28.11	16.03	
above recommended	1.67	2.48	
BMI (*M, SD*)	25.10 (4.18)	27.03 (4.75)	<0.001
underweigh*t* (%)	5.01	4.02	
normal (%)	48.53	33.04	
overweight (%)	34.51	39.73	
obese (%)	11.96	23.21	
ADL (*M, SD*)	0.44 (1.02)	0.61 (1.17)	<0.001
IADL (*M, SD*)	0.27 (0.76)	0.43 (0.91)	<0.001

Note. BMI= Body mass index; ADL= Activities of daily living difficulties; IADL= Instrumental activies of daily living difficulties.

Non-parametric t-tests were used to assess ordinal and interval level differences; Mantel-Haenszel chi-square tests were used to test nominal level differences.

ADL disability

Table 2 summarizes the results of the models examining trajectories of ADL disability in White and Black older adults.

Table 2

Trajectories of ADL disability

	Whole sample		Whole sample		Whites		Blacks	
	Model I		Model II		Model III		Model IV	
Fixed effects solution	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*
Intercept	0.57	<0.001	0.71	<0.001	0.73	<0.001	0.50	0.087
Time	0.07	<0.001	0.00	0.915	0.01	0.655	-0.00	0.981
$Time^2$	-0.01	<0.001	0.02	0.010	0.02	0.018	0.01	0.676
Race	0.11	0.018	0.05	0.324				
Time*Race	0.04	0.019	0.07	0.034				
$Time^2$*Race	-0.00	0.699	-0.02	0.306				
Physical activity			-0.13	<0.001	-0.13	<0.001	-0.11	0.185
Drinking			-0.02	0.636	-0.02	0.638	-0.03	0.898
BMI			0.01	0.357	0.03	0.052	-0.20	<0.001
BMI^2			0.11	<0.001	0.10	<0.001	0.26	<0.001
Time*Physical activity			-0.04	0.015	-0.04	0.009	0.02	0.771
Time*Drinking			-0.01	0.409	-0.01	0.359	0.02	0.783
Time*BMI			-0.01	0.200	-0.01	0.133	-0.20	0.304
Time*BMI^2			0.04	<0.001	0.04	0.002	0.07	0.133
$Time^2$*BMI^2			-0.02	0.005	-0.02	0.018	-0.05	0.143
Covariance parameter estimates								
Intercepts	0.55	<0.001	0.51	<0.001	0.49	<0.001	0.60	<0.001
Intercept * Slope	0.14	<0.001	0.06	<0.001	0.05	<0.001	0.11	<0.001
Slopes	0.04	<0.001	0.04	<0.001	0.05	<0.001	0.00	.
Time-specific residuals	0.42	<0.001	0.42	<0.001	0.39	<0.001	0.77	<0.001

Note. ADL= Activities of daily living difficulties; BMI= Body mass index. All models are controlled for age, gender, marital status, education, household wealth, self-reported health, multiple morbidity, cognitive performance, institutionalization, and non-random attrition.

The results of Model I indicate that non-linear, quadratic changes over time offer a good fit for the ADL trajectory (est.= -0.01, $p< .001$). After controlling for SES and health factors, there are still residual longitudinal White-Black differences in ADL (est.= 0.04, p= .019).

In the preliminary analyses of the effects of each of the health behaviors at univariate level in fully adjusted models there were no main or time effects of smoking on ADL (results not shown). Therefore, the main and time effects of smoking were not included in the final full models (Models II-IV). The significant main and time effects at univariate level of the health behaviors included in the final full model are listed in Table 2: Models II-IV.

The covariance parameter estimates for Model II indicate that there is significant inter-individual heterogeneity at baseline (i.e., intercepts) and over time (i.e., slopes) around the mean values (Table 2). Additionally, the positive correlation between intercepts and slopes indicate that those who had more ADL disability at baseline also had a greater increase in ADL disability over time.

The fixed effects solution for Model II shows that after accounting for the effects of health behaviors and adjusting for SES and health factors, the longitudinal White-Black differences persisted (est.= 0.07, p= .034). Participation in physical activity was associated with less increase in ADL disability over time (est. = -0.04, p= .015). The significant linear and quadratic, main and time effects of BMI indicate that participants in extreme BMI groups (e.g., underweight and obese) had more increase in ADL disability over time compared to those in the normal weight and overweight groups. Drinking did not affect longitudinal changes in ADL disability.

To examine distinct effects of these predictors on trajectories of ADL disability in Whites and in Blacks, this final model fully adjusted was run separately for the two race/ethnic groups. There was significant heterogeneity in baseline levels and rates of change over time in ADL disability in Whites as indicated by the covariance parameter estimates for Model III. Additionally, Whites who had higher levels of ADL disability at baseline also had more increase in ADL disability over time. Whites who had participated in physical activity had had less increase in ADL disability over time (Figure 1).

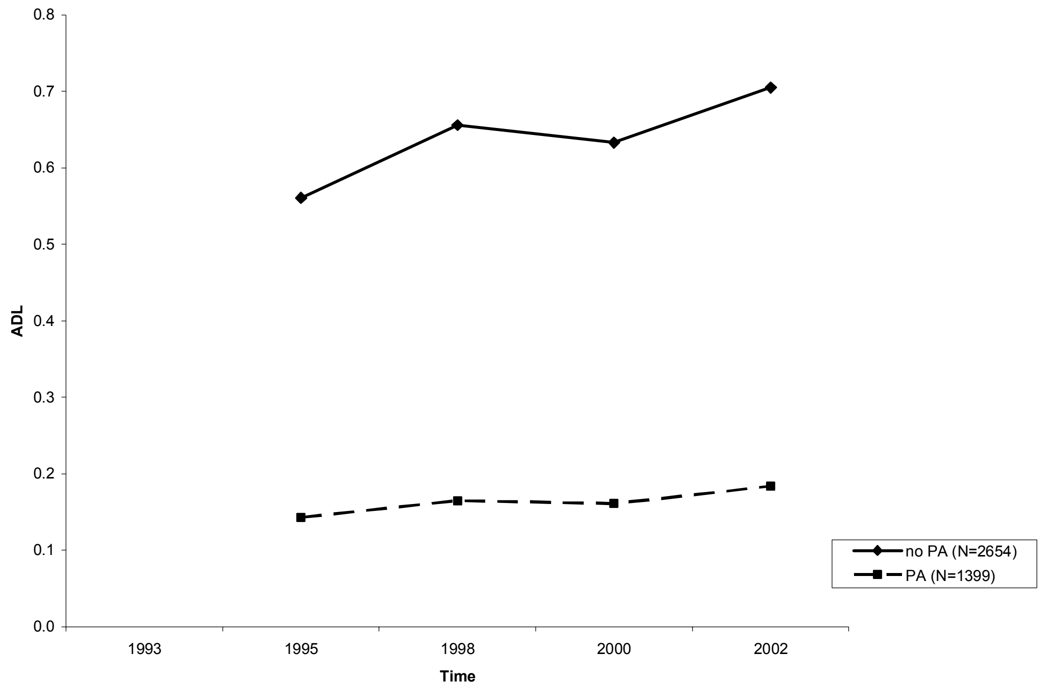


Figure 1. Trajectories of ADL disability by physical activity (PA) participation in Whites. Whites reporting no PA participation are represented by the continuous line; and Whites reporting PA participation by the dotted line.

Similarly, Whites in the normal weight or overweight BMI groups had had less increase over time in ADL disability compared to those in the underweight or obese groups (Figure 2). Therefore a U-shaped relationship between ADL and BMI was identified at each wave of data collection (Figure 3). Again, drinking did not affect longitudinal changes in ADL disability in Whites.

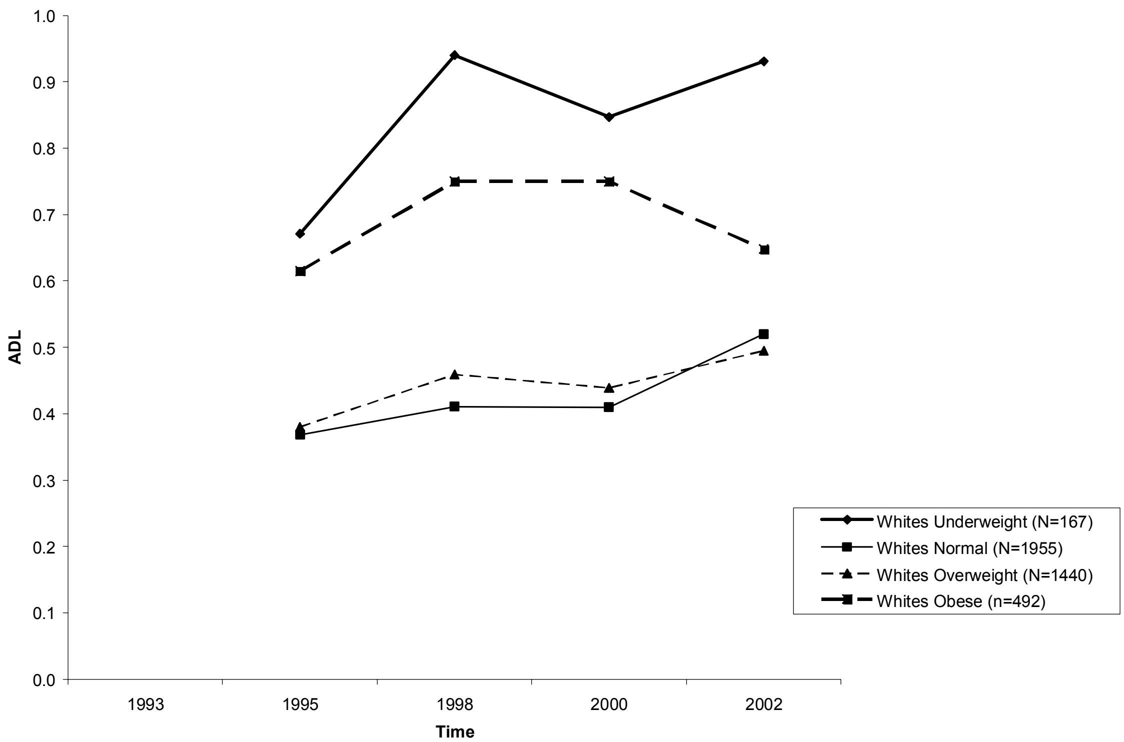


Figure 2. Trajectories of ADL disability by body mass index (BMI) group in Whites. Underweight Whites are represented by the thick continuous line; normal weight by the thin continuous line; overweight Whites by the thin dotted line; and obese Whites by the thick dotted line.

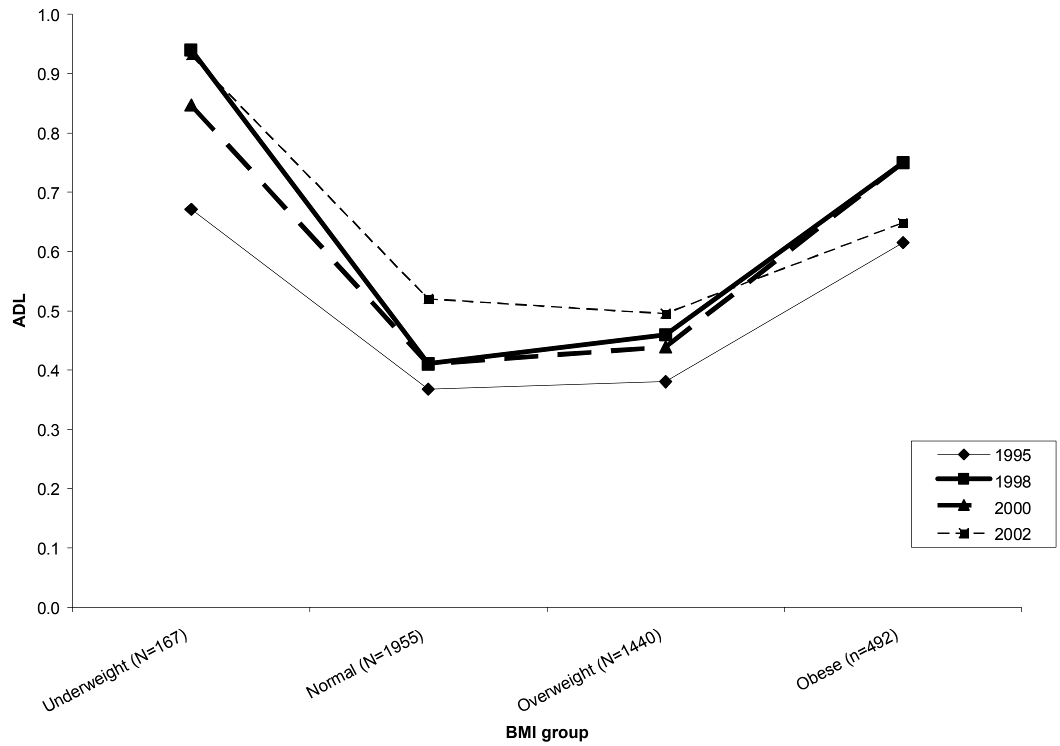


Figure 3. Distribution of ADL disability level by BMI group and by year. The 1995 distribution is represented by the continuous thin line; the 1998 distribution is represented by the continuous thick line; the 2000 distribution is represented by the dotted thick line; and the 2002 distribution is represented by the dotted thin line.

The sample of Blacks was significantly heterogeneous in terms of ADL disability at baseline but not over time, and Blacks who had more ADL at baseline had more increase in ADL over time (Model IV). However, none of the health behaviors affected longitudinal changes in ADL among Blacks, independent of SES and health status, as indicated by the levels of significance ($p > .05$) of the interaction terms between time and these predictors.

IADL disability

The findings of the four models examining trajectories of IADL disability in White and Black older adults are summarized in Table 3.

Table 3

Trajectories of IADL disability

	Whole sample		Whole sample		Whites		Blacks	
	Model I		Model II		Model III		Model IV	
Fixed effects solution	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*
Intercept	0.57	<0.001	0.60	<0.001	0.62	<0.001	0.41	0.050
Time	0.04	<0.001	0.04	<0.001	0.04	0.00	0.08	0.081
Time^2	0.02	<0.001	0.00	0.052	0.01	0.049	-0.01	0.461
Race	0.07	0.040	0.04	0.243				
Time*Race	0.03	0.112	0.02	0.539				
Time^2*Race	-0.03	0.003	-0.03	0.141				
Physical activity			-0.08	<0.001	-0.08	<0.001	-0.08	0.123
Drinking			-0.03	0.031	-0.02	0.028	-0.04	0.531
Time*Physical activity			-0.04	0.001	-0.03	0.004	-0.05	0.288
Time*Drinking			-0.02	0.082	-0.02	0.066	0.01	0.772
Covariance parameter estimates								
Intercepts	0.31	<0.001	0.29	<0.001	0.27	<0.001	0.47	<0.001
Intercept * Slope	0.06	<0.001	0.05	<0.001	0.05	<0.001	0.06	<0.001
Slopes	0.03	<0.001	0.04	<0.001	0.04	<0.001	0.01	0.121
Time-specific residual	0.25	<0.001	0.24	<0.001	0.24	<0.001	0.30	<0.001

Note. IADL= Instrumental activities of daily living difficulties; BMI= Body mass index. All models are controlled for age, gender, marital status, education, household wealth, self-reported health, multiple morbidity, cognitive performance, institutionalization, and non-random attrition.

Model I determines that the trajectories of IADL disability underwent quadratic changes over time (est.= 0.02, $p < .001$). Also, after adjusting for SES and health factors, there were residual White-Black differences in the rates of change over time in IADL (est.= -0.03, $p = .003$).

The main and time effects of the four health behaviors that were significant at univariate level and subsequently included in Model II are noted in Table 3. As in the case of ADL, there were no significant main or time effects for smoking at univariate level on IADL, therefore smoking was not included in the final full model. The covariance parameter estimates for Model II show significant inter-individual variability in levels of IADL disability at baseline and over time independent of SES and health status. In addition, participants who had higher levels of IADL disability at baseline had a higher increase in IADL disability over time.

The fixed effects solution for Model II indicate that the longitudinal White-Black differences in IADL disability were no longer significant (est.= -0.03, $p = .143$) when the effects of health behaviors were entered in the equation, controlling for SES and health factors. Participation in physical activity was the only significant predictor of longitudinal changes in IADL, and was associated with less increase over time in IADL disability, after adjusting for socio-economic and health status.

Model III tests the contributions of the health behaviors on trajectories of IADL disability in Whites, adjusting for SES and health factors. Similar to the results from the whole sample, there was significant heterogeneity in IADL disability at baseline and over time, and a positive correlation between baseline levels and rates of change. Whites who had participated in physical activity had had less increase in IADL disability over time (est.= -0.08, $p < .001$) (Figure 4).

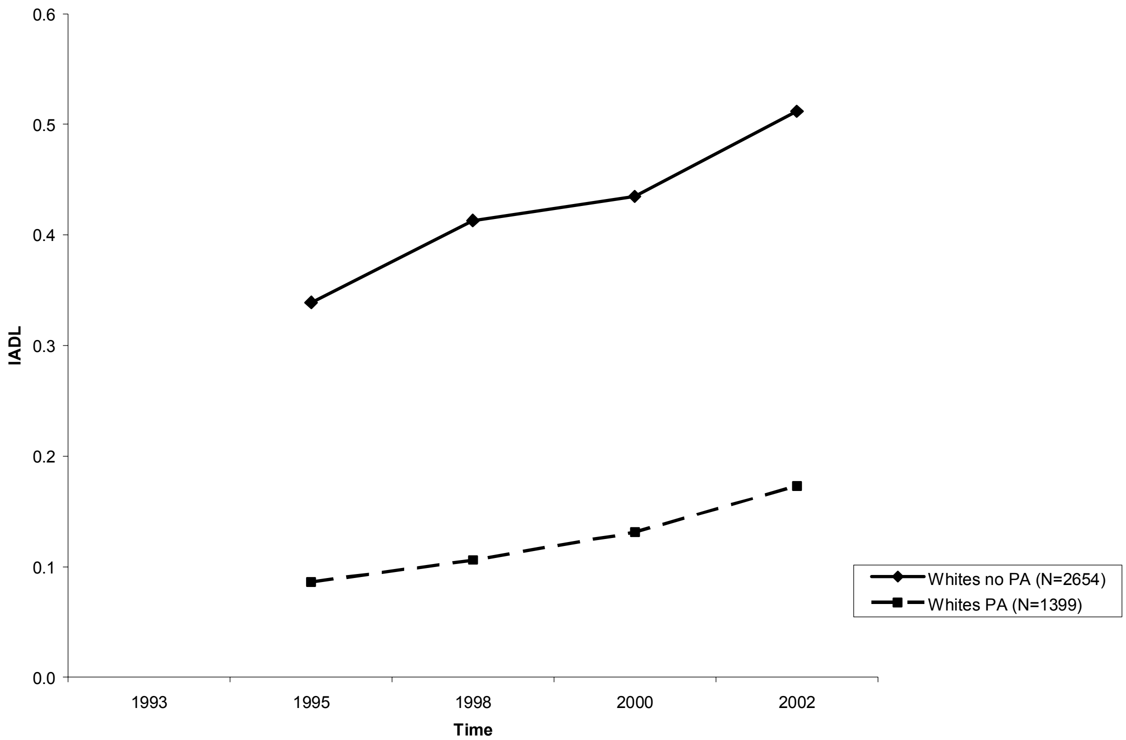


Figure 4. Trajectories of IADL disability by physical activity (PA) participation in Whites. Whites reporting no PA participation are represented by the continuous line; and Whites reporting PA participation by the dotted line.

The effects of health behaviors in trajectories of IADL disability in Blacks are illustrated in Model IV. The covariance parameter estimates for this model show that although there was significant heterogeneity in IADL disability at baseline, the rates of change over time in IADL disability were similar in Blacks. None of the health behaviors affected the longitudinal changes in IADL disability in Blacks, after controlling for SES and health factors.

Discussion

This study examined whether there were remaining White-Black differences in ADL and IADL trajectories after adjusting for SES and health status; whether these residual differences were accounted for by differences in health behaviors; and whether health behaviors affected the trajectories of disability in White and in Black older adults. The hypothesis of this study was confirmed partially.

After adjusting for SES and health factors, there were residual longitudinal White-Black differences in both ADL and IADL. When the effects of the health behaviors were included, adjusting for SES and health status, there were still residual White-Black differences in longitudinal changes in ADL but not for IADL. Therefore, health behaviors accounted for the residual differences in IADL, making the trajectories of IADL comparable between Whites and Blacks, but did not eliminate the divergence in the White-Black ADL trajectories.

Separate analyses for each race/ethnic group revealed that Whites who had participated in physical activity and who had maintained a normal or overweight status had lower rates of increase over time in ADL compared to those who had not, independent of SES and health status. Similar effects of physical activity participation were found for IADL in Whites. Among Blacks, none of the health behaviors affected longitudinal changes in ADL or IADL, adjusting for SES and health status.

White-Black disparities in disability have been documented by cohort panel studies (Clark, 1997; Crimmins & Saito, 2001; Schoeni, Freedman, & Martin, 2005) and longitudinal studies (Kelley-Moore & Ferraro, 2004; Mendes de Leon et al., 1997; Mendes de Leon et al., 2005). Some of these disparities have been attributed to SES and health factors (Clark & Maddox, 1992; Kelley-Moore & Ferraro, 2004; Mendes de Leon et al., 1997; Mendes de Leon et al., 2005; Wray & Blaum, 2001; Zsembik et al., 2000) but little is known about the effects of health and lifestyle behaviors on these disparities. Results from this study show that health behaviors accounted for the residual White-Black longitudinal differences in IADL, after controlling for SES and health status and during a longer follow-up. These results suggest that public health interventions aimed at risk factors reduction may be effective on eliminating White-Black disparities in IADL disability particularly if the targeted behaviors become a permanent lifestyle.

The remaining longitudinal White-Black disparities in ADL, which may be credited to access to and quality of health care, stress, or social support characteristics, suggest that the contribution of such factors should be examined as well. A large body of research indicates that older Blacks are less likely to use primary health care services (U.S. Department of Health and Human Services [USDHHS], 2005) and more likely to use hospital outpatient and emergency room health services (Brega, Goodrich, Powell, & Grigsby, 2005; Gornick et al., 1996), which makes them less likely to receive information about health promotion and disease prevention through healthy lifestyle behaviors. In addition, social support characteristics are known to have protective effects on functional status (Seeman et al., 1995), and may be conducive to practicing healthy lifestyle behaviors.

In the whole sample, participation in physical activity had protective effects on both ADL and IADL disability over time. Previous studies found similar beneficial effects of physical activity on disability in older adults (Berk et al., 2006; Ferraro & Kelley-Moore, 2003; He & Baker, 2004; Reynolds & Silverstein, 2003) but did not examine race/ethnic differences in these effects. This study addressed this knowledge gap by doing separate analyses for each race/ethnic groups and finding protective effects of physical activity on ADL and IADL disability only in Whites but not in Blacks. In Whites, participation in physical activity had enduring protective effects on ADL and IADL disability over time, while lack of participation resulted in a downward spiraling in ADL and IADL disability, despite influences from other correlates of disability. Finding no significant effects on physical activity participation on ADL and IADL in Blacks is intriguing, but may be the result of the small number of Black participants reporting participation in physical activity.

A U-shaped relationship between BMI and functional status was reported previously in a cross-sectional (Galanos et al., 1994) and in a two-wave longitudinal study (Ferraro & Booth, 1999). This study replicated this finding for a longer follow-up for ADL disability in the whole sample, suggesting that the detrimental effects of extreme BMI values on ADL disability are lasting and resulting in an accelerated spiraling down in ADL disability, independent of SES and health status. The novelty of this study consists of the separate by race analyses, which found a U-shaped relationship between ADL and BMI over time but only in Whites. Not finding a significant relationship between BMI and ADL over time among Blacks is intriguing again, particularly because

Blacks had been more likely to be overweight or obese during the entire follow-up (results not shown). Also, this finding is particularly discouraging considering older Blacks' higher likelihood to be obese compared to older Whites (Roberts & Reither, 2004), which places them at proven higher risk for other health outcomes (e.g., cardio-vascular disease, diabetes, osteoarthritis) and would make them a particular target for risk factors reduction interventions. More in-depth analyses are necessary to extricate the potential suppressing effect of confounding variables that may have led to this lack of effects in Blacks.

Finding among Whites a protective effect of normal weight or overweight status over time on ADL but not on IADL may parallel the differences in the tasks measured by these two indices. While performance of ADL tasks (e.g., walking, bathing, dressing) requires more physical abilities, the IADL tasks appraised in this study (e.g., using a phone, taking medications, handling money) are less physically demanding. In view of the biological processes associated with extremely high body weight (e.g., increased load on weight-bearing joints, or reduced cardio-vascular capacity associated with atherosclerosis), or extremely low body weight (e.g., decreases in muscle mass and bone mass; or undernutrition due to depression, social, or financial factors) that may trigger the disablement process, it is possible less physically taxing activities such as IADL tasks are less likely to be affected by obesity or underweight. One piece of supportive evidence for this assumption is the fact that weight loss represents one of the defining criteria of frailty, which is associated with unfavorable outcomes on ADL disability (Boyd, Xue, Simpson, Guralnik, & Fried, 2005; Fried et al., 2001). Yet, weight loss alone is not sufficient to the define frailty, but does so in combination with at least two of the following criteria: exhaustion, weakness, slow gait, or reduced physical activity (Fried et al., 2001).

Drinking had no influence on longitudinal changes in ADL or IADL in Whites or in Blacks at the multivariate level after adjusting for SES and health status. Contrary to other findings of protective effects of moderate alcohol consumption (LaCroix et al., 1993), unfavorable effects of excessive alcohol consumption (Ensrud et al., 1994; Ostermann & Sloan, 2001), or equally detrimental effects of both consuming no alcohol or excessive alcohol (Landerman et al., 1998) on disability, the analyses in this study yielded no relationship between drinking and disability. This lack of effects of drinking on disability may be the result of the skewed distribution of this variable in both Whites and Blacks. In both Whites and Blacks, a very small proportion of participants reported excessive alcohol consumption (e.g., <2%) while a very large proportion of participants reported being abstainers (e.g., >70%). This non-normal distribution of the alcohol consumption variable may have biased the results.

Previous studies found robust evidence that smoking has detrimental effects on functional status (Branch, 1985; Landerman et al., 1998; Ostermann & Sloan, 2001; Reynolds & Silverstein, 2003). Some studies found that smoking was not associated with change in physical performance when the baseline health status was controlled for (Seeman et al., 1995) or that smoking was related to lower disability levels (Kelley-Moore & Ferraro, 2004). In this sample of older adults smoking was not related to ADL or IADL at univariate level when only the effect of smoking was tested while adjusting for SES and health factors. The small proportion of participants reporting current smoking may have influenced these results.

None of the health behaviors affected longitudinal changes in ADL or IADL among Blacks, independent of SES and health factors. Among Blacks there was significant inter-individual variability in baseline levels of ADL and IADL, but there was no significant heterogeneity in the rates of change over time in ADL and IADL. These findings are intriguing because they suggest that Blacks changed over time in a similar fashion, hence those who had practiced healthy lifestyle behaviors during the follow-up had not experienced any beneficial effects on disability. These results should be interpreted with caution given that the size and direction of the estimates of the significant effects of lifestyle behaviors in trajectories of disability in Whites were comparable to those in Blacks. The smaller sample size of Blacks and the non-normal distribution of the health behavior variables may underpin the lack of statistical significance of the effects of lifestyle behaviors among Blacks. Future studies should replicate these analyses on larger samples of Blacks to determine more accurately the effects of health behaviors on disability. Moreover, future studies should use statistical methods to manage the non-normal distribution of these health behavior variables, particularly in Black older adults.

This study aimed at identifying modifiable risk factors for White-Black disparities in disability in older adults and found significant influences over time for physical activity participation and weight status. The complex interactions among the health behaviors examined in this study as well as their distribution in this sample of older adults may underlie the lack of effects for some associations that have been previously demonstrated in the literature. However, the mere detection of risk factors for disability without integrating them into practical applicable prevention agendas would serve no purpose for the elderly population. Modifiable risk factors should lay the foundation for intervention programs aimed at postponing the onset of, reducing the severity of, and recovering from disability (Jette, 1996).

Ferraro and Kelley-Moore (2003) reported that physical activity participation rather than exiting the obese stage resulted in reduced disability over time, suggesting that "intervention via a countervailing mechanism may be equal or superior to risk-factor elimination" (p. 724). Similarly, He and Baker (2004) found that doing vigorous physical activity for more than three times a week reduced the odds of developing new mobility difficulty both in normal weight and in obese people. Findings from this study that both physical activity participation and maintaining a normal weight or overweight status are associated with lower levels of disability over time suggest that disability reduction interventions need to address both these risk factors, despite the beneficial effects of physical activity even in the presence of obesity. The lack of significant influences of physical activity and weight status on trajectories of disability in Blacks, particularly considering Blacks' lower likelihood of participating in physical activity and of maintaining a normal weight or overweight status, raises concerns about the effectiveness of such interventions on White-Black disparities elimination. Nevertheless, the small sample size and the non-normal distribution of these variables among Blacks may have yielded insufficient power to detect significant effects. Therefore, despite the lack of statistical significance detected by the analyses on the sample of Blacks in this study, the existing robust evidence should prevail and Blacks should be targeted by such risk factor reduction interventions. Moreover, such tailored interventions addressing modifiable health risk factors may minimize or eliminate the White-Black disparities in disability.

The particular contribution of this study is the examination of the effects of health behaviors on White-Black disparities in disability in older adults. In addition, this study examined longitudinal changes in health behaviors paralleling longitudinal changes in disability, so that it captures dynamic variations in predictors leading to changes in the outcome. Identifying such modifiable sources of White-Black differences in disability represents one of the basic steps in the course of elimination of disparities, and addresses a major policy agenda contained in *Healthy People 2010* (USDHHS, 2000).

References

Berk, R. A. (1983). An introduction to sample selection bias in sociological data. *American Sociological Review, 48*, 386-398.

Berk, D. R., Hubert, H. B., & Fries, J. F. (2006). Associations of changes in exercise level with subsequent disability among seniors: A 16-year longitudinal study. *Journal of Gerontology Medical Sciences, 61A*, 97-102.

Berkman, L., Singer, B., & Manton, K. (1989). Black/White differences in health status and mortality among the elderly. *Demography, 26*, 661-677.

Binder, E. F., Schechtman, K. B., Ehsani, A. A., Steger-May, K., Brown, M., Sinacore, et al. (2002). Effects of exercise training on frailty in community-dwelling older adults: Results of a randomized, controlled trial. *Journal of the American Geriatrics Society, 50*, 1921-1928.

Boyd, C. M., Xue, Q.-L., Simpson, C. F., Guralnik, J. M., & Fried, L. P. (2005). Frailty, hospitalization, and progression of disability in a cohort of disabled women. *The American Journal of Medicine, 118*, 1225-1231.

Branch, L. G. (1985). Health practices and incident disability among the elderly. *American Journal of Public Health, 75,* 1436-1439.

Brega, A. G., Goodrich, G. K., Powell, M. C., & Grigsby, J. (2005). Racial and ethnic disparities in the outcomes of elderly home care recipients. *Home Health Care Services Quarterly, 24,* 1-21.

Capodaglio, P., Ferri, A., & Scaglioni, G. (2005). Effects of a partially supervised training program in subjects over 75 years of age. *Aging Clinical and Experimental Research, 17,* 174-180.

Centers for Disease Control and Prevention (2006a). US Physical activity statistics: 2003 State demographic data comparison. Retrieved May 31, 2006, from http://apps.nccd.cdc.gov/PASurveillance/PrintDemoCompareV.asp#result

Centers for Disease Control and Prevention (2006b). Trends in health and aging. Smoking status by age, sex, and race/ethnicity: United States, 1997-2004. NHIS (NHISS04). Retrieved June 2, 2006, from http://209.217.72.36/aging/TableViewer/tableView/aspx

Clark, D. O. (1997). U.S. trends in disability and institutionalization among older Blacks and Whites. *American Journal of Public Health, 87*, 438-442.

Clark, D. O., & Maddox, G. L. (1992). Racial and social correlates of age-related changes in functioning. *Journal of Gerontology Social Sciences, 47*, S222-S232.

Crimmins, E. M. & Saito, Y. (2001). Trends in healthy life expectancy in the United States, 1970-1990: gender, racial, and educational differences. *Social Sciences and Medicine, 52,* 1629-1641.

Di Francesco, V., Zamboni, M., Zoico, E., Bortolani, A., Maggi, S., Bissoli, L., et al. (2004). Relationships between leisure-time activity, obesity, and disability in elderly men. *Aging Clinical and Experimental Research, 17*, 201-206.

Dziura, J., Mendes de Leon, C., Kasl, S., & Di Pietro, L. (2004). Can physical activity attenuate aging-related weight loss in older people? The Yale Health and Aging Study. *American Journal of Epidemiology, 159*, 759-767.

Ensrud, K. E., Nevitt, M. C., Yunis, C., Cauley, J. A., Seeley, D. G., Fox, K. M., et al., (1994). Correlates of impaired function in older women. *Journal of the American Geriatrics Society, 42,* 481-489.

Ewing, R., Schmid, T., Killinsworth, R., Zlot, A., & Raudenbuch, S. (2003). Relationship between urban sprawl and physical activity, obesity, and morbidity. *American Journal of Health Promotion, 18,* 47-57.

Ferraro, K. F., & Booth, T. L. (1999). Age, body mass index, and functional illness. *Journal of Gerontology Social Sciences, 54B,* S339-S348.

Ferraro, K. F., & Kelley-Moore, J. A. (2003). Cumulative disadvantage and health: Long-term consequences of obesity? *American Sociological Review, 68*, 707-729.

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., et al. (2001). Frailty in older adults: Evidence for a phenotype. *Journal of Gerontology Medical Sciences, 56A*, M146-M156.

Galanos, A. N., Pieper, C. F., Cornoni-Huntley, J. C., Bales, C. W., & Fillenbaum, G. G. (1994). Nutrition and function: is there a relationship between body mass index and the functional capabilities of community-dwelling elderly? *Journal of the American Geriatrics Society, 42*, 368–373.

Gornick, M. E., Eggers, P. W., Reilly, T. W., Mentnech, R. M., Fitterman, L. K., Kucken, L. E., & Vladeck, B. C. (1996). Effects of race and income on mortality and use of services among Medicare beneficiaries. *The New England Journal of Medicine, 335*, 791-799.

Guralnik, J. M., Land, K. C., Blazer, D., Fillenbaum, G. G., & Branch, L. G. (1993). Educational status and active life expectancy among older Blacks and Whites. *New England Journal of Medicine, 329*, 110-116.

He, X. Z., & Baker, D. W. (2004). Body mass index, physical activity, and the risk of decline in overall health and physical functioning in late middle age. *American Journal of Public Health, 94,* 1567-1573.

Hertzog, C., & Nesselroade, J. R. (2003). Assessing psychological change in adulthood: An overview of methodological issues. *Psychology and Aging, 18*, 639-657.

Herzog, A. R., & Wallace, R. B. (1997). Measures of cognitive functioning in the AHEAD Study [Special Issue]. *The Journals of Gerontology Series B, 52B,* 37-48.

Hubert, H. B., Bloch, D. A., Oehlert, J. W., & Fries, J. F. (2002). Lifestyle habits and compression of morbidity. *Journal of Gerontology Medical Sciences, 57A,* M347-M351.

Inelmen, E. M., Sergi, G., Miotto, F., Peruzza, S., & Enzi, G. (2003). Can obesity be a risk factor in elderly people? *Obesity Reviews, 4*, 147-155.

Johnson, M. (2006). Individual growth analysis using PROC MIXED. *Statistics and Data Analysis,* Paper 253-27. Retrieved March 17, 2006, from http://www2.sas.com/proceedings/sugi27/p253-27.pdf

Julie, J. K., & Jette, A. M. (2001). Have we oversold the benefit of late-life exercise? *Journals of Gerontology Medical Sciences, 56A*, M412-M423.

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

Kelley-Moore, J. A. & Ferraro, K. F. (2004). The black/white disability gap: Persistent inequality in later life? *Journal of Gerontology, 59B*, S34-S43.

LaCroix, A. Z., Guralnik, J. M., Berkman, L. F., Wallace, R. B., & Satterfield, S. (1993). Maintaining mobility in later life. II. Smoking, alcohol consumption, physical activity, and body mass index. *American Journal of Epidemiology, 137*, 858-869.

Landerman, L. R., Fillenbaum, G. G., Pieper, C. F., Maddox, G. L., Gold, D. T., & Guralnik, J. M. (1998). Private health insurance coverage and disability among older Americans. *Journal of Gerontology Social Sciences, 53B*, S258-S266.

Li, L. W. (2005). Predictors of ADL disability trajectories among low-income frail elders in the community. *Research on Aging, 27,* 615-642.

Littell, R. C., Milliken, G. A., Stroup, W. W., & Wolfinger, R. D. (2005). *SAS system for mixed models.* Cary, NC: SAS Publishing.

Mendes de Leon, C. F., Beckett, L. A., Fillenbaum, G. G., Brock, D. B., Branch, L. G., Evans, D. A., & Berkman, L. F. (1997). Black-White differences in risk of becoming disabled and recovering from disability in old age: A longitudinal analysis of two EPESE populations. *American Journal of Epidemiology, 145*, 488-497.

Mendes de Leon, C. F., Barnes, L. L., Bienias, J. L., Skarupski, K. A., & Evans, D. A. (2005). Racial disparities in disability: Recent evidence from self-reported and performance-based disability measures in a population-based study of older adults. *Journal of Gerontology Social Sciences, 60B*, S263-S271.

Moody-Ayers, S. Y., Mehta, K. M., Lindquist, K., Sands, L., & Covinsky, K. E. (2005). Black-White disparities in functional decline in older persons: The role of cognitive function. *Journal of Gerontology Medical Sciences, 60A,* 933-939.

National Institute on Alcohol Abuse and Alcoholism (NIAA: 2006). *Social work education for the prevention and treatment of alcohol use disorders. Module 10C: Older adults and alcohol problems.* Retrieved May 31, 2006, from http://pubs.niaaa.nih.gov/publications/Social/Module10COlderAdults/Module10C.html

Nelson, M. E., Layne, J. E., Bernstein, M. J., Nuernberger, A., Castaneda, C., Kaliton, D., et al. (2004). The effects of multidimensional home-based exercise on functional performance in elderly people. *Journal of Gerontology Medical Sciences, 59A*, 154-160.

Ostermann, J., & Sloan, F. A. (2001). Effects of alcohol consumption on disability among the nearly elderly: A longitudinal analysis. *The Milbank Quarterly, 79.* Retrieved April 23, 2006, from http://www.milbank.org/quarterly/7904feat.html

Peeters, A., Bonneux, L., Nusselder, W. J., De Laet, C., & Barendregt, J. J. (2003). Adult obesity and the burden of disability throughout life. *Obesity Research, 12*, 1145-1151.

Penninx, B. W. J. H., Rejeski, W. J., Pandya, J., Miller, M. E., Di Bari, M., Applegate, W. B., & Pahor, M. (2002). Exercise and depressive symptoms: A comparison of aerobic and resistance exercise effects on emotional and physical function in older persons with high and low depressive symptomatology. *Journal of Gerontology Psychological Sciences, 57B,* P124-P132.

Phelan, E. A. Williams, B., Penninx, B. W. J. H., LoGerfo, J. P., & Leveille, S. G. (2004). Activities of daily living function and disability in older adults in a randomized trial of the Health Enhancement Program. *Journal of Gerontology Medical Sciences, 59A,* 838–843.

RAND Center for the Study of Aging (2006). *Data products: Datasets and files.* Retrieved January 5, 2006 from https://ssl.isr.umich.edu/hrs/files.php

Raudenbush, S. W., & Chan, W. S. (1993). Application of a hierarchical linear model to the study of adolescent deviance in an overlapping cohort design. *Journal of Consulting and Clinical Psychology, 61,* 941-951.

Reynolds, S. L., Saito, Y., & Crimmins, E. M. (2005). The impact of obesity on active life expectancy in older American men and women. *The Gerontologist, 45*, 438-444.

Reynolds, S. L., & Silverstein, M. (2003). Observing the onset of disability in older adults. *Social Science and Medicine, 57,* 1875-1889.

Roberts, S. A., & Reither, E. N. (2004). A multilevel analysis of race, community disadvantage, and body mass index among adults in the US. *Social Science and Medicine, 59,* 2421-2434.

Seeman, T. E., Berkman, L. F., Charpentier, P. A., Blazer, D. G., Albert, M. S., & Tinetti, M. E. (1995). Behavioral and psychological predictors of physical performance: MacArthur Studies of Successful Aging. *Journal of Gerontology Medical Sciences, 50A*, M177-M183.

Soldo, B. J., Hurd, M. D., Rodgers, W. L., & Wallace, R. B. (1997). Asset and Health Dynamics Among the Oldest Old: An overview of the AHEAD study [Special Issue]. *Journals of Gerontology Series B, 52B,* 1-20.

Sturm, R., Ringel, J. S., & Andreyeva, T. (2004). Increasing obesity rates and disability trends. *Health Affairs, 23,* 199-205.

Sudano, J. J., & Baker, D. W. (2006). Explaining US racial/ethnic disparities in health declines and mortality in late middle age: The roles of socioeconomic status, health behaviors, and health insurance. *Social Science and Medicine, 62*, 909-922.

Tabachnick B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4^{th} ed.) (pp.66-71). Boston: Allyn and Bacon.

U.S. Department of Health and Human Services (2000). *Healthy People 2010: Understanding and Improving Health* (2^{nd} ed). Washington, DC: U.S. Government Printing Office.

U.S Department of Health and Human Services (2005). *Health, United States, 2005.* Retrieved on June 1, 2006, from http://www.cdc.gov/nchs/data/hus/hus05.pdf.

Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Social Sciences and Medicine, 38,* 1-14.

Wannamethee, S. G., Shaper, A. G., Whincup, P. H., & Walker, M. (2004). Overweight and obesity and the burden of disease and disability in elderly men. *International Journal of Obesity, 28,* 1374-1382.

Wei, M., Kampert, W. M., Barlow, C. E., Nichman, M. Z., Gibbons, L. W., Paffenbarger, R. S., & Blair, S. N. (1999). Relationship between low cardio-respiratory fitness and mortality in normal-weight, overweight, and obese men. *Journal of the American Medical Association, 282*, 1547-1553.

Winkleby, M. A., Cubbin, C., Ahn, D. K., & Kraemer, H. C. (1999). Pathways by which SES and ethnicity influence cardiovascular disease risk factors. *Annals of the New York Academy of Sciences, 896*, 191-209.

World Health Organization (2007). *Global database on body mass index: BMI classification*. Retrieved March 27, 2007 from http://www.who.int/bmi/index.jsp?introPage=intro_3.html

Wray, L. A., Alwin, D. F., & McCammon, R. J. (2005). Social status and risky health behaviors: Results from the Health and Retirement Survey [Special Issue]. *Journal of Gerontology Series B, 60B)*, 85-92.

Wray, L. A., & Blaum, C. S. (2001). Explaining the role of sex on disability: A population-based study. *The Gerontologist, 41*, 499-510.

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

Zoico, E., Di Francesco, V., Guralnik, J. M., Mazzali, G., Bortolani, A., Guariento, S., et al. (2004). Physical disability and muscular strength in relation to obesity and different body composition indexes in a sample of healthy elderly women. *International Journal of Obesity, 28,* 234-241.

STUDY 2

WHITE-BLACK DISPARITIES IN DISABILITY: THE INFLUENCE OF HEALTH CARE UTILIZATION

Abstract

White-Black disparities in disability have been attributed to factors that have little potential to be amended, such socio-economic status or chronic conditions. The effects of health care utilization, a modifiable influence on disability, on White-Black disparities in disability has received modest attention in the gerontological research. This study addresses this knowledge gap by examining differences in the effects of using specific health care services on trajectories of disability in White and Black older adults, after controlling for established determinants of health care utilization.

Using data from the 1993-2002 waves of the Asset and Health Dynamics Among the Oldest Old study, this study examines distinct influences of doctor visit, hospital, short-stay nursing home, and home health care utilization on trajectories of basic (ADL) and instrumental (IADL) activities of daily living in a sample of 4,774 White and 513 Black older adults. Trajectories of ADL and IADL disability were fit using mixed effects models with time-varying predictors.

Independent of determinants of health care utilization, there were no White-Black differences in trajectories of ADL and IADL disability associated with doctor visit

utilization. Hospital utilization was associated with higher levels of ADL and IADL disability over time in Whites, but had no effect on Blacks. Short-stay nursing home and home health care utilization did not affect trajectories of ADL and IADL disability in Whites, but were associated with lower levels of ADL and IADL disability over time in Blacks.

Policies and regulations assuring equal quality and availability of health care services for older adults may represent a stepping stone toward minimizing or eliminating White-Black disparities in disability.

Introduction

One overarching goal of *Healthy People 2010,* the 10-year health objectives agenda developed by the U.S. Department of Health and Human Services (USDHHS), targets eliminating health disparities in the U.S. population (USDHHS, 2000). Previous studies found White-Black disparities in disability in the older population related to differences in socio-economic status (Crimmins & Saito, 2001; Geronimus, Bound, Waidman, Colen, & Steffick, 2001; Mendes de Leon et al., 1997; Mendes de Leon, Barnes, Bienias, Skarupski, & Evans, 2005), chronic illness (Kelley-Moore & Ferraro, 2004), or cognitive limitation (Zsembik, Peek, & Peek, 2000), which, to a large extent, cannot be changed. However, little is known about the influence of modifiable factors on White-Black disparities in disability, such as health care utilization.

Two theoretical frameworks provide explanatory mechanisms for the relationship between disability and health care utilization, and for patterns of health care utilization. The disablement model posits that the rate of progression from pathological processes specific to a disease to impairments, functional limitations, and disability can be attenuated or reversed by interventions such as health care services (Verbrugge & Jette, 1994). Furthermore, a primary disability may trigger feedback effects over time with additive outcomes on global disability (Verbrugge & Jette, 1994), and this may result in a downward spiraling in disability which may be influenced as well by health care utilization. Therefore, utilization of health care services may affect changes in disability over time, and differences in health care utilization may result in disparities in trajectories of disability.

Andersen's behavioral model (1995) states that health care utilization is determined by predisposing (e.g., socio-demographics), enabling (e.g., economic status and health insurance), and need factors (e.g., health conditions). Several studies have reported supportive evidence for this model (Branch et al., 1988; Chernew, Goldman, Pan, & Shang, 2005; Dunlop, Manheim, Song, & Chang, 2002; Fortinsky, Fenster, & Judge, 2004; Freedman, Aykan, Wolf, & Marcotte, 2004; French & Kamboj, 2002; Klein, Turvey, & Wallace, 2004; Hurd & McGarry, 1997; Stump, Johnson, & Wolinsky, 1995; Wolinsky & Johnson, 1991).

Although disability was often examined as a predictor for health care utilization, few studies investigated the effects of health care utilization on disability independent of predisposing, enabling, and need factors, particularly as a potential determinant of White-Black disparities in disability. If health care services aim at maintaining or improving health status, do White and Black older adults experience similar benefits on disability from using health care services, independent of predisposing, enabling, and need factors?

The gerontological literature provides little guidance to answer this question. One study examining the Duke sample of the Established Populations for the Epidemiologic Study of the Elderly during six annual follow-ups (Landerman et al., 1998) found that the number of physician visits and hospitalizations predicted higher odds of disability onset in those not disabled at baseline, independent of demographics, socio-economic and health status, and health insurance. Another study examined a sample of older stroke patients from the Longitudinal Study of Aging over a 2-year period and reported that more physician visits and more hospitalizations resulted in better disability outcomes after adjusting for socio-economic and health status (Dighe, Aparasu, & Rappaport, 1997). However, neither of these two studies examined White-Black differences in this relationship.

White-Black differences in the outcome of home health care utilization on disability were investigated by two studies reporting incongruent findings, probably resulting from the differences in the samples of older adults examined. Brega and colleagues (2005) used a nationally representative sample of older recipients of home health care services and found that Whites had better overall improvement in disability at discharge compared to Blacks, independent of demographics, health status, and health insurance. Peng and colleagues (2003), however, examined a sample of older home health care services recipients from a major urban area, and found no significant White-Black differences in improvement in disability after similar adjustments.

White-Black Differences in Health Care Services Utilization

Inconsistent patterns of physician visit utilization for White and Black older adults are reported in the literature. For instance, statistics from the USDHHS (2005) indicate that White older adults are more likely to see their doctors compared to Blacks. Some researchers reported that White older adults have more physician visits compared to Blacks when adjusting for age and gender (Gornick et al., 1996); others found that Blacks use more physician visits independent of predisposing, enabling, and need factors (Wolinsky & Johnson, 1991). Still others reported that older Black males are less likely to have any physician contact and older Black females to have more physician visits compared to older White males, regardless of economic access and health needs (Dunlop et al., 2002).

Two studies reported that Blacks are less likely to be admitted to the hospital but equally likely to use nursing home care compared to Whites independent of predisposing, enabling, and need factors (Dunlop et al., 2002; Wolinsky & Johnson, 1991). Other findings indicate that older Blacks have more hospital outpatient and emergency room visits, higher rates of hospitalization, and longer average length of stay in short-stay hospitals than older Whites (Gornick et al., 1996; USDHHS, 2005). These latter patterns of hospital services utilization in older Blacks suggest that they are admitted to the hospital in a deteriorated health status that requires longer health care, receive poorer disease management from outpatient services, or underuse outpatient services.

Inconsistent data on White-Black differences in rates of home health care utilization, as well as the effects of home health care utilization on disability, are also reported in the literature. For example, Dunlop and colleagues (2002) found no White-Black differences in home health care utilization after controlling for health needs and economic access, while Wolinsky and Johnson (1991) found that Blacks were more likely to use these health services after similar adjustments.

The inconsistencies in health care utilization by race, as well as the scant and inconsistent knowledge on the effects of health services utilization on disability by race, call attention to the need for further investigation. In light of the *Healthy People 2010* agenda of elimination of health disparities, this study investigates longitudinal effects of health care utilization on disability in White and Black older adults, and addresses the following research question: Are there White-Black differences in the effects of using specific health care services on trajectories of disability, independent of predisposing, enabling, and need determinants of health care utilization?

Considering the empirical evidence for White-Black disparities in access to health care (Crimmins & Saito, 2005; Mayberrry, Mili, & Ofili, 2000; USDHHS, 2000) and health status (Hayward, Crimmins, Miles, & Yang, 2000; Kelley-Moore & Ferraro, 2004; Mayur, Zhang, & Hagan Hennessy, 1999; Reynolds & Silverstein, 2003), as well as the disparities in health care utilization independent of these correlates (Dunlop et al., 2002; Wolinsky & Johnson, 1991) it is likely that the White-Black differences in health care utilization are reflected in different trajectories of disability.

Methods

Data and Study Population

The data for this study come from Asset and Health Dynamics Among the Oldest Old (AHEAD) study, which was compiled and made publicly available by RAND Center for the Study of Aging (RAND, 2006). The AHEAD cohort is a nationally representative sample of 8,222 community-dwelling elders aged 70 years and older at baseline in 1993, including spouses/ partners regardless of age. Participants were re-interviewed in 1995, 1998, 2000, and 2002. A detailed description of the study design and sampling methods is presented elsewhere (Soldo, Hurd, Rodgers, & Wallace, 1997).

The inclusion criteria for selecting this study sample from the original AHEAD cohort include age 70 and older, White and Black race, non-demented cognitive status (Herzog & Wallace, 1997), non-proxy responses, non-institutionalized, and having

Medicare coverage. After applying these inclusion criteria, the baseline sample includes 5,287 participants: 4,774 (90.30%) Whites and 513 (9.70%) Blacks. The overall attrition rate during the 9 years of follow-up was 54.73% in Whites (e.g., 34.41% due to death, 6.89% due to proxy responses, and 4.94% due to institutionalization) and 57.70% in Blacks (e.g., 38.60% due to death, 7.01% due to proxy responses, and 3.89% due to institutionalization).

Measures

Outcome variables

The outcome variables for this study are self-reported difficulties with basic (ADL) and instrumental (IADL) activities of daily living. Difficulties with ADLs are measured by a summary index including six tasks (i.e., bathing, eating, dressing, walking across a room, using the toilet, and getting in and out of bed) (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963). The range of scores for this index varies from 0 to 6, where 0 represents no difficulty and 6 represents difficulty with all six ADLs. Difficulty with IADLs is measured by a summary index including five tasks (e.g., using a phone, taking medications, handling money, shopping, and preparing meals). The scores for this index range from 0 to 5, where 0 represents no difficulty and 5 represents difficulty with all five IADLs.

Predictor variables

Health care utilization in the reference period is measured by participants' self-reported utilization of any physician visit, hospital stay, post-acute nursing home stay, and home care services. All these health care utilization indicators are measured at each wave by dummy variables indicating whether or not the participant reported using that specific service.

To account for potential differences in the effects of health care utilization on disability related to the amount of services used, utilization of each of these health services is controlled for amount of utilization. The exception is home health care for which such information is not available in the AHEAD dataset. Therefore, number of doctor visits is a control variable for the model estimating the effects of any doctor visits utilization; average length of hospitalization (e.g., the ratio between total number of nights hospitalized and the total number of hospitalizations during the reference period) is a control variable for the model estimating the effects of any hospital utilization; and average length of nursing home stay (e.g., the ratio between total number of nights spent in the nursing home and the total number of stays during the reference period) is a control variable for the model estimating the effects of any nursing home stay on trajectories of disability.

Control variables

Demographics include age, gender (0= male; 1=female), race (0= White; 1= Black), and marital status (0=married, 1= not married). Socio-economic status is measured by educational attainment (range: 0-17 years of formal education; centered at 12 years) and net household wealth. The net wealth variable represents the sum of all self-reported wealth (i.e., housing, real estate, checking, savings, bonds, CDs, assets, transportation, business, IRA, stocks) minus all debt (i.e., mortgage, debt). Outlier values for the wealth variable were replaced with the corresponding value of +/-3.29 of their standardized z score (Tabachnick & Fidell, 2001). Because the wealth variable has a very wide range of values and a skewed distribution, the original continuous variable was recoded into an ordinal variable based on the quartile distribution of the baseline values.

Health status is measured at each wave by two variables: a self report of general health (i.e., 5= excellent, 4= very good, 3= good, 2= fair, and 1= poor) and a multiple morbidity index. The multiple morbidity index sums the conditions the participants reported being diagnosed with, and includes eight illnesses: high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis.

The cognitive status variable measures self-reported performance in memory (e.g., self-rated memory, immediate word recall, delayed word recall, and serial 7's test), mental status (e.g., backwards count, date naming, object naming, and president/vice-president naming), abstract reasoning (e.g., similarities), and vocabulary. The range of possible scores is 0 to 35, and at baseline all participants had scores above the cutoff score of 8 indicative of severe cognitive impairment (Herzog & Wallace, 1997).

Health insurance coverage is measured by a dichotomous variable indicating having Medicare only (with a value of 0) versus having Medicare and any other type of health insurance (with a value of 1).

Because differences in survival associated with age, gender, race/ethnicity, and health status (Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993) may result in non-random attrition over time and bias the results, all models control for non-random attrition as well. A non-random attrition indicator was calculated using a binary probit method (Berk, 1983) based on predictors identified previously in the literature to be associated with drop-out (e.g., age, gender, race, and health status: Guralnik et al., 1993). This probit method estimated a hazard rate (called inverse Mills ratio or attrition lambda) reflecting likelihood of dropping out of the study. A higher value of attrition lambda indicates a higher likelihood of not completing the study.

Statistical Analysis

Mixed effects models analyses with time-varying predictors are used to examine the effects of health care utilization on longitudinal trajectories of disability. The random effects specified in all models are intercept and slope which vary among subjects, while all other predictors, covariates, and interaction terms defined above are defined as fixed effects. To reduce multicollinearity between linear and quadratic regression coefficients, age is centered at the mean (Johnson, 2006). Time also is centered at the mean.

In the first step of the analytic plan, models including the main and time effects of race (e.g., Race, Time-by-Race) and health care utilization (e.g., Health care service, Time-by-Health care service), as well as the race differences in the time effects of health care utilization (e.g., Time-by-Race-by-Health care service) are run to examine potential race differences in the longitudinal effects of health care services on rates of change in disability. If race differences in the time effects of health care utilization are identified, then the models are run separately by race to distinguish distinct effects of health care utilization within each race group. All models are controlled for predisposing (e.g., age, gender, marital status), enabling (e.g., education, wealth, health insurance), and need factors (e.g., self-reported health, number of chronic illnesses), as well as for cognitive status and non-random attrition. Additionally, all models but the one for home health care utilization are also controlled for amount of utilization, which is number of doctor visits, average length of hospital stay, and average length of nursing home stay.

Separate models are run for each disability outcome (i.e., ADL, IADL), and for each indicator of health care utilization (i.e., doctor visits, hospitalization, nursing home stay, and use of home health care).

Results

At baseline White and Black participants are comparable in terms of age and gender (Table 4).

Table 4
Baseline sample description

Variable	Whites (N=4774)	Blacks (N= 513)	*p*
Age (*M, SD*)	76.99 (5.44)	76.48 (5.13)	0.070
Gender (% women)	61.19	65.11	0.086
Marital status (% married/partnered)	55.73	38.29	<0.001
Education (*M, SD*)	11.76 (3.10)	9.84 (3.67)	<0.001
Household wealth (*M, SD*)	191,665 (251,724)	61,396 (103,835)	<0.001
Multiple morbidity (M, SD)	1.41 (1.17)	1.64 (1.19)	<0.001
Cognition (*M, SD*)	21.11 (4.78)	17.51 (4.90)	<0.001
Self reported health (%)			<0.001
excellent (%)	12.05	6.63	
very good (%)	25.71	17.54	
good (%)	32.84	30.80	
fair (%)	20.77	30.80	
poor (%)	8.63	14.23	
Health insurance (% Medicare only)	11.81	32.55	<0.001
Any doctor visit (% yes)	89.66	90.89	0.392
Number of doctor visits (*M, SD, range*)	4.99 (4.51; 1-24)	5.51 (4.95; 1-24)	0.045
Any hospitalization (% yes)	20.78	22.42	0.392
Average length of hospitalization (*M, SD, range*)	5.72 (4.92; 0.50-29.00)	6.12 (5.82; 0.33-29.00)	0.886
Any nursing home stay (% yes)	0.90	0.78	0.781
Average length of nursing home stay (*M, SD, range*)	19.33 (8.55; 2.00-28.00)	21.00 (8.08; 14.00-28.00)	0.701
Any home health care (% yes)	7.64	8.50	0.483
ADL *(M, SD)*	0.25 (0.72)	0.40 (0.96)	<0.001
IADL (*M, SD*)	0.29 (0.70)	0.35 (0.76)	0.041

Note. ADL= Activities of daily living disability; IADL= Instrumental activities of daily living disability. Non-parametric t-tests were used to assess ordinal and interval level differences; Mantel-Haenszel chi-square tests were used to test nominal level differences. Average length of hospitalization, nursing home stay, and home health care are measured in days per occurrence.

Blacks were less likely to be married or partnered, and more likely to have less education, less household wealth, more multiple morbidities, and lower levels of cognitive performance compared to Whites. Blacks were also more likely to report fair or poor health and to have only Medicare coverage than Whites.

The reference period for health care utilization at baseline represents the 12 months previous to the interview. Similar proportion of Whites and Blacks reported having any doctor visit, but Blacks reported on average higher numbers of doctor visits than in Whites.

There were no White-Black differences in the rates of using any hospital or nursing home services or the average amount of utilization in these services, and no differences in the rates of using home health care services. Blacks had more ADL and IADL disability at baseline compared to Whites, with mean level values showing difficulty with less than one ADL/IADL task in both groups.

Doctor visit utilization

There were no significant White-Black differences in the rates of change in ADL (est.=-0.09, p= .188) or IADL (est. = 0.01, p= .896) disability associated with doctor visit utilization, independent of correlates of health care utilization and number of doctor visits (Table 5). Therefore, analyses stratified by race were not examined.

Table 5
The effects of using any doctor visit on trajectories of disability

	Model I		Model II	
	ADL		IADL	
Predictors	Estimate	*p*	Estimate	*p*
Intercept	0.47	<0.001	0.52	<0.001
Time	0.05	0.009	-0.01	0.599
Race	0.09	0.453	-0.02	0.836
Time*Race	0.13	0.060	0.02	0.690
Any doctor visit	-0.06	0.107	0.01	0.601
Any doctor visit*Race	-0.09	0.440	-0.05	0.610
Time*Any doctor visit	0.01	0.774	0.04	0.015
Time*Race*Any doctor visit	-0.09	0.188	0.01	0.896

Note. Model I predicts ADL trajectories; Model II predicts IADL trajectories. Both models are controlled for age, gender, marital status, education, wealth, self-reported health, number of chronic illnesses, cognition, health insurance, number of doctor visits, and non-random attrition.

Hospital utilization

Table 6 summarizes the results of the analytic models examining the effects of having had any hospital stay on trajectories of disability.

Table 6

The effects of using any hospitalization on trajectories of disability

	ADL						IADL					
	Model I		Model II		Model III		Model IV		Model V		Model VI	
	Whole sample		Whites		Blacks		Whole sample		Whites		Blacks	
Predictors	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*
Intercept	0.46	<0.001	0.48	<0.001	0.18	0.407	0.55	<0.001	0.58	<0.001	0.09	0.554
Time	0.05	<0.001	0.05	<0.001	0.09	<0.001	0.02	<0.001	0.02	<0.001	0.07	<0.001
Race	0.01	0.830					-0.09	0.009				
Time*Race	0.05	0.007					0.04	0.012				
Any hospitalization	0.02	0.029	0.02	0.161	-0.01	0.909	0.02	0.136	0.02	0.118	0.10	0.043
Any hospitalization*Race	0.02	0.672					0.10	0.016				
Time*Any hospitalization	0.05	<0.001	0.05	<0.001	-0.01	0.804	0.03	<0.001	0.03	<0.001	-0.02	0.562
Time*Race*Any hospitalization	-0.07	0.042					-0.06	0.031				

Note. Models I-III predict ADL trajectories; Model IV-VI predict IADL trajectories. All models are controlled for age, gender, marital status, education, wealth, self-reported health, number of chronic illnesses, cognition, health insurance, average length of hospitalization, and non-random attrition.

Model I, using the whole sample, revealed significant White-Black differences in the longitudinal effects of hospitalization on ADL disability (est. = -0.07, *p*= .042), after controlling for correlates of health care utilization and average length of hospitalization. Further analyses stratified by race, fully adjusted, indicate that in Whites hospitalization is related to higher levels of ADL over time (est. = 0.05, *p*< .001) (Table 6: Model II), while in Blacks there was no significant effect of hospitalization on ADL trajectories (est. = -0.01, *p*= .804) (Table 6: Model III).

Similar patterns were detected for IADL trajectories, where in the fully adjusted model using the entire sample there were White-Black differences associated with hospitalization (est.= -0.06, *p*= .031) (Table 6: Model IV). Analyses stratified by race indicate that being hospitalized is associated with higher levels of IADL disability over time in Whites (est. = 0.03, *p*< .001) (Table 6: Model V), while being hospitalized did not affect IADL trajectories in Blacks (est. = -0.02, *p*= .562) (Table 6: Model V).

Short-stay nursing home utilization

Having used any post-acute nursing home services resulted in significantly different rates of change in ADL between Whites and Blacks (est.= -0.29, *p*= .023), independent of established determinants of health care utilization and average length of nursing home stay (Table 7: Model I). In analyses stratified by race the effects of having any post-acute nursing home stay were no longer significant for Whites (est.= 0.02, *p*= .376) (Table 7: Model II) but for Blacks nursing home utilization resulted in lower levels of ADL disability over time (est.= -0.51, *p*= .003) (Table 7: Model III).

Table 7

The effects of using any nursing home stay on trajectories of disability

	ADL						IADL					
	Model I		Model II		Model III		Model IV		Model V		Model VI	
	Whole sample		Whites		Blacks		Whole sample		Whites		Blacks	
Predictors	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*
Intercept	0.50	<0.001	0.52	<0.001	0.11	0.626	0.56	<0.001	0.61	<0.001	0.08	0.615
Time	0.06	<0.001	0.06	<0.001	0.07	0.001	0.03	<0.001	0.03	<0.001	0.06	<0.001
Race	-0.01	0.823					-0.05	0.118				
Time*Race	0.03	0.132					0.03	0.031				
Any nursing home stay	0.28	<0.001	0.30	<0.001	0.40	0.253	0.30	<0.001	0.29	<0.001	0.66	0.009
Any nursing home stay*Race	0.98	<0.001					0.01	0.926				
Time*Any nursing home stay	0.02	0.434	0.02	0.376	-0.51	0.003	0.04	0.115	0.03	0.152	-0.31	0.010
Time*Race*Any nursing home stay	-0.29	0.023					-0.44	<0.001				

Note. Models I-III predict ADL trajectories; Model IV-VI predict IADL trajectories. All models are controlled for age, gender, marital status, education, wealth, self-reported health, number of chronic illnesses, cognition, health insurance, average length of nursing home stay, and non-random attrition.

In the model examining IADL trajectories in the entire sample there were significant White-Black differences in rates of change associated with using any post-acute nursing home services (est.= -0.44, $p< .001$), after adjusting for established determinants of health care utilization and average length of nursing home stay (Table 7: Model IV). Using nursing home care had no effect on IADL trajectories among Whites (est. = 0.03, $p= .152$), but resulted in lower levels of IADL disability over time in Blacks (est. = -0.31, $p= .010$). Therefore, short-stay nursing home utilization had a positive effect among Blacks on both ADL and IADL trajectories, independent of established correlates of health care utilization and amount of utilization.

Home health care utilization

There were significant White-Black differences in ADL and IADL trajectories associated with home health care utilization (ADL: est. = -0.18, $p < .001$; IADL: est. = -0.17, $p < .001$) in fully adjusted models (Table 8: Model I, Model IV). Blacks who have used home health care services had lower rates of change in both ADL (est. = -0.15, $p = .016$) and IADL (est. = -0.17, $p < .001$) disability over time. However, home health care utilization did not affect ADL or IADL trajectories among Whites (Table 8: Model II, Model V).

Table 8

The effects of using any home health care on trajectories of disability

	ADL						IADL					
	Model I		Model II		Model III		Model IV		Model V		Model VI	
	Whole sample		Whites		Blacks		Whole sample		Whites		Blacks	
Predictors	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*
Intercept	0.46	<0.001	0.49	<0.001	0.21	0.352	0.56	<0.001	0.58	<0.001	0.26	0.095
Time	0.06	<0.001	0.06	<0.001	0.09	<0.001	0.03	<0.001	0.03	<0.001	0.07	<0.001
Race	0.02	0.714					-0.09	0.008				
Time*Race	0.05	0.007					0.04	0.015				
Any home health care	0.42	<0.001	0.42	<0.001	0.36	<0.001	0.33	<0.001	0.34	<0.001	0.56	<0.001
Any home health care*Race	-0.08	0.272					0.22	<0.001				
Time*Any home health care	0.01	0.729	0.00	0.847	-0.15	0.016	-0.00	0.942	-0.00	0.950	-0.17	<0.001
Time*Race*Any home health care	-0.18	<0.001					-0.17	<0.001				

Note. Models I-III predict ADL trajectories; Model IV-VI predict IADL trajectories. All models are controlled for age, gender, marital status, education, wealth, self-reported health, number of chronic illnesses, cognition, health insurance, and non-random attrition.

Discussion

The aim of this study was to determine whether there are White-Black differences in the effects of using specific health care services on trajectories of disability, independent of correlates of health care utilization. This study had two unique contributions. One is the utilization of time varying predictors, where trajectories of disability are estimated using dynamic predictors measured at each wave, and therefore addressing changes over time in predictors as well. The other is the modeling of the effects of distinct health care services utilization on trajectories of disability after accounting for established correlates of health care utilization.

The results of this study revealed complex patterns of influence of health care utilization on disability in White and Black older adults. There were no White-Black differences in ADL or IADL trajectories associated with using doctor visits, after controlling for established determinants of health care utilization and number of doctor visits. Hospital utilization resulted in increased levels in both ADL and IADL over time among Whites but had no effects among Blacks, independent of determinants of health care utilization and average length of stay. Using short-stay nursing home and home health care services was related with decreased levels in both ADL and IADL over time among Blacks but had not effect among Whites, after similar adjustments.

Older Blacks' higher disability levels have been ascribed to their lower socio-economic status or poorer health (Kelley-Moore & Ferraro, 2004; Mendes de Leon et al., 1997; Mendes de Leon et al., 2005; Zsembik et al., 2000). Medicare has the potential to reduce the health disparities accumulated during the life course in the older population (Markides & Black, 1996; Sudano & Baker, 2006) through its almost universal health care coverage (Eichner & Vladeck, 2005). Nevertheless, White-Black disparities in disability still persist (USDHHS, 2005) probably because Medicare benefits are not comprehensive, and older Blacks are less able to afford co-payments, deductibles, uncovered services, medication, or supplemental insurance (Dunlop et al., 2002; Heisler et al., 2004; Klein et al., 2004; USDHHS, 2000). Finding that health insurance mediates the effects of income on disability (Landerman et al., 1998) supports this assumption.

When reaching the health care system, older Blacks are more likely to be in poorer health status than Whites. Blacks have earlier onset for chronic diseases such as high blood pressure, stroke, or diabetes compared to Whites, independent of socio-economic status (Hayward et al., 2000). This earlier disease onset indicates that the disablement process may start earlier on among Blacks. As a result, Blacks may reach older age with more advanced stages of chronic diseases that are more difficult to manage and more advanced stages of disability development which may be more difficult to reverse.

Although Blacks appear to reach older age with a lifelong accumulation of health adversity, their disadvantage in health could be minimized by experiencing similar benefits from using health care services, independent of factors determining health care utilization. Differences in trajectories of disability stemming from different patterns of health care utilization in White and Black older adults may indicate differences in quality and availability of health care services, or of health care providers' attitudes about and prejudices against specific categories of patients (Ford & Cooper, 1995).

Doctor Visit Utilization

Blacks' higher likelihood of hospitalization for diseases that can be managed in ambulatory settings, such as hypertension or ischemic heart disease (Holmes, Arispe, & Moy, 2005), and lower likelihood of being screened for early cancer detection paid for Medicare, such as mammography (Preston et al., 1997), or for preventive care for diabetes complications, such as eye care (Wang & Javitt, 1996), indicates that they receive poorer disease management from outpatient services compared to Whites or they underuse outpatient services. The results of this study indicate that, when accounting for the effects of established correlates of health care utilization as well as number of doctor visits, there are no White-Black differences in trajectories of disability associated with doctor visits utilization. This suggests that the routine checkups, early disease detection, and risk factors identification offered in these ambulatory settings have the potential to eliminate White-Black disparities. However, Medicare regulations do not preclude physicians from picking and choosing their patients and this selection may work against minorities and those without additional insurance (Eichner & Vladeck, 2005).

Hospital Utilization

Existing studies reported favorable (Dighe et al., 1997) as well as unfavorable (Landerman et al., 1998) ADL and IADL outcomes associated with greater number of hospitalizations, after controlling for correlates of health care utilization. The unfavorable effects of hospital utilization on disability among Whites found in this study may reflect influences from covariates unmodeled in these analyses, such as clinical complexity or severity of disease at admission, types of therapies received for the admission diagnosis, or geographical location of the hospital (e.g., rural vs. urban) as an indicator of therapeutic or interventional services available.

Despite previous evidence of inequalities in severity of disease at admission and in therapies received during hospitalization, older Blacks in this study did not experience any changes in disability as a result of hospital services utilization. For instance, existing studies show that Blacks are more often hospitalized for advanced stages of disease that require radical therapeutic approaches, such as organ removal (e.g., in prostate cancer) or amputation (e.g., in diabetes) compared to Whites (Mayberry et al., 2000). Blacks are also less likely to receive technologically advanced therapeutic procedures such as dialysis or revascularization, newer pharmacological therapies, or risk factor control, independent of health insurance compared to Whites (Daumit, Herman, Coresh, & Powe; 1999; Ford & Cooper, 1995; Gornick et al., 1996; Jha et al., 2003; Mayberry et al., 2000; Sonel et al., 2005).

Short-stay Nursing Home Utilization

The robust protective effects of nursing home stay found in Blacks after controlling for access to, need for, and amount of care suggest that the skilled care or rehabilitative services offered in these settings could contribute to the reduction in White-Black disparities in disability. However, additional information on clinical complexity is necessary to correctly interpret these results.

Home Health Care Utilization

The availability of home health care services has increased under the provisions of the Omnibus Budget Reconciliation Act of 1981, but older adults covered only by Medicare are still disadvantaged because they can only receive acute health care services. One study found better outcomes of home health care use on disability in Whites compared to Blacks (Brega et al., 2005), while another one found similar outcomes on disability (Peng et al., 2003), independent of demographics, health status, and health insurance. Contrary to previous findings, older Blacks in this study experienced beneficial effects on ADL and IADL trajectories from using home health care services, while no significant effects were found in older Whites, after adjusting for determinants of health care utilization.

Although these optimistic findings for older Blacks may represent a building block for interventions targeting disability disparities, additional factors known to influence home health care utilization were not included in these predictive models. Information about the amount of home health care received is not available in AHEAD and may have biased the results. Another important unaccounted factor in these models is informal care, which also is unavailable in AHEAD. Availability of sources of informal care (Branch et al., 1988; Shaw & Janevic, 2004; Waite & Hughes, 1999) and amount of informal care received are related to functional status and disability (Freedman et al., 2004; Mendes de Leon, Gold, Glass, Kaplan, & George, 2001). Because informal care can supplement formal care with cumulative effects on functional status, such information is necessary for an accurate understanding of the relationship between home health care use and disability. Considering the White-Black variations in the availability and amount of received informal care (Gibson & Jackson, 1987; Barnes, Mendes de Leon, Bienias, & Evans, 2004; Li & Fries, 2005), this information could extricate distinct, more accurate effects of home health care utilization on trajectories of disability among White and Black older adults.

Limitations and Conclusion

One limitation of this study rests in its measures of health care utilization based on self-reports which tend to be underestimated (Roberts, Bergstralh, Schmidt, &

Jacobsen, 1996) when compared to administrative records. However, accounting for both reports of any utilization in addition to the amount of care utilized may have reduced this bias. Also, not having information about severity or stage of disease, time from disease diagnosis, admission diagnosis, or types of therapies received limits the interpretation of the detected associations. Although the number of coexisting chronic conditions was controlled for, discrete differences in the disability outcome related to these clinical severity indicators are likely and necessary to be accounted for.

Another potential source of bias is represented by time and place variations in health care provisions and access to care. Various legislative changes in Medicare and Medicaid over time, such as the Interim Payment System (1997- 2000) or the Prospective Payment System (since 2000) regulating Medicare home care, or the Balanced Budget Act of 1997 reducing the payments that providers received from Medicare may have affected selectively vulnerable groups of older adults. Additionally, state and regional variations in the health care practices could introduce variation that was unaccounted for in this study.

This exploratory study found results inspiring of further investigations. The complexity of the effects of health care services utilization on disability demands more methodical examinations of this matter. In the light of the considerable health care costs incurred by the older population and the persistently reported White-Black health disparities, it is paramount to assure cost-efficacy and equal quality of care.

References

Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: Does it matter? *Journal of Health and Social Behavior, 36*, 1-10.

Barnes, L. L., Mendes de Leon, C. F., Bienias, J. L., & Evans, D. A. (2004). A longitudinal study of White-Black differences in social resources. *Journal of Gerontology Social Sciences, 59B,* S146-S153.

Berk, R. A. (1983). An introduction to sample selection bias in sociological data. *American Sociological Review, 48*, 386-398.

Branch, L. G., Wetle, T. T., Scherr, P. A., Cook, N. R., Evans, D. A., Hebert, L. E., et al. (1988). A prospective study of incident comprehensive medical home care use among the elderly. *American Journal of Public Health, 78*, 255-259.

Brega, A. G., Goodrich, G. K., Powell, M. C., & Grigsby, J. (2005). Racial and ethnic disparities in the outcomes of elderly home care recipients. *Home Health Care Services Quarterly, 24,* 1-21.

Chernew, M. E., Goldman, D. P., Pan, F., & Shang, B. (2005). Disability and health care spending among Medicare beneficiaries. *Health Affairs, 24,* W5-R42-R52.

Crimmins, E. M. & Saito, Y. (2001). Trends in healthy life expectancy in the United States, 1970-1990: gender, racial, and educational differences. *Social Sciences and Medicine, 52,* 1629-1641.

Daumit, G. L., Herman, J. A., Coresh, J., & Powe, N. R. (1999). Use of cardiovascular procedures among Black persons and White persons: A 7-year nationwide study in patients with renal disease. *Annals of Internal Medicine, 130*, 173-182.

Dighe, M. S., Aparasu, R. R., & Rappaport, H. M. (1997). Factors predicting survival, changes in activity limitations, and disability in a geriatric post-stroke population. *The Gerontologist, 37,* 483-489.

Dunlop, D. D., Manheim, L. M., Song, J., & Chang, R.W. (2002). Gender and ethnic/racial disparities in health care utilization among older adults. *Journal of Gerontology Social Sciences, 57B,* S221-S233.

Eichner, J. & Vladeck, B. C. (2005). Medicare as a catalyst for reducing health disparities. *Health Affairs, 24,* 365-375.

Ford, E. S., & Cooper, R. S. (1995). Racial/ethnic differences in health care utilization of cardio-vascular procedures: A review of the evidence. *Health Services Research, 30,* 237-252.

Fortinsky, R. H., Fenster, J. R., & Judge, J. O. (2004). Medicare and Medicaid home health and Medicaid waiver services for dually eligible older adults: Risk factors for use and correlates of expenditures. *The Gerontologist, 44*, 739-749.

Freedman, V. A., Aykan, H., Wolf, D. A., & Marcotte, J. E. (2004). Disability and home care dynamics among older unmarried Americans. *Journal of Gerontology Social Sciences, 59B*, S25-S33.

French E., & Kamboj, K. (2002). Analyzing the relationship between health insurance, health cost, and health care utilization. *Economic Perspectives, 3Q*, 60-72.

Geronimus, A. T., Bound, J., Waidman, T. A., Colen, C. G., & Steffick, D. (2001). Inequality in life expectancy, functional status, and active life expectancy across selected black and white populations in the United States. *Demography, 38*, 227-251.

Gibson, R. C., & Jackson, J. S. (1987). Health, physical functioning, and informal supports of the Black elderly. *Milbank Quarterly, 65*, 421-454.

Gornick, M. E., Eggers, P. W., Reilly, T. W., Mentnech, R. M., Fitterman, L. K., Kucken, L. E., & Vladeck, B. C. (1996). Effects of race and income on mortality and use of services among Medicare beneficiaries. *The New England Journal of Medicine, 335*, 791-799.

Guralnik, J. M., Land, K. C., Blazer, D., Fillenbaum, G. G., & Branch, L. G. (1993). Educational status and active life expectancy among older Blacks and Whites. *New England Journal of Medicine, 329*, 110-116.

Hayward, M. D., Crimmins, E. M., Miles, T. P., & Yang, Y. (2000). The significance of socioeconomic status in explaining the racial gap in chronic health conditions. *American Sociological Review, 65,* 910-930.

Heisler, M., Langa, K. M., Eby, E. L., Fendrick, A. M., Kabeto, M. U., & Piette, J. D. (2004). The health effects of restricting prescription medication use because of cost. *Medical Care, 42*, 626-634.

Herzog, A. R., & Wallace, R. B. (1997). Measures of cognitive functioning in the AHEAD Study [Special Issue]. *The Journals of Gerontology Series B, 52B,* 37-48.

Holmes, J. S., Arispe, I. E., & Moy, E. (2005). Heart disease and prevention: Race and age differences in heart disease prevention, treatment, and mortality. *Medical Care, 43*, 33-41.

Hurd, M. D., & McGarry, K. (1997). Medical insurance and the use of health care services by the elderly. *Journal of Health Economics, 16*,129-154.

Jha A. K., Varosy, P. D., Kanaya, A. M., Hunninghake, D.B., Hlatky, M.A., Waters, D.D., et al. (2003). Differences in medical care and disease outcomes among Black and White women with heart disease. *Circulation, 108,* 1089-1094.

Johnson, M. (2006). Individual growth analysis using PROC MIXED. Statistics and Data Analysis, Paper 253-27. Retrieved March 17, 2006, from http://www2.sas.com/proceedings/sugi27/p253-27.pdf

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

Kelley-Moore, J. A. & Ferraro, K. F. (2004). The black/white disability gap: Persistent inequality in later life? *Journal of Gerontology, 59B*, S34-S43.

Klein, D., Turvey, C., & Wallace, R. (2004). Elders who delay medication because of cost: Health insurance, demographics, health, and financial correlates. *The Gerontologist, 44*, 779-787.

Landerman, L. R., Fillenbaum, G. G., Pieper, C. F., Maddox, G. L., Gold, D. T., & Guralnik, J. M. (1998). Private health insurance coverage and disability among older Americans. *Journal of Gerontology Social Sciences, 53B*, S258-S266.

Li, L. W. & Fries, B. E. (2005). Elder disability as an explanation for racial differences in informal home care. *The Gerontologist, 45*, 206-215.

Markides, K. S. & Black, S. A. (1996). Race, ethnicity, and aging: The impact of inequality. In Binstock, R. H., & George, L. K. (Eds.), Handbook of aging and the social sciences (4^{th} Ed.) (pp.153-171). San Diego: Academic Press.

Mayberry, R. M., Mili, F., & Ofili, E. (2000). Racial and ethnic differences in access to medical care. *Medical Care Research and Review, 57*, 108-145.

Mayur, M. D., Zhang, P., & Hagan Hennessy, C. (1999). Surveillance for morbidity and mortality among older adults: United States, 1995-1996. *Surveillance Summaries, 48*, 7-25.

Mendes de Leon, C. F., Beckett, L. A., Fillenbaum, G. G., Brock, D. B., Branch, L. G., Evans, D. A., & Berkman, L. F. (1997). Black-White differences in risk of becoming disabled and recovering from disability in old age: A longitudinal analysis of two EPESE populations. *American Journal of Epidemiology, 145*, 488-497.

Mendes de Leon, C. F., Gold, D. T., Glass, T. A., Kaplan, L., & George, L. K., (2001). Disability as a function of social networks and support in elderly African Americans and Whites. *Journal of Gerontology Social Sciences,56B,* S179-S190.

Mendes de Leon, C. F., Barnes, L. L., Bienias, J. L., Skarupski, K. A., & Evans, D. A. (2005). Racial disparities in disability: Recent evidence from self-reported and performance-based disability measures in a population-based study of older adults. *Journal of Gerontology Social Sciences, 60B*, S263-S271.

Peng, T. R., Navaie-Waliser, M., & Feldman, P. H. (2003). Social support, home health services use, and outcomes among four racial-ethnic groups. *The Gerontologist, 43,* 503-513.

Preston, J. A., Scinto, J. D., Ni, W., Wang, Y., Galusha, D., Schulz, A. F., & Petrillo, M. K. (1997). Mammography underutilization among older women in Connecticut. *Journal of the American Geriatrics Society, 45*, 1310-1314.

RAND Center for the Study of Aging (2006). *Data products: Datasets and files.* Retrieved January 5, 2006 from https://ssl.isr.umich.edu/hrs/files.php

Reynolds, S. L. & Silverstein, M. (2003). Observing the onset of disability in older adults. *Social Sciences and Medicine, 57,* 1875-1889.

Roberts, R. O., Bergstralh, E. J., Schmidt, L., & Jacobsen, S. J. (1996). Comparison of self-reported and medical record health care utilization measures. *Journal of Clinical Epidemiology, 49*, 989-995.

Shaw, B. A., & Janevic, M. (2004). Associations between anticipated support, physical functioning, and education level among a nationally representative sample of older adults. *Journal of Aging and Health, 16*, 539-561.

Soldo, B. J., Hurd, M. D., Rodgers, W. L., & Wallace, R. B. (1997). Asset and Health Dynamics Among the Oldest Old: An overview of the AHEAD study. *Journals of Gerontology Series B, 52B (Special Issue),* 1-20.

Sonel, A. F., Good, C. B., Mulgund, J., Roe, M. T., Gibler, W.B., Smith, S. C., et al. (2005). Racial variations in treatment and outcomes of Black and White patients with high-risk non-ST-elevation acute coronary syndromes: Insights from CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines?). *Circulation, 111*, 1225-1232.

Stump, T. E., Johnson, R. J., & Wolinsky, F. D. (1995). Changes in physician utilization over time among older adults. *Journal of Gerontology Social Sciences, 50B*, S45-S58.

Sudano, J. J., & Baker, D. W. (2006). Explaining US racial/ethnic disparities in health declines and mortality in late middle age: The roles of socioeconomic status, health behaviors, and health insurance. *Social Science and Medicine, 62*, 909-922.

Tabachnick B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4^{th} Ed.) (pp. 86-111). Boston: Allyn and Bacon.

U.S. Department of Health and Human Services (USDHHS, 2000). *Healthy People 2010: Understanding and Improving Health.* 2^{nd} ed. Washington, DC: U.S. Government Printing Office, November 2000.

U.S Department of Health and Human Services (USDHHS, 2005). *Health, United States, 2005.* Retrieved on June 1, 2006, from http://www.cdc.gov/nchs/data/hus/hus05.pdf

Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Social Sciences and Medicine, 38,* 1-14.

Waite, L. J., & Hughes, M. E. (1999). At risk on the cusp of old age: Living arrangements and functional status among Black, White, and Hispanic adults. *Journal of Gerontology Social Sciences, 54B*, S136-S144.

Wang, F., & Javitt, J. C. (1996). Eye care for the elderly Americans with Diabetes Mellitus: Failure to meet the current guidelines. Ophthalmology, 103, 1744-1750.

Wolinsky, F. D., & Johnson, R. J. (1991). The use of health services by older adults. *Journal of Gerontology Social Sciences, 46*, S345-357.

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

STUDY 3

THE WHITE-BLACK DISPARITIES IN DISABILITY REVISITED: IS THE EFFECT OF HEALTHY LIFESTYLE BEHAVIORS ON DISABILITY MEDIATED BY COGNITION?

Abstract

Cognitive function represents a risk factor in the disablement process, and empirical findings indicate that some of the White-Black disparities in disability result from older Blacks' lower cognitive status. Considering the vast evidence of the beneficial effects of lifestyle behaviors such as physical activity participation, moderate alcohol consumption, and not smoking on both cognitive performance and disability, this study examines whether cognition mediates the effects of these behaviors on disability, and whether these mediation effects vary between White and Black older adults.

Data from White and Black participants from the Asset and Health Dynamics among the Oldest Old study (AHEAD) (N=4,472) who were followed up biannually from 1995 to 2002 are used to test these multilevel mediation models. Disability is measured by difficulty with basic activities of daily living (ADL) and difficulty with three cognitive instrumental activities of daily living (IADL).

During the 7-year follow-up, cognition mediated the effects of physical activity on both ADL and cognitive IADL in the entire sample, where about 17% of the total effects of physical activity participation on ADL and 49% of the effect on cognitive IADL were mediated by cognition. Similar effects were found among Whites, but the mediation effect was not significant among Blacks. The mediation models for alcohol consumption and smoking did not converge.

Finding that cognitive function mediates the effect of physical activity on disability independent of known correlates of cognitive decline, such as age, education, or chronic illness suggests that this lifestyle factor plays an important role in improving the quality of life and maintaining the independence of older adults.

Introduction

Black older adults fare worse than their White counterparts with regards to cognitive functioning and disability levels. Older Blacks have lower cognitive performance (Herzog & Wallace, 1997; Leveille, Guralnik, Ferrucci, et al., 1998; Manly, Jacobs, Sano, et al., 1998; Sloan & Wang, 2005; Zsembik & Peek, 2001), higher levels of disability (Berkman, Singer, & Manton, 1989; Kelley-Moore & Ferraro, 2004; Li, 2005; Mendes de Leon, Beckett, Fillenbaum, et al., 1997), and higher likelihood of having correlates of lower cognitive performance and higher disability, such as lower levels of education and more health conditions compared to Whites (Johansson, Berg, Hofer, et al., 2004; van Exel, Gussekloo, de Craen, et al. , 2001; Zsembik & Peek, 2001).

Verbrugge and Jette (1994) postulated that deficits in cognitive functioning represent a risk factor in the disablement process, and empirical findings support this hypothesis (Aguero-Torres, Fratiglioni, Guo, et al., 1998; Blaum, Ofstedal, & Liang, 2002; Greiner, Snowdon, & Schmitt, 1996; Herzog & Wallace, 1997; Zarit, Femia, Gatz, & Johansson, 1999). Existing research shows that differences in cognitive performance explain some of the White-Black disparities in disability in basic (ADL; Moody-Ayers, Mehta, Lindquist, Sands, & Covinsky,2005) and instrumental (IADL; Moody-Ayers et al., 2005; Zsembik, Peek, & Peek, 2000) activities of daily living, even after controlling for education level and chronic illness. Although normal aging is accompanied by decline in cognitive performance and increased disability levels, current empirical findings suggest these changes are potentially manageable. Therefore, factors that improve disability both directly and indirectly through improvements in cognitive status would have a cumulative beneficial outcome on disability. Given older Blacks' disadvantage in cognitive performance and disability, it is important to detect such factors in order to reduce White-Black disparities in disability.

According to the concept of functional reserve, neuronal structures have the ability to compensate for structural damage, and this ability is under the influence of genetic and environmental factors (Andel, Hughes, & Crowe, 2005; Fillit, Butler, O'Connell, et al., 2002; Kramer, Bherer, Colcombe, Dong, & Greenough, 2004; Mortimer, 1997; Small, Hughes, Hultsch, & Dixon, 2006). Brain plasticity, which underlies the concept of functional reserve, is preserved even in older age and represents the capability of the brain to undergo structural changes at vascular and neuronal level under particular influences (Fillit et al., 2002; Kramer et al., 2004). Among factors suggested to positively influence brain plasticity, this study examines the healthy lifestyle behaviors including physical activity participation, not smoking, and moderate alcohol consumption (Fillit et al., 2002). A large body of empirical evidence also suggests that healthy lifestyle behaviors are associated with cross-sectional and longitudinal beneficial outcomes on disability among older adults.

The Effects of Physical Activity on Disability and Cognition

Self-reported physical activity participation is related to delayed onset of disability and slower rates of progress in disability over time, independent of additional risk factors (Berk, Hubert, & Fries, 2006; He & Baker, 2004; Reynolds & Silverstein, 2003; Seeman, Berkman, Charpentier, et al., 1995). Although inconsistent, intervention studies found better physical functioning, higher odds of recovering from disability, and lower odds of worsening in the intervention group compared to the control group (Binder, Schechtman, Ehsani, et al., 2002; Capodaglio, Ferri, & Scaglioni, 2005; Julie & Jette, 2001; Nelson, Layne, Bernstein, et al., 2004; Penninx, Rejeski, Pandya, et al., 2002).

Regarding physical activity and cognition, findings from studies on older adults are inconsistent although animal models demonstrated benefits from physical activity participation at molecular, cellular, and neurochemical levels in the brain tissue (Fillit et al., 2002). Imaging techniques in older adults detected a decrease in the aging-related loss in gray and white matter in the cortical areas most affected by such changes (frontal, prefrontal, and temporal regions) associated with cardio-vascular fitness (Colcombe, Erickson, Raz, et al., 2003; Kramer et al., 2004). Intervention studies involving short-term physical activity participation are likely to find no differences between the intervention and the control groups (Churchill, Galvez, Colcombe, et al., 2002). However, in a meta-analysis pooling data from 18 studies with consistent design, Colcombe and Kramer (2003) found substantial beneficial effects from aerobic and strength training, particularly on executive control and visuospatial processes. Observational studies report benefits in cognitive performance mostly in lifetime exercisers for aerobic exercise (Churchill et al., 2002; Colcombe & Kramer, 2003), where regular participation in aerobic physical activity is inversely associated with baseline levels and rates of change in cognitive performance, independent of socio-demographics and health status (Laurin, Verreault, Lindsay, MacPherson, & Rockwood, 2001; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001).

The Effects of Smoking on Disability and Cognition

The relationship between smoking and health has been long demonstrated. Smoking also predicts onset of disability (Reynolds & Silverstein, 2003) and higher odds of having any physical functioning limitations (Landerman, Fillenbaum, Pieper, et al., 1998; Ostermann & Sloan, 2001).

Smoking, especially of more than a pack of cigarettes a day, is associated with lower performance in psychomotor speed measures (Hill, 1989), problem solving and free recall (Hill, Nilsson, Nyberg, & Backman, 2003), memory and overall mental status (Bryan & Ward, 2002; Herzog & Wallace, 1997), executive functioning measures (Razani, Boone, Lesser, & Weiss, 2004), and faster decline in verbal memory over time (Richards, Jarvis, Thompson, & Wadsworth, 2003) compared to never smoking. The mechanisms through which smoking affects cognition have not been clarified yet, especially since nicotine tends to improve attention, accuracy, and speed (Fillit et al., 2002; Hulse, Lautenschlager, Tait, & Almeida, 2005). Nevertheless, the fact that smoking is a well-established risk factor for stroke suggests an association between smoking and cognition in vascular dementia resulting from multiple transient ischemic attacks (Hulse et al., 2005; Isselbacher, Braunwald, Wilson, et al., 1995).

The Effects of Alcohol Consumption on Disability and Cognition

Moderate alcohol consumption has some protective effects on physical functioning (LaCroix, Guralnik, Berkman, et al., 1993), but excessive consumption is associated with higher levels of disability (Ensrud, Nevitt, Yunis, et al., 1994) and higher odds of developing incident disability (Ostermann & Sloan, 2001). Landerman and colleagues (1998) found that both abstainers and heavy drinkers were at significantly high risk of developing mobility limitations compared to those who consumed the recommended amount.

Excessive alcohol intake is also associated with neuropathological and structural modifications in the brain both directly, through neuronal and dendritic loss, and indirectly, through nutritional deficits (i.e., folate and vitamin B12) or higher risk of stroke (Hulse et al., 2005). In addition to the extreme manifestation of these modifications as a medically diagnosed condition (i.e., the Wernicke-Korsakoff syndrome), long-term consumption of alcohol above the recommended amount was shown to underlie non-dementia cognitive deficits (Fillit et al., 2002; Hulse et al., 2005).

Some studies reported that moderate consumption has beneficial effects on cognition and abstinence and excessive consumption are associated with poor cognitive performance (Bond, Burr, McCurry, Borenstein Graves, & Larson, 2001; Galanis, Joseph, Masaki, et al., 2000). Others found that current alcohol consumption has protective effects on cognition compared to abstinence both cross-sectionally (Bond, Burr, Murguia Rice, et al., 2003; Bond, Burr, McCurry, et al., 2005; Bryan & Ward, 2002; Herzog & Wallace, 1997) and longitudinally (Bond et al., 2005).

Cognition and Disability

An inverse relationship between cognitive function and limitations in overall and task-specific ADLs (Rapp, Schnaider Beeri, Schmeidler, et al., 2005), IADLs (De Ronchi, Bellini, Berardi, et al., 2005; Schoepflin Sanders, Lyness, Eberly, King, & Caine, 2006), or both ADLs and IADLs (Blaum et al., 2002; Herzog & Wallace, 1997;

Nourashemi, Andrieu, Gillette-Guyonnet, et al., 2002; Zarit et al., 1999), independent of socio-demographics or multiple morbidities is consistently reported in cross-sectional studies. Longitudinal studies also found that cognitive deficits predict higher odds of onset in ADL disability (Aguero-Torres et al., 1998; Black & Rush, 2002; Moritz, Kasl, & Berkman, 1995), IADL disability (Liang, Shaw, Krause, et al., 2003), or both (Reynolds & Silverstein, 2003; Spiers, Matthew, Jagger, et al., 2005); and a faster rate of deterioration over time in ADL disability (Li, 2005). Cognitive deficits are also associated with increased severity at follow-up in ADL (Greiner et al., 1996; Pedone, Ercolani, Catani, et al., 2005), IADL (McGuire, Ford, & Ajani, 2006), or both ADL and IADL disability (Dodge, Kadowaki, Hayakawa, et al., 2005), regardless of socio-demographics or multiple morbidities.

On the contrary, in a sample of older adults with no IADL disability at baseline Furner and colleagues (1995) found that cognitive impairment measured by self reports of experiencing trouble recalling things and getting confused often, did not predict likelihood of developing IADL disability in any of the six tasks, controlling for demographics and self-reported health. Likewise, McGuire and colleagues (2006) found no relationship between ADLs and cognitive performance measured with the Telephone Interview for Cognitive Status (TICS; Brandt, Spencer, & Folstein, 1998).

Although the mechanisms through which impaired cognition leads to difficulty in performing basic and instrumental activities of daily living have not been clarified, deficits in cognitive functions necessary for ADL and IADL performance represent the most frequently suggested link (Raji, Kuo, Al Snih, et al., 2005; Rapp et al., 2005). One source of such cognitive deficit is the aging-related structural and functional changes in the central nervous system that translate into declines in cognitive tasks such as speed of processing, executive control, or memory (Christensen, 2001; Colcombe & Kramer, 2003; Fillit et al., 2002). Another source is the cognitive deficits associated with vascular and neuronal changes in the central nervous system resulting from some chronic diseases that are more prevalent in older age, such as high blood pressure, diabetes, or stroke (Christensen, 2001; Fillit et al., 2002; Hassing, Johansson, Pedersen, et al., 2003; Zelinski, Crimmins, Reynolds, & Seeman, 1998; Zelinski & Gilewski, 2003; Zsembik & Peek, 2001).

The empirical findings presented above suggest that healthy lifestyle behaviors may have favorable outcomes on disability both directly, and indirectly via affecting cognitive performance. In light of this assumption, the first research question addressed in this study is: (1) Does cognitive status mediate the effect of lifestyle behaviors (i.e., physical activity participation, alcohol consumption, and smoking) on disability among older adults?

Despite the beneficial effects of healthy lifestyle behaviors on disability and cognition described previously, older Blacks are less likely to practice them. Older Blacks are less likely to participate regularly in physical activity and more likely to be inactive (Center for Disease Control [CDC], 2006a); and more likely to be current smokers (CDC, 2006b; Sudano & Baker, 2006; Wray, Alwin, & McCammon, 2005). Considering that older Blacks' higher disability levels are attributable to their lower cognitive performance (Moody-Ayers et al., 2005; Zsembik et al., 2000), the second research question addressed in this study is: (2) Are there any differences between White and Black older adults in the mediating effect of cognition on the relationship between lifestyle behaviors and disability?

Methods

Data and Study Population

The data for this study come from Asset and Health Dynamics among the Oldest Old (AHEAD) study, which was compiled and made publicly available by RAND Center for the Study of Aging (2006). The AHEAD cohort is a nationally representative sample of 8,222 community-dwelling elders aged 70 years and older at baseline in 1993, including spouses/ partners regardless of age. Participants were re-interviewed in 1995, 1998, 2000, and 2002. A detailed description of the study design and sampling methods is presented elsewhere (Soldo, Hurd, Rodgers, & Wallace, 1997).

The baseline sample included all White and Black older adults, aged 70 and older, who were not demented, as defined by Herzog and Wallace (1997). Participants who had a proxy reporting on their behalf during the follow-up were excluded from that respective wave. Becoming institutionalized during the follow-up was not an exclusion criterion, and participants who were interviewed in nursing homes were included in the analyses while controlling for their institutionalized status.

Because physical activity was not assessed at the baseline interview in 1993, this study uses the 1995 interview as its baseline. Therefore, in the rest of this paper the term “baseline” refers to the 1995 interview. After applying these inclusion criteria, the sample size is 4,472, representing 4054 (90.65%) Whites and 418 (9.34%) Blacks. The overall attrition rates for the whole period of follow-up were 45.99% in Whites (e.g., 41.25% due to death, 2.70% due to institutionalization and not being interviewed, and 3.41% due to proxy responses) and 47.06% in Blacks (e.g., 47.53% due to death, 1.65% due to institutionalization and not being interviewed, and 1.88% due to proxy responses).

Measures

Outcome Variables

The outcome variables for this study are self-reported difficulties with basic (ADL) and instrumental (IADL) activities of daily living. Difficulties with ADLs are measured by a summary index including six tasks (i.e., bathing, eating, dressing, walking across a room, using the toilet, and getting in and out of bed) (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963). The range of scores for this index varies from 0 to 6, where 0 represents no difficulty and 6 represents difficulty with all six ADLs.

In a recently published study using factor analysis, Ng and colleagues (2006) identified two IADL factors with different underlying physical and cognitive dimensions. One factor, which the authors named cognitive IADL, includes managing money, taking medications, and using the telephone, and has a strong association with MMSE scores (Ng, Niti, Chiam, & Kua, 2006). This study uses this cognitive IADL index under the assumption that due to its reported strong correlation with mental status it would be more likely to be influenced by healthy lifestyle behaviors. The range of scores for this cognitive IADL index varies from 0 to 3, where 0 indicates no difficulty and 3 indicates difficulty with all three tasks.

Predictor Variables

Healthy lifestyle behaviors are represented by physical activity participation, smoking, and alcohol consumption. Participants reported on whether or not they have participated in vigorous physical activities (i.e., sports, heavy housework, or a physically demanding job) for at least three times a week during the last12 months.

Smoking is originally measured in AHEAD using two dummy variables indicating current smoking and having ever smoked. In order to differentiate distinct levels of risk on disability, a new ordinal variable was created to indicate never smoking=0, former smoking=1, and current smoking=2.

To reconcile inconsistent measures of alcohol consumption across waves and the fact that the National Institute on Alcohol Abuse and Alcoholism (2006) recommendation of no more than a drink a day or seven drinks a week does not uncover problematic or binge drinking, a new variable was created from the original AHEAD variables, with three response options: 0= does not drink/abstainer, 1=1 to 2 drinks/day, 2= 3 drinks or more/day.

Mediator Variable

The cognitive measures used in AHEAD are derived from the Telephone Interview for Cognitive Status (Brandt et al., 1988). These measures include an immediate free recall test and a delayed free recall test (i.e., recall of ten nouns immediately after being read and after five minutes), a working memory test (i.e., the Serial 7s test), a test of knowledge, language, and orientation (i.e., counting back from 20 for 10 continuous numbers, identification of the date including the day of the week, identification of the object usually used to cut paper, identification of the prickly plant that grows in the desert, and naming the full names of the President and Vice President of the US), and a self-rating of memory. The overall score of the cognitive function index summing these measures ranges from 0 to 35. A detailed description of this test is provided by Herzog and Wallace (1997).

Following the method Herzog and Wallace (1997) used to deal with missing data, values of "Don't know" are scored as incorrect answers. Refusals for the entire immediate free recall test are assigned a value of 2, for the entire delayed free recall a value of 0, and for the working memory a value of 1. Refusals for the rest of the measures are recoded as incorrect answers. Using this method, Hertzog and Wallace (1997) obtained a quasi-normal distribution of scores on the cognitive function index, and suggested a cut-off score of 8 to denote severe cognitive impairment.

Control Variables

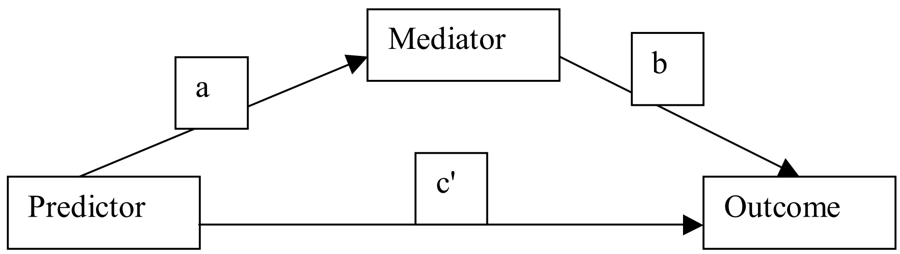
Demographics include age, gender (0=male; 1= female), race (0= Whites, 1= Black), and marital status (0= married/ partnered, 1= not married/ partnered). Socio-economic status is measured by educational attainment (range= 0-17 years of formal education; centered at 12 years) and net household wealth. The net wealth variable represents the sum of all self-reported wealth (i.e., housing, real estate, checking, savings, bonds, CDs, assets, transportation, business, IRA, stocks) minus all debt (i.e., mortgage, debt). Outlier values for the wealth variable were replaced with the corresponding value of +/-3.29 of the standardized score (Tabachnick & Fidell, 2001). Because the wealth variable has a very wide range of values and a skewed distribution, the original continuous variable was recoded into an ordinal variable based on the quartile distribution of the baseline values.

Health status is measured by two variables: a self report of health (i.e., 1= excellent, 2= very good, 3= good, 4= fair, and 5= poor) and a multiple morbidity index. The multiple morbidity index sums eight potential conditions participants reported to be diagnosed with (e.g., high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis).

All analyses were also adjusted for institutionalization and non-random attrition. Because differences in survival associated with age, gender, race/ethnicity, and health status (Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993) may result in non-random attrition over time and bias the results, all models control for non-random attrition as well. A non-random attrition indicator was calculated using a binary probit method (Berk, 1983) based on predictors identified previously in the literature to be associated with drop-out (e.g., age, gender, race, and health status: Guralnik et al., 1993). This probit method estimated a hazard rate (called inverse Mills ratio or attrition lambda) reflecting likelihood of dropping out of the study. A higher value of attrition lambda indicates a higher likelihood of not completing the study.

Statistical Analysis

The analytic method used in this study is based on a multilevel model developed by Bauer and colleagues (2006). This model estimates the total effect of the predictor on the outcome (*c*) as the sum between the direct effect (*c`*), and the indirect effect mediated by the mediator variable (*ab*) between the predictor and the outcome (*c*= *ab*+*c`*).



All the effects of the three causal pathways in this multilevel mediation model are specified as random. The conventional assumptions applicable to multilevel models are extended in this model to pertain to both within and across equations, and to both levels of analysis (e.g., Level 1= repeated measures, Level 2= individuals). The estimated random intercepts indicate overall differences in the outcome levels across individuals, and the estimated random slopes indicate differences in the effect of the predictor on the outcome across individuals during the entire follow-up (Bauer et al., 2006). This method also allows an estimation of the average indirect and total effects and their confidence intervals based on the normal approximation. However, the fixed effects estimates and the average effect size estimates represent overall average effects for the entire duration of the repeated observation without distinction for time patterns.

In the first step of the analyses, multilevel mediation models test whether the effect of each lifestyle behavior (e.g., physical activity participation, alcohol consumption, and smoking) on disability is mediated by cognitive status in the entire sample. Then, the same mediation models are examined for each race group. All models are controlled for demographics, socio-economic status, health status, institutionalization, and non-random attrition.

Results

The age and gender composition was similar for Whites and Blacks at baseline. Whites were more likely to be married or partnered, to have more education and household wealth, to have fewer chronic conditions, and to report better health compared to Blacks. Whites were more likely to report participating in physical activity and drinking alcohol within the recommended amount than Blacks in the reference period. There were no White-Black differences at baseline in self-reports of smoking. Whites also had better cognitive performance scores and fewer reported difficulties with ADL and cognitive IADL (Table 9).

Table 9

Baseline sample description

	Whites (N=4054)	Blacks (N=418)	*p*
Age (*M, SD*)	78.94 (5.44)	78.48 (5.08)	0.131
Gender (% women)	61.14	64.90	0.099
Marital status (% married/ partnered)	52.68	33.76	<0.001
Education (*M, SD*)	11.77 (3.12)	9.90 (3.66)	<0.001
Household wealth (M, SD)	286,191 (500,857)	76, 507 (206,285)	<0.001
Morbidity (*M, SD*)	1.85 (1.31)	1.99 (1.32)	0.028
Cognition (*M, SD*)	21.58 (4.56)	18.18 (4.75)	<0.001
Self reported health (%)			<0.001
excellent	11.42	4.69	
very good	26.24	21.43	
good	31.67	28.79	
fair	20.93	31.70	
poor	9.74	13.39	
Physical activity (% yes)	34.46	22.82	<0.001
Smoking (%)			0.613
never	46.83	50.89	
former	45.85	39.29	
current	7.33	9.82	
Drinking (%)			<0.001
abstainer	70.22	81.49	
recommended	28.11	16.03	
above recommended	1.67	2.48	
ADL (*M, SD*)	0.44 (1.02)	0.61 (1.17)	<0.001
Cognitive IADL (*M, SD*)	0.17 (0.55)	0.43 (0.91)	0.016

Note. BMI= Body mass index; ADL= Activities of daily living difficulties; IADL= Instrumental activies of daily living difficulties.

Non-parametric t-tests were used to assess ordinal and interval level differences; Mantel-Haenszel chi-square tests were used to test nominal level differences.

Cognition as a Mediator of the Effect of Physical Activity on ADL

Table 10 displays the results of the multilevel mediation models for the entire sample (Model I), Whites (Model II), and Blacks (Model III), where the outcome is ADL.

Table 10

Test of the mediation effect of cognition on the effect of physical activity on ADL disability

	Model I		Model II		Model III	
	Whole sample		Whites		Blacks	
	Estimate	*p*	Estimate	*p*	Estimate	*p*
Fixed effects solution						
Cognition	19.54	<0.001	19.90	<0.001	16.16	<0.001
ADL	0.60	<0.001	0.61	<0.001	0.35	0.260
Cognition* Physical activity	1.13	<0.001	1.05	<0.001	1.59	<0.001
ADL* Cognition	-0.02	<0.001	-0.02	<0.001	-0.02	0.018
Physical activity* ADL	-0.21	<0.001	-0.22	<0.001	-0.07	0.308

Note. All models are controlled for age, gender, marital status, education, household wealth, self-reported health, chronic illnesses, institutionalization, and non-random attrition.

ADL= Difficulty with basic activities of daily living.

The fixed effects solution in Model I show that all three pathways of the mediation model were statistically significant and varied significantly across individuals, which indicates that cognition mediates the effect of physical activity on ADL. During the 7 year follow-up period there were significant overall average differences across individuals in cognition (est. = 19.54, p<.001) and ADL (est. = 0.60, p<.001). On aggregate, physical activity participation was associated with 1.13 higher scores on cognitive performance and 0.21 units lower ADL level, and with each 1 unit increase in cognitive performance scores the ADL level was 0.02 units lower. The estimated average indirect effect (e.g., ab) for this model was -.043 (95% CI: -.061, -.025), and the estimated average total effect (e.g., c=ab + c') was -.256 (95% CI: -.290, -.221).

Therefore, 17% of the total effects of physical activity participation on ADL were mediated by cognition in the whole sample.

Cognition mediated the effect of physical activity participation on ADL among Whites, as evidenced by the significance levels of the three pathways of the mediation model (Table 10: Model II). There was significant aggregate heterogeneity across individuals for the average values of cognition (est. = 19.90, p<.001) and ADL (est. = 0.61, p<.001) during the follow-up. Overall, participation in physical activity resulted in 1.05 better cognitive performance scores and 0.22 units lower ADL level. With each 1 unit increase in cognitive performance scores there ADL level was 0.02 units lower. The estimated average indirect effect was -.038 (95% CI: -.056, -.020) and the estimated average total effect was -.259 (95% CI: -.294, -.225), illustrating that 15% of the effect of physical activity on ADL was mediated by cognition among Whites.

Cognition did not mediate the effect of physical activity on ADL among Blacks (Table 10: Model III) because only two out of the three causal pathways were statistically significant. Although physical activity participation resulted in better cognition scores (est. = 1.59, p<.001) and better cognition was related to lower ADL levels (est. = -0.02, p= .018), physical activity did not affect ADL directly (est. = -0.07, p= .308).

Cognition as a Mediator of the Effect of Physical Activity on Cognitive IADL

Table 11 summarizes the results of the multilevel mediation models for which the outcome is cognitive IADL, examined in the whole sample (Model I), Whites (Model II), and Blacks (Model III). Cognition mediates the effect of physical activity participation on cognitive IADL in the entire sample as indicated by the statistical significance of all three causal pathways of the model (Table 11: Model I).

Table 11

Test of the mediation effect of cognition on the effect of physical activity on cognitive IADL disability

	Model I		Model II		Model III	
	Whole sample		Whites		Blacks	
	Estimate	*p*	Estimate	*p*	Estimate	*p*
Fixed effects solution						
Cognition	19.87	<0.001	20.18	<0.001	16.88	<0.001
IADL	0.31	<0.001	0.31	<0.001	0.32	0.013
Cognition* Physical activity	1.07	<0.001	0.99	<0.001	1.42	<0.001
IADL* Cognition	-0.02	<0.001	-0.02	<0.001	-0.01	<0.001
Physical activity* IADL	-0.03	<0.001	-0.04	<0.001	0.03	0.360

Note. All models are controlled for age, gender, marital status, education, household wealth, self-reported health, chronic illnesses, institutionalization, and non-random attrition.
IADL= Difficulty with cognitive instrumental activities of daily living.

There were significant individual differences in cognition levels (est. = 19.87, $p<.001$) and cognitive IADL level (est. = 0.31, $p<.001$) during the entire follow-up. Participation in physical activity resulted in better cognitive performance scores (est. = 1.07, $p<.001$) and lower cognitive IADL levels (est. = -0.03, $p<.001$), and better cognitive performance resulted in lower cognitive IADL levels (est. = -0.02, $p<.001$). The estimated average indirect effect was -.029 (95%CI: -.038, -.020), and the estimated total effect was -.059 (95%CI: -.074, -.043), therefore 49% of the effect of physical activity participation on cognitive IADL was mediated by cognition in the entire sample.

Cognition also mediated the effects of physical activity participation on cognitive IADL among Whites (Table 11: Model III). All three causal pathways of the model were statistically significant and varied across White participants. Participation in physical activity was associated with better cognitive performance scores (est. = 0.99, $p<.001$) and lower cognitive IADL scores (est.= -0.04, $p<.001$), and better cognition was related to lower cognitive IADL levels (est.= -0.02, $p<.001$). The average cognitive performance (est. = 20.18, $p<.001$) and cognitive IADL (est. = 0.31, $p<.001$) scores varied across individuals during the follow-up as well. Among Whites, the estimated average indirect effect was -.027 (%95CI: -.036, -.017) and the estimated average total effect was -.064 (%95CI: -.080, -.048). About 41% of the effect of physical activity on cognitive IADL was mediated by cognition in Whites.

Cognition did not mediate the effect of physical activity on cognitive IADL among Blacks (Table 11: Model III). Only two out of the three causal pathways were statistically significant in Blacks. Physical activity was associated with better cognitive performance (est.= 1.42, $p<.001$) and better cognitive performance resulted in lower cognitive IADL levels (est. = -0.01, $p<.001$), but physical activity did not directly affect cognitive IADL (est.= 0.03, $p= .360$).

Cognition as a Mediator of the Effect of Alcohol Consumption and Smoking on Disability

The multilevel mediation models for the effects of drinking and smoking on ADL or cognitive IADL did not converge. This lack of convergence may result from the non-normal distribution of the residuals of the drinking and smoking variables over time. Although there were significant changes over time in drinking (results not shown), the distribution of the residuals of these changes show non-normality (skewness=.77, kurtosis= 3.90) and small variance across individuals (variance= .04). Similarly, despite significant changes in smoking over time, non-normal patterns of residuals distribution and small variance across individuals were detected for the smoking variable (skewness= -.37, kurtosis= 42.01, variance= .00). The effects of these non-normal residual distribution and variance on the stability of the model may have been further augmented by the non-normality in the ADL (skewness= 1.49, kurtosis= 6.63) and cognitive IADL (skewness= 1.46, kurtosis= 6.28) residuals distribution. All together, this multivariate non-normality may have seriously violated the assumptions of the model, leading to non-convergence.

Discussion

Given the beneficial effects of physical activity participation, moderate alcohol consumption, and not smoking on disability and cognitive function, as well as the inverse relationship between cognitive function on disability, this study investigated whether cognitive status mediates the effect of lifestyle behaviors on disability among older adults. This mediation was further tested separately for Whites and for Blacks to examine potential race differences in this mediation model. The mediation models converged only for physical activity participation. Although the large sample size of this study should have assured unconstrained solutions, the small number of Level 1 observations (e.g., 4 waves of data collection), potentially small effect sizes of the relationship between the predictor and the mediator as well as between the mediator and the outcome, and violations of the distributions of the residuals probably lead to non-convergence of the models for alcohol consumption and smoking (Bauer, Preacher, & Gil, 2006).

During the 7-year follow-up physical activity participation had favorable effects on both ADL and cognitive IADL, both directly and indirectly through improvements in cognitive function. In the entire sample, about 17% of the total effects of physical activity participation on ADL and about 49% of the total effect of physical activity participation on cognitive IADL were mediated by cognition, independent of socio-demographics and health status. The vast difference between the magnitude of the cognition-mediated effects of physical activity on ADL and on cognitive IADL may reflect differences in the cognitive tasks necessary to perform these activities. That is, performance of ADL tasks requires mostly physical abilities, while performance of cognitive IADL requires more complex cognitive mechanisms and resources (Ng et al., 2006).

Physical activity participation positively affects mainly executive control and visuospatial processes (Barnes, Yaffe, Satariano, & Tager, 2003; Colcombe & Kramer, 2003). In animal models the mechanisms underpinning this effect are represented by angiogenesis, synaptogenesis, or neurogenesis. Although these mechanisms have not been demonstrated in older adults, two recent studies using imaging techniques found that aerobic exercise, which was previously thought to affect only the vascular component of the brain, is related to reduced neuronal degeneration in the cortical areas that sustain executive functioning (Colcombe et al., 2003; Colcombe, Erikson, Scalf, et al., 2006).

On the other hand, indirect global neuronal benefits are hypothesized to result from physical activity participation through increased blood flow in the brain, reduced vascular and cardio-vascular risk, and improved prognosis of chronic diseases associated with impaired cognitive function (Andel et al., 2005; Fillit et al., 2002; Katzmarzyk, Church, & Blair, 2004; Rogers, Meyer, & Mortel, 1990; Rosnick, Small, Borenstein Graves, & Mortimer, 2004; Sesso, Paffenbarger, Ha, & Lee, 1999).

Therefore, it is possible that the cognition-mediated effects of physical activity on cognitive IADL result mainly from improvements in executive control and visuospatial processes, while the cognition-mediated effects of physical activity on ADL may result from improvements in brain vascularization and in the prognosis of coexisting chronic conditions. Previously reported robust associations between executive functioning and

IADL performance (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Dodge, Du, Saxton, & Ganguli, 2006) support this assumption. One study though reported that executive functioning deficits and ADL disability are also related, independent of age, gender, or education (Rapp et al., 2004), contradicting this assumption. However, ADL disability in Rapp and colleagues' study was measured using the Community Affairs, Home and Hobbies, and Personal Care categories of the Clinical Dementia Rating scale (Berg, 1988), which include tasks beyond basic activities of daily living that are not comparable to the ADL tasks (Katz et al., 1963) used in this study.

From the existing studies on exercise and cognition in older adults researchers have drawn the conclusion that lifetime aerobic exercise has definite beneficial effects on cognition, while the effects of short-term exercise intervention programs are less clear-cut (Churchill et al., 2002; Kramer et al., 2004). The significant mediation relationship during the 7-year follow-up identified in this study corroborates this conclusion, and suggests that incorporating regular exercise in older adults' routine lifestyle brings benefits to both cognitive functioning and disability, with cumulative effects on disability. Finding that cognitive function mediates the effect of participation in physical activity on disability independent of proven correlates of cognitive decline, such as age, education, or chronic illness (Christensen, 2001; Colcombe & Kramer, 2003; Fillit et al., 2002; Hassing et al., 2003; Zelinski et al., 1998; Zelinski & Gilewski, 2003; Zsembik & Peek, 2001) suggests that this lifestyle activity plays an important role in improving the quality of life and maintaining the independence of older adults.

Cognition mediated the effect of physical activity participation on ADL and cognitive IADL in Whites but not in Blacks in this study. In Whites, about 15% of the effect of physical activity on ADL and about 41% of the effect of physical activity on cognitive IADL was mediated by cognition. In Blacks, the indirect effect was statistically significant, indicating that physical activity had beneficial effects on cognitive performance, which in turn had positive influences on disability, but the direct pathway between physical activity and disability was not significant. The indirect causal pathway was statistically significant despite older Blacks' lower education and higher number of chronic conditions compared to Whites, providing some optimistic foundation for future research.

The significant effect of cognition on disability detected in this study is opposite to results published by Leveille and colleagues (1998) who found in White but not in Black older women an association between cognition and disability, after controlling for education. Moreover, the magnitude of this effect was similar for Whites and Blacks in this study, which again is contrary to results published by Black and Rush (2002) who found smaller odds of ADL disability onset predicted by cognitive decline in Blacks than in Whites, independent of age, education, and chronic conditions. Although the lack of a direct effect between physical activity and disability among Blacks is surprising, it may result from the non-normal distribution of these variables within and across waves, and from the small sample size of Blacks which could have deterred achieving enough power.

Contrary to the lack of cognition-mediated effects on disability among Blacks in this study, Moody-Ayers and colleagues (2005; p. 933) concluded that cognitive function "mediated the higher frequency of functional decline among black elders" based on the decreased odds ratios for ADL decline in Blacks when cognitive function was included in models adjusted for socio-demographics, health status, and smoking status. Although their results indicate that cognitive performance accounts for some of the White-Black disparities in ADL, as also reported by Zsembik and colleagues (2000), their analytic model did not meet the conventional requirements for mediation (Baron & Kenny, 1986), and less so those for mediation with repeated measures (Bauer et al., 2006). Considering these inconsistencies, future research should examine more in-depth White-Black differences in the relationship between cognition and disability, and replicate this mediation model in larger samples of older Blacks to examine this relationship more accurately.

The analytic approach used in this study represents a methodological advance in examining the direct and indirect effects of healthy lifestyle behaviors on disability in the older population. Although the models for alcohol consumption and smoking did not converge, the models for physical activity participation detected cognition-mediated effects of this lifestyle behavior on disability. Although a mediation effect was found for self-reported physical activity participation in this study, some researchers consider cardiorespiratory fitness a better measure of underlying health status to be examined in relationship to cognition. For example, Barnes and colleagues (2003) found the association between self-reported measures of physical activity participation and cognitive function to be less reliable compared to the association between objectively measured indicators of cardiorespiratory fitness and cognitive function. Future research should replicate this mediation model using objective measures of cardiorespiratory fitness. Additionally, because the benefits of physical activity have been reported previously for selected cognitive domains related to fluid abilities which are more likely to show ageing-related declines than crystallized abilities, future studies should examine this mediation effect using these specific domains of cognitive performance.

References

Aguero-Torres, H., Fratiglioni, L., Guo, Z., Viitanen, M., von Strauss, E., & Winblad, B. (1998). Dementia is the major cause of functional dependence in the elderly: 3-year follow-up data from a population-based study. *American Journal of Public Health, 88*, 1452-1456.

Andel, R., Hughes, T.F., & Crowe, M. (2005). Strategies to reduce the risk of cognitive decline and dementia. *Aging Health, 1,* 107-116.

Baron, R.M., & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Jornal of Personality and Social Psychology, 51*, 1173-1182.

Barnes, D.E., Yaffe, K., Satariano, W.A., & Tager, I.B. (2003). A longitudinal study of cardiorespiratory fitness and cognitive change in healthy older adults. *Journal of the American Geriatrics Society, 51*, 459-465.

Bauer, D. J., Preacher, K. J., & Gil, K. M. (2006). Conceptualizing and testing random indirect effects and moderated mediation in multilevel models: New procedures and recommendations. *Psychological Methods, 11*, 142-163.

Bell-McGinty, S., Podell, K., Franzen, M., Baird, A.D., & Williams, M.J. (2002). Standard measures of executive function in predicting instrumental activities of daily living in older adults. *International Journal of Geriatric Psychiatry, 17*, 828-834.

Berg, L. (1988). Clinical dementia rating (CDR). *Psychopharmacological Bulletin, 24*, 637-639.

Berk, R. A. (1983). An introduction to sample selection bias in sociological data. *American Sociological Review, 48*, 386-398.

Berk, D. R., Hubert, H. B., & Fries, J. F. (2006). Associations of changes in exercise level with subsequent disability among seniors: A 16-year longitudinal study. *Journal of Gerontology Medical Sciences, 61A*, 97-102.

Berkman, L., Singer, B., & Manton, K. (1989). Black/White differences in health status and mortality among the elderly. *Demography, 26*, 661-677.

Binder, E. F., Schechtman, K. B., Ehsani, A. A., Steger-May, K., Brown, M., Sinacore, et al. (2002). Effects of exercise training on frailty in community-dwelling older adults: Results of a randomized, controlled trial. *Journal of the American Geriatrics Society, 50*, 1921-1928.

Black, S.A., & Rush, R.D. (2002). Cognitive and functional decline in adults aged 75 and older. *Journal of the American Geriatrics Society, 50*, 1978-1986.

Blaum, C.S., Ofstedal, M.B., & Liang, J. (2002). Low cognitive performance, comorbid disease, and task specific disability: Findings from a national representative study. *Journal of Gerontology Medical Sciences, 57A*, M523-M531.

Bond, G.E., Burr, R., Murguia Rice, M., McCurry, S.M., Borenstein Graves, A., Teri, L., et al. (2003). Alcohol, aging, and cognitive performance: A cross-cultural comparison. *Journal of Aging and Health, 15*, 371-390.

Bond, G.E., Burr, R., McCurry, S.M., Borenstein Graves, A., & Larson, E.B. (2001).Alcohol, aging, and cognitive performance in a cohort of Japanese

Americans aged 65 and older: The Kame Project. *International Psychogeriatrics, 13,* 207-223.

Bond, G.E., Burr, R., McCurry, S.M., Murguia Rice, M., Borenstein Graves, A., & Larson, E.B. (2005). Alcohol and cognitive performance: A longitudinal study of older Japanese Americans. The Kame Project. *International Psychogeriatrics, 17,* 1-16.

Brandt, J., Spencer, M., & Folstein, M. (1988). The telephone interview for cognitive status. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 1,* 111-117.

Bryan, J., & Ward, L. (2002). Smoking, alcohol use, and engagement in exercise and cognitive performance among older adults. *Australasian Journal of Ageing, 21*, 67-71.

Capodaglio, P., Ferri, A., & Scaglioni, G. (2005). Effects of a partially supervised training program in subjects over 75 years of age. *Aging Clinical and Experimental Research, 17,* 174-180.

Centers for Disease Control and Prevention (2006a). US Physical activity statistics: 2003 State demographic data comparison. Retrieved May 31, 2006, from http://apps.nccd.cdc.gov/PASurveillance/PrintDemoCompareV.asp#result

Centers for Disease Control and Prevention (2006b). Trends in health and aging. Smoking status by age, sex, and race/ethnicity: United States, 1997-2004. NHIS (NHISS04). Retrieved June 2, 2006, from http://209.217.72.36/aging/TableViewer/tableView/aspx

Christensen, H. (2001). What cognitive changes can be expected with normal ageing? *Australian and New Zeeland Journal of Psychiatry, 35,* 768-775.

Churchill, J.D., Galvez, R., Colcombe, S., Swain, R.A., Kramer, A.F., & Greenough, W.T. (2002). Exercise, experience and the aging brain. *Neurobiology of Aging, 23,* 941-955.

Colcombe, S.J., Erickson, K.I., Raz, N., Webb, A.G., Cohen, N.J., McAuley, E., & Kramer. A.F. (2003). Aerobic fitness reduces brain tissue loss in aging humans. *Journal of Gerontology Medical Sciences, 58A,* 176-180.

Colcombe, S.J., Erickson, K.I., Scalf, P.E., Kim, J.S., Prakash, R., McAuley, E., et al. (2006). Aerobic exercise training increases brain volume in aging humans. *Journal of Gerontology Medical Sciences, 61A*, 1166-1170.

Colcombe, S., & Kramer, A.F. (2003). Fitness effects on the cognitive function of older adults: A meta-analytic study. *Psychological Science, 14*, 125-130.

De Ronchi, D., Bellini, F., Berardi, D., Serretti, A., Ferrari, B., & Dalmonte, E. (2005). Cognitive status, depressive symptoms, and health status as predictors of functional disability among elderly persons with low-to-moderate education. *American Journal of Geriatric Psychiatry, 13*, 672-685.

Dodge, H.H., Du, Y., Saxton, J.A., & Ganguli, M. (2006). Cognitive domains and trajectories of functional dependence in nondemented elderly persons. *Journal of Gerontology Medical Sciences, 61A*, 12, 1330-1337.

Dodge, H.H., Kadowaki, T., Hayakawa, T., Yamakawa, M., Sekikawa, A., & Ueshima, H. (2005). Cognitive impairment as a strong predictor of incident disability in specific ADL-IADL tasks among community-dwelling older adults: The Azuchi study. *The Gerontologist, 45*, 222-230.

Ensrud, K. E., Nevitt, M. C., Yunis, C., Cauley, J. A., Seeley, D. G., Fox, K. M., et al., (1994). Correlates of impaired function in older women. *Journal of the American Geriatrics Society, 42,* 481-489.

van Exel, E., Gussekloo, J., de Craen, A.J.M., Bootsma-van der Wiel, A., Houx, P., Knook, D.L., & Westendorp, R.G.J. (2001). Cognitive function in the oldest old: Women perform better than men. *Journal of Neurology, Neurosurgery, and Psychiatry, 71*, 29-32.

Fillit, H.M., Butler, R.N., O'Connell, A.W., Albert, M.S., Birren, J.E., Cotman, C.W., et al. (2002). Achieving and maintaining cognitive vitality with aging. *Mayo Clinic Proceedings, 77*, 681-196.

Folstein, M.F., Folstein, S.E., & McHugh, P.R. (1975). Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189-198.

Furner, S.E., Rudberg, M.A., & Cassel, C.K. (1995). Medical conditions differentially affect the development of IADL disability: Implications for medical care and research. *The Gerontologist, 35*, 444-450.

Galanis, D.J., Joseph, C., Masaki, K.H., Petrovitch, H., Ross, G.W., & White, L. (2000). A longitudinal study of drinking and cognitive performance in elderly Japanese American men: The Honolulu-Asia Aging Study. *American Journal of Public Health, 90,* 1254-1259.

Greiner, P.A., Snowdon, D.A., & Schmitt, F.A. (1996). The loss of independence in activities of daily living: The role of low normal cognitive function in elderly nuns. *American Journal of Public Health, 86*, 62-66.

Guralnik, J. M., Land, K. C., Blazer, D., Fillenbaum, G. G., & Branch, L. G. (1993). Educational status and active life expectancy among older Blacks and Whites. *New England Journal of Medicine, 329*, 110-116.

Hassing, L.B., Johansson, B., Pedersen, N.L., Nilsson, S.E., Berg, S., & McClearn, G. (2003). Type 2 diabetes mellitus and cognitive performance in a population-based sample of the oldest old: Impact of comorbid dementia. *Aging Neuropsychology and Cognition, 10*, 99-107.

He, X. Z., & Baker, D. W. (2004). Body mass index, physical activity, and the risk of decline in overall health and physical functioning in late middle age. *American Journal of Public Health, 94,* 1567-1573.

Herzog, A.R., & Wallace, R.B. (1997). Measures of cognitive functioning in the AHEAD Study. *The Journals of Gerontology Series B, 52B (Special Issue),* 37-48.

Hill, R.D. (1989). Residual effects of cigarette smoking on cognitive performance in normal aging. *Psychology and Aging, 4,* 251-154.

Hill, R.D., Nilsson, L.-G., Nyberg, L., & Backman, L. (2003). Cigarette smoking and cognitive performance in healthy Swedish adults. *Age and Ageing, 32*, 548-550.

Hulse, G.K., Lautenschlager, N.T., Tait, R.J., & Almeida, O.P. (2005). Dementia associated with alcohol and other drug use. *International Psychogeriatrics, 17,* S109-S127.

Isselbacher, K.S., Braunwald, E., Wilson, J.D., Martin, J.B., Fauci, A.S., & Kasper, D.L. (1995). Harrison's principles of internal medicine (13th ed.). New York: McGraw-Hill, Inc., Health Professions Division.

Johansson, B., Berg, S., Hofer, S.M., Allaire, J.C., Maldonado-Molina, M.M., Piccinin, A.M., Pedersen., N.L., & McClearn, G.E. (2004). Change in cognitive capabilities in the oldest old: The effects of proximity to death in genetically related individuals over a 6-year period. *Psychology and Aging, 19,* 145-156.

Julie, J. K., & Jette, A. M. (2001). Have we oversold the benefit of late-life exercise? *Journals of Gerontology Medical Sciences, 56A*, M412-M423.

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

Katzmarzyk, P.T., Church, T.S., & Blair, S.N. (2004). Cardio-respiratory fitness attenuates the effects of the metabolic syndrome on all-cause and cardio-vascular disease mortality in men. *Archives of Internal Medicine, 164*, 1092-1097.

Kelley-Moore, J. A. & Ferraro, K. F. (2004). The black/white disability gap: Persistent inequality in later life? *Journal of Gerontology, 59B*, S34-S43.

Kramer, A.F., Bherer, L., Colcombe, S.J., Dong, W., & Greenough, W.T. (2004). Environmental influences on cognitive and brain plasticity during aging. *Journal of Gerontology Medical Sciences, 59A,* 940-957.

LaCroix, A. Z., Guralnik, J. M., Berkman, L. F., Wallace, R. B., & Satterfield, S. (1993). Maintaining mobility in later life. II. Smoking, alcohol consumption, physical activity, and body mass index. *American Journal of Epidemiology, 137*, 858-869.

Landerman, L. R., Fillenbaum, G. G., Pieper, C. F., Maddox, G. L., Gold, D. T., & Guralnik, J. M. (1998). Private health insurance coverage and disability among older Americans. *Journal of Gerontology Social Sciences, 53B*, S258-S266.

Laurin, D., Verreault, R., Lindsay, J., MacPherson, K., & Rockwood, K. (2001). Physical activity and risk of cognitive impairment and dementia in elderly persons. *Archives of Neurology, 58,* 498-504.

Leveille, S.G., Guralnik, J.M., Ferrucci, L., Corti, M.C., Kasper, J., & Fried, L.P. (1998). Black/White differences in the relationship between MMSE scores and disability: The Women's Health and Aging Study. *Journal of Gerontology Psychological Sciences, 53B*, P201-P208.

Li, L.W. (2005). Predictors of ADL disability trajectories among low-income frail older adults in the community. *Research on Aging, 27*, 615-642.

Liang, J., Shaw, B.A., Krause, N.M., Bennett, J.M., Kobayashi, E., Fukaya, T., Sugihara, Y., Sugisawa, H. (2003). Changes in functional status among older adults in Japan: Successful and usual aging. *Psychology and Aging, 18*, 684-695.

Manly, J.J., Jacobs, D.M., Sano, M., Bell, K., Merchant, C.A., Small, S.A., & Stern, Y. (1998). Cognitive test performance among non-demented elderly African Americans and whites. *Neurology, 50*, 1238-1245.

McGuire, L.C., Ford, E.S., & Ajani, U.A. (2006). Cognitive functioning as a predictor of functional disability in later life. *American Journal of Geriatric Psychiatry, 14*, 36-42.

Mendes de Leon, C. F., Beckett, L. A., Fillenbaum, G. G., Brock, D. B., Branch, L. G., Evans, D. A., & Berkman, L. F. (1997). Black-White differences in risk of becoming disabled and recovering from disability in old age: A longitudinal analysis of two EPESE populations. *American Journal of Epidemiology, 145*, 488-497.

Moody-Ayers, S.Y., Mehta, K.M., Lindquist, K., Sands, L., & Covinsky, K.E. (2005). Black-White disparities in functional decline in older persons: The role of cognitive function. *Journal of Gerontology Medical Sciences, 60A,* 933-939.

Moritz, D.J., Kasl, S.V., & Berkman, L.F. (1995). Cognitive functioning and the incidence of limitations in activities of daily living in an elderly community sample. *American Journal of Epidemiology, 141*, 41-49.

Mortimer, J.A. (1997). Brain reserve and the clinical expression of Alzheimer's disease. *Geriatrics, 52* (Suppl. 2), S50-S53.

National Institute on Alcohol Abuse and Alcoholism (2006). *Social work education for the prevention and treatment of alcohol use disorders. Module 10C: Older adults and alcohol problems.* Retrieved May 31, 2006, from http://pubs.niaaa.nih.gov/publications/Social/Module10COlderAdults/Module10C.html

Nelson, M. E., Layne, J. E., Bernstein, M. J., Nuernberger, A., Castaneda, C., Kaliton, D., et al. (2004). The effects of multidimensional home-based exercise on functional performance in elderly people. *Journal of Gerontology Medical Sciences, 59A*, 154-160.

Ng, T.-P., Niti, M., Chiam, P.-C., & Kua, E.-H. (2006). Physical and cognitive domains of the instrumental activities of daily living: Validation in a multiethnic population of Asian older adults. *Journal of Gerontology Medical Sciences, 61A,* 726-735.

Nourashemi, F., Andrieu, S., Gillette-Guyonnet, S., Reynish, E., Aldarede, J.-L., Grandjean, H., & Vellas, B. (2002). Is there a relationship between fat-free soft tissue mass and low cognitive function? Results from a study of 7,105 women. *Journal of the American Geriatrics Society, 50*, 1796-1801.

Ostermann, J., & Sloan, F. A. (2001). Effects of alcohol consumption on disability among the nearly elderly: A longitudinal analysis. *The Milbank Quarterly, 79.* Retrieved April 23, 2006, from http://www.milbank.org/quarterly/7904feat.html

Pedone, C., Ercolani, S., Catani, M., Maggio, D., Ruggiero, C. Quartesan, R., et al. (2005). Elderly patients with cognitive impairment have a high risk for functional decline during hospitalization: The GIFA Study. *Journal of Gerontology Medical Sciences, 60A,* 1576-1580.

Penninx, B. W. J. H., Rejeski, W. J., Pandya, J., Miller, M. E., Di Bari, M., Applegate, W. B., & Pahor, M. (2002). Exercise and depressive symptoms: A comparison of aerobic and resistance exercise effects on emotional and physical function in older persons with high and low depressive symptomatology. *Journal of Gerontology Psychological Sciences, 57B,* P124-P132.

Raji, M.A., Kuo, Y.-F., Al Snih, S., Markides, K.S., Peek, M.K., & Ottenbacher, K.J. (2005). Cognitive status, muscle strength, and subsequent disability in older Mexican Americans. *Journal of the American Geriatrics Society, 53,* 1462-1468.

RAND Center for the Study of Aging (2006). *Data products: Datasets and files.* Retrieved January 5, 2006 from https://ssl.isr.umich.edu/hrs/files.php

Rapp, M.A., Schnaider Beeri, M., Schmeidler, J., Sano, M., Silverman, J.M., & Haroutunian, V. (2005). Relationship of neuropsychological performance to functional status in nursing home residents and community-dwelling older adults. *American Journal of Geriatric Psychiatry, 13*, 450-459.

Razani, J., Boone, K., Lesser, I., & Weiss, D. (2004). Effects of cigarette smoking history on cognitive functioning in healthy older adults. *American Journal of Geriatric Psychiatry, 12*, 404-411.

Reynolds, S.L. & Silverstein, M. (2003). Observing the onset of disability in older adults. *Social Sciences and Medicine, 57,* 1875-1889.

Richards, M., Jarvis, M.J., Thompson, N., & Wadsworth, E.J. (2003). Cigarette smoking and cognitive decline in midlife: Evidence form a prospective birth cohort study. *American Journal of Public Health, 93*, 994-998.

Rogers, R.L., Meyer, J. S., & Mortel, K. F. (1990). After reaching retirement age physical activity sustains cerebral perfusion and cognition. *Journal of the American Geriatrics Society, 38*, 123-128.

Rosnick, C.B., Small, B.J., Borenstein Graves, A., & Mortimer, J.A. (2004). The association between health and cognitive performance in a population-based study of older adults: The Charlotte County Healthy Aging Study (CCHAS). *Aging Neuropsychology and Cognition, 11*, 89-99.

Schoepflin Sanders, M.L., Lyness, J.M., Eberly, S., King, D.A., & Caine, E.D. (2006). Cerebrovascular risk factors, executive dysfunction, and depression in older primary care patients. *American Journal of Geriatric Psychiatry, 14,* 145-152.

Seeman, T. E., Berkman, L. F., Charpentier, P. A., Blazer, D. G., Albert, M. S., & Tinetti, M. E. (1995). Behavioral and psychological predictors of physical performance: MacArthur Studies of Successful Aging. *Journal of Gerontology Medical Sciences, 50A*, M177-M183.

Sesso, H.D., Paffenbarger, R.S., Ha, T., & Lee, I.M. (1999). Physical activity and cardio-vascular disease risk in middle-aged and older women. *American Journal of Epidemiology, 150*, 408-416.

Sloan, F.A., & Wang, J. (2005). Disparities among older adults in measures of cognitive function by race or ethnicity. *Journal of Gerontology Psychological Sciences, 60B,* P242-P250.

Small, B. J., Hughes, T. F., Hultsch, D. F., & Dixon, R. A. (2006). Lifestyle activities and late-life changes in cognitive performance. In Y. Stern (Ed.), *Cognitive reserve* (pp. 173-186). New York, NY: Psychology Press.

Soldo, B. J., Hurd, M. D., Rodgers, W. L., & Wallace, R. B. (1997). Asset and Health Dynamics Among the Oldest Old: An overview of the AHEAD study [Special Issue]. *Journals of Gerontology Series B, 52B,* 1-20.

Spiers, N.A., Matthews, R.J., Jagger, C., Mathhews, F.E., Boult, C., Robinson, T.G., & Brayne, C. (2005). Disease and impairments as risk factors for onset of disability in the older population in England and Wales: Findings from the Medical Research Council Cognitive Function and Ageing Study. *Journal of Gerontology Medical Sciences, 60A,* 248-254.

Tabachnick B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4^{th} ed.). Boston: Allyn and Bacon.

Verbrugge, L.M., & Jette, A.M. (1994). The disablement process. *Social Science and Medicine, 38,* 1-14.

Wray, L. A., Alwin, D. F., & McCammon, R. J. (2005). Social status and risky health behaviors: Results from the Health and Retirement Survey [Special Issue]. *Journal of Gerontology Series B, 60B)*, 85-92.

Zarit, S.H., Femia, E.E., Gatz, M., & Johansson, B. (1999). Prevalence, incidence, and correlates of depression in the oldest old: The OCTO Study. *Aging and Mental Health, 3*, 119-128.

Zelinski, E.M., Crimmins, E., Reynolds, S., & Seeman, T. (1998). Do medical conditions affect cognition in older adults? *Health Psychology, 17,* 504-512.

Zelinski, E.M., & Gilewski, M.J. (2003). Effects of demographic and health variables on Rasch cognitive scores. *Journal of Aging and Health, 15*, 435-464.

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

Zsembik, B.A., & Peek, M.K. (2001). Race differences in cognitive functioning among older adults. *Journal of Gerontology Social Sciences, 56B,* S266-S274.

Yaffe, K., Barnes, D., Nevitt, M., Lui, L.Y., & Covinsky, K. (2001). A prospective study of physical activity and cognitive decline in elderly women: Women who walk. *Archives of Internal Medicine, 161*, 1703-1708.

CONCLUSIONS

White-Black disparities in disability are persistently reported in the literature despite overall declines in levels of disability in the older population since early 1980's (Waidman & Manton, 1998; Freedman, Crimmins, Schoeni, et al., 2004). According to the disablement model, the development of disability is shaped by complex interrelated factors, including intra-individual biologic, behavioral, psychological, or socio-economic factors, and extra-individual social and policy factors (Verbrugge & Jette, 1994). There is empirical evidence of the contribution of socio-economic and health status to White-Black disparities in health, but modest knowledge on the role of modifiable intra- and extra-individual factors on these disparities. The three studies included in this dissertation examined the effects of health and lifestyle behaviors as intra-individual determinants of disability, and the effects of health care utilization as extra-individual determinants of disability. Given the goal of *Healthy People 2010* of eliminating health disparities in the US population, and the considerable formal and informal resources consumed by older adults with difficulties in performing daily activities, identifying modifiable determinants of White-Black disparities in disability is imperative.

Previous research shows that healthy lifestyle behaviors, including physical activity, moderate alcohol consumption, not smoking, and maintaining a normal body weight have multiple beneficial effects on the health of older adults. Yet, there is hardly any research examining differential effects of healthy lifestyle behaviors in White and in

Black older adults. Most of the studies on the effects of healthy lifestyle behaviors on health used race as a control variable, because of its confounding effects on socio-economic or health status. However, previous findings indicate persistent race disparities in health even within similar levels of socio-economic status, probably resulting from discrimination, residential segregation, or poor quality of health care (Williams, 1999).

Considering older Blacks' lower likelihood of practicing healthy lifestyle behaviors compared to older Whites, I have argued that health behaviors could account for White-Black disparities in disability, independent of the effects of socio-economic and health status. However, I found persistent race disparities in trajectories of ADL disability after accounting for the effects of health behaviors, independent of socio-economic and health status. It is possible that these persistent disparities in ADL trajectories are similarly rooted in discrimination, residential segregation, or poor quality of health care (Williams, 1999). On the other hand, the size of the average White-Black differences in levels of ADL disability during the entire duration of the study was larger then the size of the White-Black differences in the rates of change over time in ADL disability. This suggests that older Whites and Blacks reach older age with disparities in disability which have accumulated during the life course and, although these disparities continue to increase, the magnitude of this increase is not substantial. Therefore, addressing these disparities during the entire lifecourse may prevent some of the disparities in disability in older age. In addition, intervention programs promoting healthy lifestyle behaviors among older Blacks should target not only the individuals, but also their physical, social, and policy environment. Although practicing health behaviors is greatly shaped by behavioral role models, cultural norms, and social networks influences (Seeman & Crimmins, 2001), macro-level physical, social, and policy influences intimately influence one's lifestyle choices.

The influences of health behaviors closed the residual White-Black gap in trajectories of IADL disability unaccounted for by socio-economic and health status. Although statistically significant, the absolute differences in the overall levels of and in the rates of change in IADL disability during the course of the study between Whites and Blacks after adjusting for the effects of socio-economic and health status only were small. Both these differences were no longer statistically significant after the effects of health and lifestyle behaviors were included in the predictive models. This finding suggests that even though the contribution of health and lifestyle behaviors to the White-Black disparities in disability is not sizeable, it is large enough to eliminate the residual differences in IADL disability not accounted for by socio-economic and health status. Therefore, public health programs promoting healthy lifestyle behaviors among older Blacks have the potential to reduce disparities in IADL disability.

Findings from this study provide evidence for public health programs promoting physical activity participation and maintenance of normal or overweight body mass as avenues for reducing disability levels among older Whites. Even though the absolute differences in the overall levels of and in the rates of change over time in disability between Whites who did and did not participate in physical activity, and Whites who were normal weight or overweight and Whites who were underweight or obese were not large at the individual level, at a population level the impact of these differences can be considerable. This considerable impact can be reflected in improved quality of life for the older individual, as well as in major costs savings for the society resulting from delayed institutionalization or need for assistive home care services. Results from the third study of this dissertation show additionally that among older Whites physical activity positively influences ADL and IADL disability not only directly, but also through improvements on cognitive status, which in turn positively affects disability. This finding represents a pivotal element for public health programs given the increasing likelihood of disability and cognitive decline with increasing age: one intervention factor, physical activity, amends both major threats to the independence of older adults, disability and cognitive decline, with cumulative beneficial effects on disability. Given also that physical activity participation can buffer or counteract the detrimental effects on health of other health risk factors such as obesity, smoking, or high cholesterol levels (Blair, Kampert, Kohl, et al., 1996; Paffenbarger, Hyde, Wing, et al., 1993), these study results suggest that physical activity participation should be a routine lifestyle habit. The comparable effect sizes for the main effects of and rates of change in disability associated with physical activity participation for Whites and for Blacks suggest that similar beneficial effects do exist among older Blacks. However, because the small number of older Blacks in this study sample may be the reason for not reaching statistical significance for these effects in Blacks, future studies should replicate these analyses using larger samples of Blacks.

Although previous research reported favorable disability outcomes related to moderate alcohol consumption and not smoking, results from these studies could not corroborate these findings. Considering the large proportion of older adults reporting no alcohol consumption (NIAA, 2006) and not current smoking (USDHHS, 2005) larger samples of older adults with higher representation of older Blacks are necessary to achieve the necessary statistical power to accurately examine longitudinally the effects of these health and lifestyle behaviors on disability.

Health care services are "inserted during the disablement process in an effort to avoid, retard, or reverse outcomes" (Verbrugge & Jette, 1994: pp. 8). Although previous research demonstrated that health care utilization is governed by predisposing, enabling, and need factors, findings on race differences in health care utilization are inconsistent and the knowledge on White-Black differential effects of health care utilization on disability is slim. Results from the second study of this dissertation show that older Blacks reap similar benefits from primary health care services utilization, when adjusting for the effects of established determinants of health care utilization. Further, older Blacks experienced decreasing disability levels of disability over time as a result of using short-stay nursing home and home health care services, regardless of predisposing, access, or need factors. In other words, utilization of rehabilitative health care services has the potential to reduce White-Black disparities in disability, within similar levels of predisposing, enabling, and need factors. This finding is of great importance for the *Healthy People 2010* agenda of eliminating health disparities, and indicates that the factors that determine utilization of these health care services need to be targeted by policies and regulations.

To assure that utilization of rehabilitative health care services does perform its disparities reduction potential, older Blacks' barriers to health care utilization need to be eliminated. Older Blacks are more likely to reach old age with a lifelong accumulation of disadvantage in health, are likely to experience racial prejudice in health care enabled by the Medicare regulatory loopholes (Ford & Cooper, 1995), to fall through the cracks of the Medicare restricted provisions (Dunlop, Manheim, Song, & Chang, 2002), and to live in segregated poor neighborhoods with lower availability of health care services (Kirby & Kaneda, 2005). In light of the beneficial effects of rehabilitative health care utilization in older Blacks identified in this study, regulatory health policies are necessary to overhaul older Blacks' inadequate and segregated access to and quality of health care resources. More rigorous guidelines for provision of health care services and educational campaigns targeting providers' bias towards minority patients could change this status quo.

Although the beneficial effects of health care utilization on trajectories of disability among Blacks may be biased by influences not modeled in these analyses, this exploratory study opens the door for future research. Further studies should attempt to disentangle White-Black differential disability outcomes of health care utilization by analyzing administrative records rather than self reports, and by accounting for community and geographic variations in availability of health care, and for availability of informal social support. Such knowledge could provide a better foundation for health policy and regulations.

The longitudinal design and the analytic methodology of the three studies included in this dissertation allowed the detection of temporal, dynamic relationships which is not possible in cross-sectional designs or analyses using time-invariant covariates. The utilization of mixed effects models with time-varying covariates is a methodological advancement in the research on health disparities because it reflects changes in the outcome over time shaped by changes in time-varying covariates over time. The multilevel mediation model also represents a pioneering method in this area of research because it models complex within and between individuals heterogeneity, which is not available in the analytic methods usually employed in studies on health disparities. Because the dataset used in these studies did not permit testing all the hypothesized effects, future research is necessary to extricate these relationships.

One of the major criticisms of using time-varying predictors in longitudinal data analyses is endogeneity or reciprocal causation (Singer & Willett, 2003). While not all time-varying predictors can be a reciprocal causation relationship with the outcome, the so called “internal” ones have the highest potential to introduce causation difficulties. These internal time-varying predictors represent changeable characteristics of the individual that are contemporaneous and potentially causal to the outcome. One way to deal with this situation is to model time-varying predictors that are measured at a previous point in time relative to the outcome. The other is to use different analytic models, such as latent growth models that estimate the initial level and rate of change of the time-varying predictor and use them as predictors for the initial level and rate of change in the outcome.

The internal time-varying variables prone to questionable causation in the studies included in this dissertation are smoking, BMI, and self-reported health. Physical activity participation was measured having as the reference period the 12 months prior to the interview, alcohol consumption was measured for the 3 months prior to the interview;

and health care utilization was measured for the 2 years prior to the interview. Because these latter time-varying variables are not contemporaneous to the time of assessment of the outcome, it is likely that the direction of the causal relation is the hypothesized one. However, for the former time-varying predictors a directionality bias is present. That is, current self-reported health can affect the current disability level as hypothesized in the study, as well as can be the effect of the current level of disability as previously found in the literature (Farmer & Ferraro, 2005). Similarly, the current BMI can be the result of one's current disability level, as well as the effect of one's current disability level. Therefore, future research should either model these variables as prior time measurements, or use different analytic methods that manage better causality inferences.

Throughout the three studies included in this dissertation there is evidence for a potential to reduce White-Black disparities in disability in older age. Results indicate that modifiable influences on disability exist both at individual and at policy level, and these demonstrated effects should lay the foundation for evidence-based interventions. In conclusion, proven determinants of health at both individual and community level need to be addressed to achieve the *Healthy People 2010* overarching goal of eliminating health disparities.

References

Blair, S. N., Kampert, J. B., Kohl, H. W., Barlow, C. E., Macera, C. A., Paffenbarger, R. S., & Gibbons, L. W. (1996). Influences of cardio-respiratory fitness and other precursors on cardio-vascular disease and all-cause mortality in men and women. *Journal of the American Medical Association, 276*, 205-210.

Dunlop, D. D., Manheim, L.M., Song, J., & Chang, R.W. (2002). Gender and ethnic/racial disparities in health care utilization among older adults. *Journal of Gerontology Social Sciences, 57B,* S221-S233.

Farmer, M. M., & Ferraro, K. F. (2005) Are racial disparities in health conditional on socioeconomic status? *Social Science and Medicine, 60*, 191-204.

Ford, E. S., & Cooper, R. S. (1995). Racial/ethnic differences in health care utilization of cardio-vascular procedures: A review of the evidence. *Health Services Research, 30,* 237-252.

Freedman, V. A., Crimmins, E., Schoeni, R. F., Spillman, B. C., Aykan, H., Land, K., et al. (2004). Resolving inconsistencies in trends in old-age disability: Report from a technical working group. *Demography, 41,* 417-441.

Kirby, J. B. & Kaneda, T. (2005). Neighborhood socioeconomic disadvantage and access to health care. *Journal of Health & Social Behavior, 46,* 15-31.

National Institute on Alcohol Abuse and Alcoholism ([NIAA], 2006). *Social work education for the prevention and treatment of alcohol use disorders. Module 10C: Older adults and alcohol problems.* Retrieved on May 31, 2006, from http://pubs.niaaa.nih.gov/publications/Social/Module10COlderAdults/Module10C.html

Paffenbarger, R. S., Hyde, R., Wing, A. L., Lee, I. M., Jung, D. L., & Kampert, J. B. (1993). The association of changes in physical activity level and other lifestyle characteristics with mortality among men. *New England Journal of Medicine, 328,* 574-576.

Seeman, T. E., & Crimmins, E. (2001). Social environment effects on health and aging. In Weinstein, M., Hermalin, A. I., & Stoto, M. A. (Eds.), *Population health and aging: Strengthening the dialogue between epidemiology and demography* (pp. 88-117). NY: The New York Academy of Sciences.

Singer, J. D., & Willett, J. B. (2003). Applied longitudinal data analysis: Modeling change and event occurrence. NY: Oxford University Press (pp. 159-181).

U.S Department of Health and Human Services (USDHHS, 2005). *Health, United States, 2005.* Retrieved on June 1, 2006, from http://www.cdc.gov/nchs/data/hus/hus05.pdf

Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Social Sciences and Medicine, 38,* 1-14.

Waidman, T. A., & Manton, K. G. (1998). International evidence on disability trends among the elderly. The US Department of Health and Human Services. Retrieved on April 26, 2005, from http://aspe.hhs.gov/daltcp/reports/trends.htm#usevidence

Williams, D. R. (1999). Race, socioeconomic status, and health: The added effects of racism and discrimination. In Adler, N. E., Marmot, M., McEwen, B. S., & Stewart, J. (Eds.), *Annals of the New York Academy of Sciences, 896,* 173-188.

About the Author

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